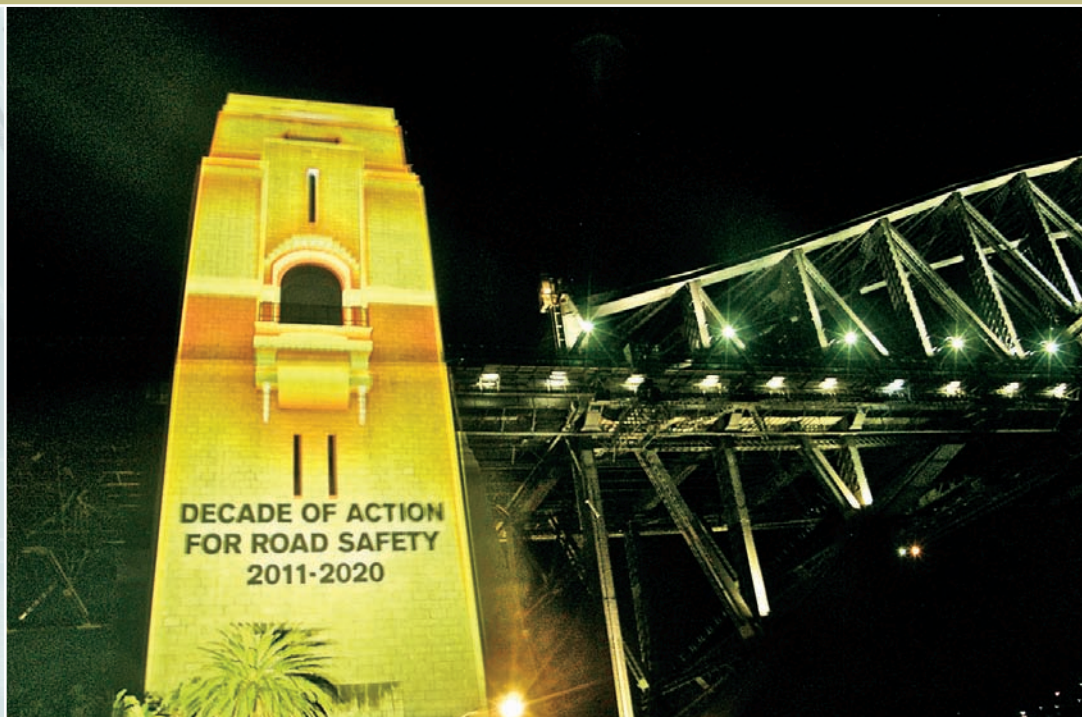




Journal of the Australasian College of Road Safety

Formerly RoadWise — Australia's First Road Safety Journal



Special issue – Heavy vehicle safety

Peer-reviewed papers

- Electronic work diary: Policy, specification and operational pilot
- Heavy vehicle road safety: A scan of recent literature
- Investigating the role of fatigue, sleep and sleep disorders in commercial vehicle crashes: A systematic review
- Safety in the transport industry

Contributed articles

- Recent ARRB research on heavy vehicle safety
- Large truck crash avoidance
- Influence of speed on concrete agitator vehicle stability
- Australian major accident investigation report on 2009 NTI data: Heavy vehicle losses > \$50,000
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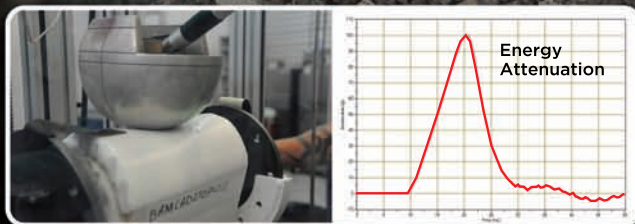
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Cover photo

The Decade of Action for Road Safety logo lit up on the pylon of the Sydney Harbour Bridge in May 2011. Cover photo and other Sydney images courtesy of David Wilmoth.

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The College encourages interested persons and organisations to submit articles, photographs or letters for publication. Published letters would normally show the name of the writer and the state or territory of residence. The journal provides the opportunity for researchers to have their work submitted for peer review, in order to improve the quality of their research papers. However, peer review cannot guarantee the validity of research nor assure scientific quality. The publisher reserves the right to reject submissions or, with approval of the author, to edit articles. No payment is offered for articles published.

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From the President



Dear ACRS Members,

Linda Cooke, our Executive Officer for the last few years, has accepted a similar position with our friends at the NRMA Road Safety Trust. We have benefited from her contribution to the College in so many ways and while we are very sorry to lose her, we congratulate her on her appointment

and wish her well. We look forward to continuing to work with her and the Trust.

We are delighted to let you know that Claire Howe has accepted the position of Executive Officer. Claire has had experience in a range of different organisations, most recently as Communications Manager for the Australian Institute of Agricultural Science and Technology based in Canberra.

This issue of the journal has a focus on heavy vehicle safety. The National Road Safety Strategy for the next decade released recently by the Australian Transport Council stated:

‘Heavy trucks and buses make up only three per cent of registered vehicles but account for about eight per cent of the vehicle-kilometres travelled on Australia’s roads...these vehicles are involved in a relatively large proportion of road fatalities.’

I have to thank Lori Mooren for being our Guest Editor for this issue and for compiling what is an important contribution to helping understand some of the processes necessary in reducing heavy vehicle related crash trauma.

I also welcome Deborah Banks as our new Journal Editor. Deborah joins us from Directions ACT and previously the Asthma Foundation. She will be keen to hear from you regarding the journal, both with comments and contributions.

As you will recall the ACRS made a detailed submission earlier this year on the draft of the National Road Safety Strategy 2011-2020. The key statement in the new Strategy announced by the Australian Transport Council in May was that ‘No person should be killed or seriously injured on Australia’s roads.’ This is to be highly commended.

Unfortunately, the Strategy fails to set out the leadership needed to achieve that vision, or any real economic analysis to support its value.

The Monash University Action Research Centre’s economic modelling, which allegedly underpinned the target of a 30% reduction in death and injury, was not presented for public analysis. The new Strategy has no comprehensive independent economic modelling of economy wide impacts of road trauma. In fact the national statistics used in the analysis of the current situation are quoted as ‘approximate’ only. With the annual costs to the economy alleged at \$27 billion and the identified trauma reduction potential of hundreds of premature deaths and thousands of people seriously injured, the full impacts across the economy are not specifically identified.

A 30% reduction target could result in annual savings to the economy of up to \$10 billion a year, every year. This target is less than targets in comparable countries, so the annual national cost savings could be greater if we were more ambitious and keen to achieve world best practice road safety results. Given the levels of concern in the community about unnecessary costs generally, and the need to enhance our national productivity at every opportunity, we believe that the Productivity Commission should independently identify the economy-wide costs of, and potential savings in reducing, road trauma.

Cost effectiveness as a key decision tool is absent in the new Strategy. There is only commentary, not real evidence of reduced trauma being directly related to specific spending or vice versa. While there is a recommendation on the need for ‘identifying funding and prioritising the allocation of resources to safety’, it is surprising that such priorities had not already been identified given we have had a 10 year Strategy and Action Plans in place to reduce road trauma over the last decade.

Current road trauma data is poor, resulting in conclusions being drawn from incomplete data. For example, a table reporting the remoteness of the distribution of crashes in NSW shows that 20% of crashes occur in ‘unknown destinations’ and another key statement is that ‘there is currently no reliable national collection of serious injury crash data’. While agencies are encouraged to ‘work towards the adoption of nationally consistent road crash classifications’ no specific dates are set. The need for such a database has been identified for over a decade.

Government processes and regulations were identified as impediments to the introduction of safer roads and safer cars but there is no national assessment of the costs of these impediments.

Similarly, there is no review of the costs or benefits of current jurisdictional responsibilities, duplication of effort, and inadequacies of governance, or capacity to address the identified problems or efficiency of current management structures. There is no review of the real economic impacts on hospitals, health care or social and welfare services despite the recognition of thousands of serious injuries occurring every year. There is no review of national workforce impacts and productivity losses although around 50% of workplace deaths are related to road and vehicle incidents.

The action proposed in the Strategy to ‘Work with the National Road Safety Council to raise the profile of road safety as a major public health issue across government, industry, business and community sectors’ is without a timetable or a set of specific outcomes and is an example of the weakness of the Strategy. Australia’s performance compared to other countries in reducing road trauma continues to decline.

I have written to Minister Shorten asking him to reverse his decision, reported in the last journal, not to ask for a review of the national costs of road trauma by the Productivity Commission. We believe an open, nation-wide review of the full costs of road trauma is absolutely essential.

I have also written to the Hon Catherine King, Parliamentary Secretary for Infrastructure and Transport, asking for her support to strengthen research, research cooperation, skills and professional development, as these will be essential to underpin the other programs necessary over the decade. I believe the College is ideally placed to assist in coordinating and managing

such a national project which we believe should be actively supported by the Federal Government and perhaps the National Road Safety Council.

I also indicated that the College is keen to assist in maintaining interest and action for the UN Decade of Action for Road Safety,

given the strong support shown not only at the Parliament House launch but also across the country on May 11th.

*Lauchlan McIntosh AM EACRS
President*

Guest editorial – Lori Mooren



Lori Mooren is the guest editor for this special issue on heavy vehicle safety. Formerly a road safety practitioner in government and private sectors over the past 20+ years, her research focus now is safety management in the heavy vehicle transport sector. Lori is currently a Senior Research Fellow at Transport and Road

Safety (TARS), University of New South Wales, where she conducts research related to road safety and transport fleet safety. Her major project, funded through an Australian Research Council grant with contributing partners including the Motor Accidents Authority of NSW, Roads and Traffic Authority of NSW, National Transport Commission, Transport Certification Australia and Zurich Financial Services Australia, aims to develop a safety management system suitable and effective for heavy vehicle transport operations.

Lori is a member of the United Nations Road Safety Collaboration, the US Transportation Research Board (TRB) Committee on Truck and Bus Safety and co-chair of both the Alternative Compliance Sub-committee and the NSW WorkCover Transport and Storage Industry Reference Group. Lori is also an executive member of the Sydney Chapter of the Australasian College of Road Safety.

This special issue of the journal aims to explore some of the important research that has been recently conducted to assist the advancement of heavy vehicle transport safety.

For the foreseeable future the transport of goods in Australia will rely on the use of heavy trucks on our roads. Indeed, according to forecasts by Chris Richardson of Deloitte Access Economics, the transport task is currently set on a growth trajectory with the current mining boom and general growth in the Australian economy. This brings both challenges and opportunities for the heavy vehicle transport sector – and with it, a range of safety issues.

The Bureau of Infrastructure, Transport and Regional Economics (BITRE) reported that in the 12-month period ending September 2010, there were 237 deaths from 195 crashes involving heavy trucks on Australian roads. While truck involvement in fatal crashes is decreasing, governments and the transport industry are striving to do more to enhance safe transport operations. With sound research into risk factors and safety solutions underpinning the improvements to vehicles and operations, the industry will be well-placed to make the needed improvements.

This special issue features a selection of the recent work in the research, government and industry sectors towards a safer heavy vehicle transport scenario in Australia and elsewhere.

RRSP Profile – Prof Raphael Grzebieta



In each issue of the journal we profile 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 they must be acknowledged as experts by their

peers. For details visit www.acrs.org.au/professionalregister.

Raph Grzebieta is Chair of Road Safety at the TARS research centre at the University of New South Wales. Raph is a structural engineer whose experience in road safety – including research and investigation in areas such as vehicle crashworthiness, road infrastructure crashworthiness and forensic engineering - spans 28 years. Raph has published over 200 papers and supervised numerous PhD and Masters students. His

current focus is on rollover crashworthiness, motorcycle and truck safety, cycling and pedestrian safety, ambulance crashworthiness and fatigue. Raph has been an active and dedicated member of the ACRS for more than a decade.

Raph was asked the following questions:

How long have you been a member of the ACRS and how did your involvement come about?

I've been a member of the College for over ten years.

I was recruited by the ACRS National Executive Committee to start and chair the Victorian Chapter in Melbourne when I was working in the Department of Civil Engineering at Monash University. I guess I was the inaugural Victorian Chapter Chair and over the years wound up as national President of the College. I have just stepped down as the Sydney Chair for the past two years. At the time when I first joined the college and was encouraged to chair the Victorian Chapter, I was quite

active in vehicle crashworthiness and vocal about issues concerning poor vehicle and road designs that I saw were resulting in needless deaths. It was also the time when the Australian New Car Assessment Program (ANCAP) and Australian Road Assessment Program (AusRAP) came into existence. There was a lot of focus on making vehicles and roads safer. I saw the College as an excellent conduit to influencing Federal and State regulators, policy makers and industry to raise the level of passive safety inherent in the Australian fleet and making roads safer.

What do you value most about your membership?

To be able to contribute at a national level to the reduction of road fatalities and serious injuries. The ability to discuss and debate with Australia's leading road safety experts about how to better design a safe road transport system. The ability to network and influence, at a national and state level, legislators, policy makers, and road professionals in areas of road safety that I see are important to reducing road trauma. The ability to contribute my expertise and help the wider community.

To tap into, and participate in, the extensive knowledge exchange between all the various road safety stakeholders. I also highly value the terrific staff at the national office and the committed executive and committee members, and the general ACRS members, who are all passionate about road safety and are so helpful and so willing to help this noble cause.

What is your particular expertise in road safety?

I am a qualified structural engineer in the area of civil engineering. My career started in passive safety mostly related to structural crashworthiness, i.e. crushing of engine mounting tubes, bending of bus frames, and the like (mostly solid mechanics, thin-walled structures and plastic mechanisms). However, I have been inspired by a number of people to apply my engineering knowledge to road safety where people are needlessly dying and being hurt.

Firstly, I was inspired by my PhD supervisor and mentor, the late Professor Noel Murray. Noel was also a structural engineer and foundation Professor of the Department of Civil Engineering at Monash University, when he published his book 'When it comes to the Crunch'. I was also inspired by Professor Claes Tingvall, a friend and past colleague who convinced the Swedish Parliament that it was unethical to accept that some people may die or be seriously injured when using the road transport system, and that we should adopt Vision Zero (zero deaths and serious injuries) as our basis for designing the road transport system. Another friend and past colleague, Dr George Rechnitzer, thought it likewise obscene that people should die or be maimed as a result of poor engineering design practices. And more recently I have been lucky to work with the wonderful research staff at UNSW whose expertise is mostly in the area of human factors, injury and biomechanics. People such as Prof Ann Williamson, Lori Mooren, Rena Friswell, Dr Mike Bambach, A/Prof Andrew

McIntosh, Dr Rebecca Mitchell, Dr Jake Olivier and Dr Julie Hatfield have all inspired and educated me. As a result of the past mentoring and these wonderful collegiate associations, I have gained skills in vehicle crashworthiness design, forensic crash investigations, roadside safety barrier design, biomechanics of injury, and even an understanding of some human factors in road safety.

What is a typical working day for you?

As a university researcher my day is very full-on. It starts at around 7.30 am and I usually don't finish until around 7.00 pm. But I couldn't be luckier. I am pursuing my dream job. For example, this morning I reviewed a road safety journal paper on road safety barrier design, learning about how other people are solving this road safety problem. Later in the day I will be working on a research grant proposal on investigating motorcycle crashes into roadside barriers and what our team at TARS want to do. I used to get heavily involved in crash testing and computer crash simulations but these days I am mostly involved in managing research projects, doing research, supervising PhD students, writing and reviewing research papers, submitting research grants and answering media and community requests, all focussed on road safety. I also get involved in expert witness work for police, coroners, WorkSafe and legal firms from time to time. I am involved in four major areas of road safety, namely, heavy truck safety, rollover crashworthiness and vulnerable road user safety (motorcycles, bicycles and pedestrians).

What current road safety issues concern you most?

An issue that concerns me greatly is the biased, unbalanced media coverage of speed enforcement issues in NSW. The attitude that some commercial TV stations, current affairs programs, Sydney's radio 'shock jocks' and the tabloid press display in particular towards mobile, fixed and point-to-point safety speed cameras is nothing short of callous and insensitive to those people and families who have been the victims of road crashes. Victoria has shown the effectiveness of good speed enforcement on reducing road trauma. Portraying speed enforcement as something that needs to be quashed, and supporting the small vocal minority of recalcitrant people who want the right to speed and break the law, without a balanced opinion is ethically unsupportable.

Another concern is how politicians are sometimes swayed by vocal community outbursts by potential voters who want to increase speed limits, get rid of speed cameras, get rid of demerit points, ban life-saving wire-rope barriers, and retract the compulsory bicycle helmet law, all of whom have no scientific evidence to support their claims. It is pretty scary when one thinks about the increase in road carnage if politicians were persuaded and such changes were made.

College News

Welcome to Silver members 2011

In 2010, the ACRS decided to offer different levels of corporate membership – Bronze, Silver and Gold. Silver and Gold memberships offer additional benefits as a way of recognising and thanking member organisations which provide financial support over and above the base-level membership subscription.

The College would like to acknowledge and welcome the following Silver corporate members:

- Linfox Logistics
- Sinclair Knight Merz
- Transport and Road Safety (TARS) Research.

Silver corporate members receive extra copies of each issue of the journal and a discount on ACRS conference and seminar fees. More information about the levels and benefits of corporate membership can be found at www.acrs.org.au/membership/corporate.

Staff changes at ACRS

Farewell to Linda Cooke and welcome to new Executive Officer

After three and a half years as the ACRS Executive Officer, Linda Cooke has left to take up the position of Secretary/Manager at the NRMA Road Safety Trust. The Executive Committee, members and staff of the College extend their thanks and appreciation to Linda for her hard work and dedication during her time at the College. We wish Linda every success in her new role.

Following Linda's departure, the College warmly welcomes **Claire Howe** in the role of Executive Officer. Claire has a science background and joins the College from the Australian Institute of Agricultural Science and Technology, a not-for-profit organisation where she spent a number of years as Communications Manager. Claire is committed to making a difference to the cause of road safety and aims to use her skills and experience to increase the profile, networking and communication power of the College.

New Journal Editor

Deborah Banks is the new managing editor of the journal. Deborah has a background in Human Resources Management and has had a long association with community/not-for-profit organisations. As the parent of teenagers, she has a keen interest

in road safety, particularly the issues that affect young drivers and their families. Deborah is keen to maintain, and build on, the high standard achieved for the journal by predecessor Nancy Lane. Deborah wishes to thank Nancy for giving generously of her time and expertise during, and since, the handover.

Chapter reports

New South Wales

The Sydney Chapter, in partnership with the RTA, was pleased to support the launch of the Decade of Action for Road Safety 2011-2020 on May 11, together with other Chapters and organisations worldwide. The launch was held together with a seminar at NSW Parliament House, with approximately 100 people attending. The new Minister for Roads and Ports, the Hon Duncan Gay, launched the Decade as his first public speech as Minister, followed by Michael Bushby, CEO, RTA. The RTA also arranged for the Decade of Action logos to be projected and lit up on the pillars of the Sydney Harbour Bridge – an achievement that received international recognition, with images posted on the United Nations website.

The Decade of Action Road Safety Seminar followed with themed presentations from the UN Road Safety Collaboration, RTA, NRMA, MAA, NSW Police, ARRB, Australian Trucking Association, Pedestrian Council of Australia, Campbelltown City Council, Parsons Brinckerhoff, and a Sydney neurosurgeon; chaired by Raphael Grzebieta (then ACRS Chair/Transport and Road Safety Research) and Rebecca Ivers (Australian Injury Prevention Network President/The George Institute for Global Health).

The Chapter also held its AGM following the National AGM on May 26. The following members were elected to the Executive: Teresa Senserrick (Chair), Raphael Grzebieta (Deputy Chair), David McTiernan (Secretary), Liz de Rome (Treasurer), Peter Croft (Web Coordinator), Lori Mooren, Harry Camkin, Jack Haley, Joanne Kemp and Doris Lee. I take this opportunity to particularly thank Raphael for Chairing the Executive over the past two years, as well as all other members of the Executive who volunteered their time to contribute to a full program of activities. I look forward to the year ahead, particularly as we plan for Sydney's turn to host the ACRS Conference in 2012.

Dr Teresa Senserrick, NSW Chapter Chair and Representative on the ACRS Executive Committee

Queensland

I am pleased to present a report on the activities of the Queensland Chapter of the ACRS.

During the last financial year, we have held four major seminars. The December 2010 seminar was used as an opportunity to present the Draft National Road Safety Strategy 2011-20. All four of these seminars were well attended and prompted considerable discussion among members and other attendees. I would like to thank all the guest speakers for contributing their time and expertise:

- June 2010 *Road Safety in Queensland*
Mr Bruce Ollason, Road Safety and System Management, DTMR
- Sept 2010 *Piecing the puzzle together: data linkages in road safety*
Ms Angela Watson, PhD student, CARRS-Q
- Dec 2010 *Presentation of the Draft National Road Safety Strategy 2011-20*
Ms Pam Palmer, Road Safety and System Management, Dept of Policy, Transport and Main Roads
- Mar 2011 *Presentation on Advanced Driving Simulator Visit/Test Drive Advanced Driving Simulator*
Associate Professor Andy Rakotonirainy, CARRS-Q

The Queensland Chapter sponsors the Australasian College of Road Safety Award for outstanding achievement to a graduating student in the Graduate Certificate or Graduate Diploma in Road Safety from the Queensland University of Technology. The total prize value is \$500.00 and the duration of sponsorship is three years. The 2010 recipient of the award was Mr Tristan Robertson.

Queensland Chapter members and associates continue to contribute to the ACRS journal with a number of papers being accepted over the past 12 months. Further, the Queensland Chapter also holds a place on both the Queensland Motorcycle Advisory Committee and the Queensland Road safety Action Group.

Finally, the Queensland Chapter played a key role in the United Nations Decade of Action for Road Safety – Queensland Launch. A breakfast hosted by the Minister for Transport and Multicultural Affairs was held at Queensland Parliament House on 11 May 2011. In addition, to mark the launch of the UN Decade of Action for Road Safety, CARRS-Q, in partnership with other road safety related agencies in Queensland, organised to project the Decade of Action logo on the front of Brisbane City Hall. (*Editor's note: See photos of the light displays in both Brisbane and Sydney at back of journal.*)

I look forward to the forthcoming year and providing members with opportunities to meet and discuss current and emerging issues of importance to road safety.

Dr Kerry Armstrong, Queensland Chapter Chair and Representative on the ACRS Executive Committee

Victoria

The Victorian Chapter has held one seminar in the past quarter while working with the Canberra Office to stage the national conference in early September in Melbourne.

The Chapter held a very successful seminar on the issue of driver training with road safety consultant, Dr Ron Christie and Robyn Seymour, Project Manager from VicRoads, presenting. Ron provided a summary of the updated review of research that relates to the effectiveness of driver training, commissioned by the RACV, while Robyn described the P-Driver Project that will compare the crash histories of two cohorts of young drivers - one that is subject to a staged driver education course that derives from 'best practice' principles and a second cohort that acts as the control group. The seminar attracted in excess of sixty attendees.

In parallel, the organisation of the national conference proceeds apace with over 200 registrants and a strong sponsor base. Papers are being finalised with a program that describes papers by stream now accessible via the College website. The Transport Accident Commission in Victoria has been especially supportive through the provision of a professional conference planner to assist us in the lead up to the conference.

We look forward to meeting the broad spectrum of College members at the conference in Melbourne on 1 and 2 September at the Exhibition and Convention Centre.

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

In the news

Compiled by A Scarce Andrew@roadclass.com.au and D Banks

TWU and NRMA survey of HV drivers

The Transport Workers Union (TWU) and NRMA jointly commissioned a survey in which heavy vehicle drivers were asked to provide their views on a number of issues affecting them such as traffic congestion, road conditions and infrastructure, and the annoying behaviour of other road-users. They were also invited to put forward ideas on how to improve road safety.

About 320 HV drivers responded to the online survey which found:

- More than two thirds of HV drivers surveyed had driven while tired, one third of them feeling compelled to do so in order to meet delivery deadlines.
- One of the drivers' biggest concerns is other motorists suddenly pulling out in front of them, or disobeying road rules in general.
- More than 70% of HV drivers want better community education about sharing the roads with heavy vehicles.

- More than 70% believe roads in NSW are inadequate for carrying heavy vehicles, with too few and substandard rest facilities provided.
- 60% want roads widened.
- 85% want more bypasses to divert heavy vehicles away from major centres.
- About two thirds of drivers surveyed do not believe that point-to-point speed cameras have made NSW roads safer.

(Sources: NRMA www.mynrma.com.au/twu-nrma-heavy-vehicle-survey.htm;

Australian Transport News www.fullyloaded.com.au/industry-news/articleid/74472.aspx)

GPS technology and Electronic Work Diaries

Road Tech, a UK-based technology solutions company, has raised concerns about using GPS technology to govern Electronic Work Diary schemes, claiming a satellite-based system cannot effectively monitor speed and driver fatigue. Road Tech General Manager, Jamie Baldwin, believes there are problems inherent in using GPS for this purpose. "GPS signals cannot be received in tunnels or whilst a vehicle is travelling under long underpasses and

as such there would be no speed recorded when the vehicle is travelling in these environments. . . There are also problems with GPS signal strength (in built-up areas) . . . a result of a restricted number of satellites being visible in the narrow area of visible sky." Instead, Road Tech advocates direct monitoring of speed through an engine management or gearbox system.

(Source: *Australian Transport News* www.fullyloaded.com.au/industry-news/articleid/74134.aspx)

In Australia, a draft policy framework for heavy vehicle driver systems has been developed by the National Transport Commission, and an Electronic Work Diary operational pilot commenced in NSW in July 2011 (see Potter et al in this issue). The trial is due to conclude in 2013. A regulatory impact statement outlining the costs and benefits of EWDs will be completed after the trial.

From New Zealand

The amended Vehicle Dimension and Mass (VDM) Rule 2010 is being implemented as a priority by the NZ Transport Agency (NZTA). The new rule applies to High Productivity Motor Vehicles (HPMVs) and allows increases to the length and weight of certain trucks as a measure to improve the safety and efficiency of freight movements. With 75% growth in road freight anticipated over the next 25 years, improving freight efficiency is one of the NZ Government's key objectives. Granting permits to allow heavy vehicles to carry more per trip aims to reduce the number of trips required, reduce congestion and minimise exposure to crashes. Further information can be found at www.nzta.govt.nz/vehicle/your/over/hpmv.

(Source: *Pathways, Newsletter of the NZ Transport Agency, Issue 11 2011*; view at www.nzta.govt.nz/resources/pathways/)

The minimum age for obtaining a learner's licence in New Zealand was raised from 15 to 16 years at the beginning of August 2011.

At the same time, the alcohol limit for young drivers (under 20) was reduced to zero. Youth drink-driving is a major road safety issue in NZ; the new law is one way of reducing the risk to young drivers, recognising that any amount of alcohol impairs driving ability and that this is particularly problematic in the case of young inexperienced drivers. The Chief Executive of the NZTA, Geoff Dangerfield, said "Too many of our young people are dying or being badly injured in crashes on our roads. Road crashes are the single biggest killer of New Zealand teens, and we have the highest road death rate in the OECD for 15-17 year olds. . . That's a situation no-one should accept".

(Source: www.nzta.govt.nz/about/media/releases/1333/news.html)

Case control study of heavy vehicle crashes

Jane Elkington from The George Institute for Global Health reports that 'The Heavy Vehicle Study: An intersectoral collaborative project' is nearing completion. The data collection phase has been completed, two years and eight months since surveys with heavy vehicle drivers began in New South Wales and Western Australia. The study is investigating the role played by key potential risk factors such as sleepiness, fatigue, sleep disorders such as obstructive sleep apnoea (OSA), scheduling, payment and characteristics of the truck and load being driven in heavy vehicle crashes. The research design is a case-control study; cases are long distance heavy vehicle drivers who have been involved in police-attended crashes in the two states, and controls are long distance heavy vehicle drivers who have not had a police-attended crash in the past 12 months. Study subjects are 531 drivers who have had a recent crash and 517 control subjects.

The study's principal investigator, Prof Mark Stevenson, reports that this study will be the first to estimate whether there is a risk associated with factors such as piece-rates, sleep-related disorders, driver schedules and the propensity to crash. It is anticipated that the findings from the study will contribute, significantly, to informing strategies to reduce HV crashes in Australia.

The study is being conducted by The George Institute for Global Health, Monash University Accident Research Centre, Curtin University, Queensland University of Technology and the University of New South Wales. The study is being funded by the Australian Research Council; Department of Infrastructure, Transport, Regional Development & Local Government; the National Transport Commission; Roads and Traffic Authority of New South Wales; DiagnoseIT; Main Roads Western Australia and Queensland Transport. Additional collaborators on the study include New South Wales Police, Western Australia Police and Queensland Police Service.

Preliminary findings related to the health status of the drivers suggest a high proportion of drivers are obese, heavy smokers, predominantly sedentary, have untreated Obstructive Sleep Apnoea and are poor judges of their own sleep health.

A full report on the study available from the National Transport Commission, and peer review papers, are expected to be available by early 2012.

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Study of motorcycle protective clothing

A study providing new evidence on the injury reduction benefits of motorcycle clothing in crashes was launched at a seminar in Sydney on 20 June 2011. The seminar was opened by the Honorable Mr John Ajaka, MLC - Parliamentary Secretary Transport & Roads in NSW, with a key note address by Mr James Strong AO - Company Director and motorcyclist. The GEAR study, funded by Swann Insurance and led by Liz de Rome, Research Fellow, The George Institute for Global Health at the University of Sydney, is the first of its kind and is published in *Accident Analysis and Prevention*.

This is the first study in over 25 years to examine the effectiveness of specialised motorcycle protective clothing and, in particular, body armour. It is also the first to control for the contribution of other factors that may affect the severity of injury, such as speed or type of impact and age of rider.

One of the key findings of the study, which involved 212 motorcycle and scooter riders, was that riders were significantly less likely to be admitted to hospital if they crashed wearing a motorcycle jacket, pants or gloves. Ms de Rome said “One of the most important findings was the difference it made to be wearing body armour, particularly for hands and knees.” When garments included fitted body armour there was a significantly reduced risk of any injury.

While there are limits to the extent clothing can prevent injury in high impact crashes, it is in low impact crashes that protective clothing is thought to offer the greatest injury reduction. There is also evidence that the majority of motorcycle crashes do not involve high impacts.

Ms de Rome commented, “Over 200 motorcyclists die and a further 8,000 are seriously injured on Australian roads each year. For many years, motorcycle safety research has been dominated by debate about the effectiveness of helmets with less focus on other protection for the rider’s body. “With the increasing human and economic costs of motorcycle injuries around the world, there was a need for research into the effectiveness of protective clothing. We hope that the results of this study will show riders that their gear protects them from more than just the weather, encouraging them to wear more protective clothing which will in turn help reduce injuries.”

The results of the study also send a clear message to the manufacturers of motorcycle protective clothing. The proportion of clothing that failed under crash conditions due to material damage indicates a need for improved quality control. While mandating usage of protective clothing is not recommended by the study’s authors, consideration could be given to providing incentives for usage of protective clothing, such as tax exemptions for safety gear, health insurance premium reductions and rebates.

Further information about the study results are presented in a podcast by Liz de Rome at
www.youtube.com/user/TheGeorgeInstitute .

(Reference: de Rome L, Ivers R, Fitzharris M, Du W, Richardson D, Haworth N, Heritier S 2011. Motorcycle protective clothing: Protection from injury or just the weather? *Accident Analysis and Prevention* 43 (6), 1893-1900)

Diary

5-7 September 2011, Gothenburg, Sweden.
2nd International Conference, ‘Driver Distraction and Inattention’. www.chalmers.se/ddi2011

27-28 September 2011, Manchester, UK. TISPOL
European Traffic Police Network Conference,
‘The Challenges Facing Road Safety’.
www.tispol.org/theconference2011

12-16 February 2012, Tampa, Florida. American Traffic Safety Services Association 42nd Annual Convention and Traffic Expo. www.atssa.com/cs/roadway-traffic-safety-calendar. For a chance to attend this conference, see the announcement of the 3M-ACRS Diamond Road Safety Award on page 1 of this journal.

1-4 October 2012, Wellington, New Zealand. World Health Organisation Safety Conference.
www.conference.co.nz/worldsafety2012.



Special issue: Heavy vehicle safety

Peer-reviewed papers

Electronic work diary: Policy, specification and operational pilot

by J Potter¹, S Talko² and D Walsh³

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Abstract

The heavy vehicle driver fatigue legislation was enacted in Queensland, New South Wales, Victoria and South Australia in September 2008. While the legislation allows for the approval of electronic work diary systems, a lack of specification on the composition of an electronic work diary was identified. The Australian Transport Council in November 2008 directed Austroads to start on the 'immediate development of a performance based specification for electronic heavy vehicle speed and driver fatigue systems, enhancing the use of in-vehicle telematics and adding value to the Intelligent Access Program'. At the same time, the National Transport Commission was tasked to develop a policy framework and

regulatory impact statement for heavy vehicle driver systems. This paper presents the findings of the draft policy paper and the accompanying draft specification that was released for public consultation in late 2010. The three presenters at the consultations have combined to produce this paper. A number of unresolved policy and technical issues were identified and submissions have since been received from governments and industry. In 2010, the NSW Minister for Transport proposed the undertaking of an Electronic Work Diary Operational Pilot and this initiative has since gained national support. The paper will also report on the scoping and plans for the pilot which commenced in July 2011.

Introduction

Excessive speed and driver fatigue have been recognised as major risk factors for all drivers of motor vehicles. Both of these factors are of particular concern to heavy vehicle drivers -fatigue due to the long distances to be covered in moving freight across Australia's large land mass, and speed due to the large mass of road freight vehicles.

Electronic and telematics devices that have the potential to improve the ability of drivers operators and schedulers to manage the amount of work and rest taken by drivers, and monitor the level of compliance with speed limits, are becoming increasingly common (EU-digital tachograph 2011, FMCSA 2011). Electronic devices offer the potential to record and use information in ways not possible within the current paper-based system. The devices can assist drivers to comply with the law and plan their work and rest times. This information can also be electronically fed back to operators to assist them in responding proactively to on-road events (such as loading delays) by changing trip schedules, roster and planned rest breaks. They also have the capability to replace paper-based records for enforcement and compliance purposes including chain of responsibility obligations.

New national laws to address heavy vehicle driver fatigue management were agreed to by Ministers in 2007, and in September 2008 the *Heavy Vehicle Driver Fatigue National Model Legislation 2008* (NTC 2008) came into force in Queensland, New South Wales, Victoria and South Australia. This new fatigue reform makes parties in the supply chain legally responsible for preventing driver fatigue. The model fatigue legislation applies to trucks with a gross vehicle mass (GVM) of over 12 tonnes and buses with more than 12 seats including the driver's seat.

These laws respond to the potential benefits of electronic record keeping by allowing for the use of an Electronic Work Diary (EWD) as an alternative to the written work diary. They also established a process for approval of an EWD. In 2008, the tasks of specifying the level of performance the electronic devices need to meet in order to satisfactorily play the role currently undertaken by a written (paper) work diary, developing the necessary policy and guidelines, and technical specifications were assigned by the Australian Transport Council to the National Transport Commission and Austroads respectively. This paper will concentrate on one aspect of this work – the creation of a policy framework and specification for electronic record keeping of drivers' hours of work and rest.

Electronic Work Diaries: A case for action

It is widely recognised that fatigue is a serious and common contributing factor to heavy vehicle crashes in Australia and around the world (NTC 2006). The 2008 heavy vehicle driver fatigue reform sought, for the first time, to apply the best available scientific information on the causes of and

countermeasures to fatigue as a basis for legislation. In particular it recognised that merely limiting hours of driving is a poor surrogate for properly managing driver fatigue and alertness, introducing a general duty to manage fatigue and offences for allowing a person to drive a regulated heavy vehicle while adversely affected by fatigue.

The new law recognised that there was still a need to prescribe work and rest hours, for sustained safe operation. Consequently, it included maximum periods of work and minimum periods of rest. Importantly, these limits are limits to the amount of work, not of driving; the fact that a driver may not have exceeded their maximum permitted hours of work in a day is not a defence to the offence of allowing a person to drive while adversely affected by fatigue.

While the regulations for the use of EWD currently exist, approvals are being impeded by the absence of agreed national processes or guidance. Guidance material is needed to ensure that decision making by regulators is informed by knowledge of the technical requirements that a device must meet in order to satisfactorily fulfil the function of regulatory record keeping. It also has an important role to play in ensuring consistency between jurisdictions when approving applications and providing potential designers, providers and users of an EWD with certainty – that they can understand the requirements for their device to be acceptable as an alternative to the written work diary.

Widespread adoption of electronic record keeping will allow industry to reduce costs by integrating electronic systems for business and fatigue regulatory compliance purposes; remove the potential for conflicting information being recorded in separate recording systems; encourage innovation and safety improvements by allowing the use of current information to manage driver fatigue; and potentially allow more effective compliance measures than are possible by relying exclusively on current enforcement practices.

Policy issues

Several issues needed to be addressed in developing a policy for the use of electronic record keeping. An important principle is that an EWD must be able to perform at least all of the functions of a paper work diary, with at least the same level of data integrity and security. It may, however, perform a much wider range of functions. The electronic record is the declaration by the driver of their hours of work and rest, and the times and locations that they changed between working and resting. Electronic record keeping could allow information on time and location (if a GPS unit is part of the device) to be filled in automatically. However, the fact that working hours, not driving hours, are prescribed in legislation means that the driver must be able to record work done away from the vehicle. The electronic record is the driver's – and it must be able to be read, and written to, by any device approved as an EWD, to allow for the many drivers who have more than one employer, or move between employers and vehicles.

The data must be able to be authenticated as being that of a specific individual. For example, when using a paper-based diary the driver's signature is prescribed as the form of authentication. A corresponding level of security for authenticating an electronic record will be required for an EWD (as set out by the National e-Authentication Framework). Furthermore, the electronic record needs to be demonstrably complete and unaltered, so as to maximise the ability for driver declarations to be used as credible evidence in any legal proceeding. Consequently, an EWD should assure the integrity of driver declarations to at least the same degree offered by the written work diary.

Roadside enforcement is, and can be expected to continue to be, a major driver of compliance with fatigue management rules and many other regulations affecting heavy vehicles. Consequently, access to the data stored in an EWD at the roadside is an essential requirement. A range of strongly held views have been expressed by both industry and the enforcement community on whether this requires a roadside printing option to be available. Resolution of this issue requires information from the national Pilot program described below.

Another key difference between written and electronic record keeping is the recording of time. Under current legislation, time is required to be recorded in 15 minute blocks, with work time being rounded up, and rest time rounded down. Consequently, the smallest breach offence in regulation is 15 minutes. Electronic time keeping allows time to be easily recorded to the nearest second. This makes it possible for breaches by trivial amounts to be detected. Industry is unlikely to adopt an alternative record keeping system which will hold them to a much higher standard of compliance than other operators who have not invested in technology to assist them in improving their management of driver fatigue. A clear policy need is to develop an enforcement and sanction policy. The policy should not only achieve the objective of improving road safety, but should also ensure that the potential benefits of accurate record keeping - as a means to improve scheduling and fatigue management - are not sacrificed for the sake of prosecuting minor timing errors that pose negligible safety risks.

A specification which describes the minimum performance requirements for a device to provide an equivalent, reliable and secure alternative to the written work diary has been developed by Transport Certification Australia (TCA) for Austroads. Any device for which approval is sought will need to meet this final approved standard, which may be modified from its current form as a result of the outcomes of the national Pilot program. State and Territory road authorities (or after January 2013, the National Heavy Vehicle Regulator) will require certification of any device as meeting the final approved standard before approving it for use as an alternative to the written work diary.

The work diary application

Under national model law, drivers of regulated heavy vehicles who travel over 100 km from their base of operations (or 200 km from their base of operations in Queensland) are required to maintain a work diary. A work diary must contain information specified in the fatigue management legislation, including the driver's identification, their work/rest option (Standard, BFM or AFM accreditation), their vehicle identification and a record of when and where a driver performed their work and rest interchanges.

The Heavy Vehicle Driver Fatigue (HVDF) legislation allows for two forms of work diary: the Written Work Diary (WWD) and the EWD. The WWD is a prescribed diary issued by Authorities. It has a single format independent of the Authority which has issued it. The EWD is envisaged as a non-prescribed system which maintains the driver's declarations but allows the transport industry and Authorities greater efficiencies in managing driver fatigue.

Roles within the electronic work diary environment

The electronic work diary system requires the involvement of up to eight participants. Each of these participants has defined roles and responsibilities as follows:

- The **Driver** is responsible for declaring their work and rest changes into the EWD system and in the case of a malfunction, maintaining supplementary (paper) records of their work and rest until the EWD system is rectified.
- The **Transport Operator** is responsible for engaging the EWD provider (or electing to take on the EWD provider's responsibility and be their own EWD provider) to instrument their heavy vehicle with an In-Vehicle Unit (IVU). The transport operator may also engage the EWD provider to supply the IVU for commercial purposes.
- The **Authority** is responsible for maintaining the HVDF regulations and ultimately approving EWDs for use.
- The **Enforcement Officer** is responsible for verifying that drivers are recording their work and rest declarations in the correct diary and inspecting these declarations for compliance against the relevant regulations.
- The **DRD Issuer** is responsible for authenticating the identity of the driver, recording the details for the DRD against the identity of the driver and ensuring that only one DRD is disseminated to the driver at a time.
- The **Record Keeper** is responsible for maintaining the records as specified by the HVDF legislation.
- The **EWD Provider** is to ensure that the EWD system is correctly installed, and performs during day to day operation in the same manner as it did when it was approved.
- The **System Manager** is to maintain the technical specifications for the EWD system and may be required to assist Authorities and certification bodies, or may be a certification body itself.

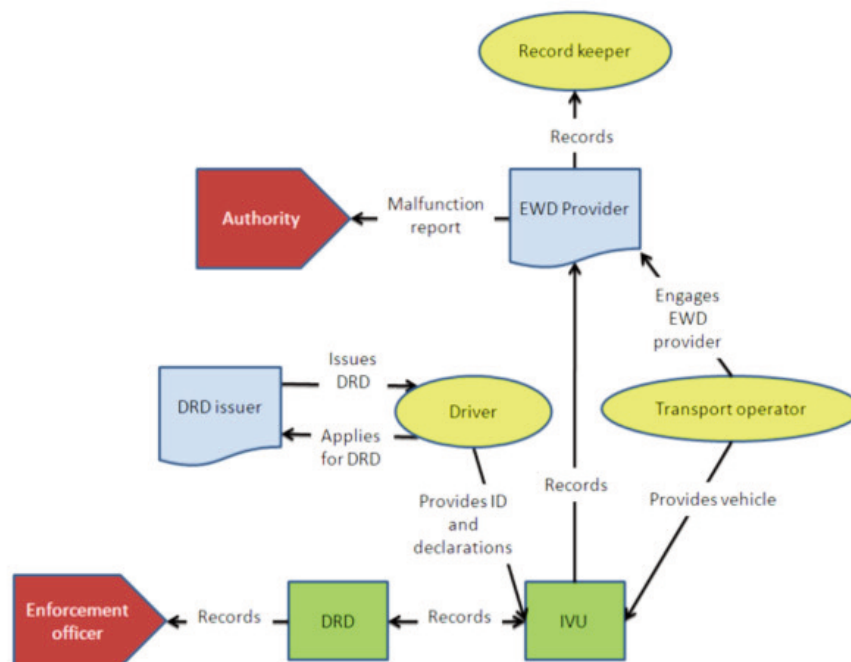


Figure 1. The specified EWD system

Technical architecture

The architecture of the EWD system is shown in Figure 1. Complementing the roles shown above, the specified EWD system includes two key pieces of technology: a Driver Recording Device (DRD) and an In-Vehicle Unit (IVU).

Note: There may be a need for the IVU to feature an in-cabin printer, should Authorities and/or enforcement agencies determine that this is necessary.

The purpose of the technology is described below in context of the operation of the specified EWD system.

Driver Recording Device (DRD)

Similar to the WWD, the DRD acts as the driver's single electronic record repository for their work and rest declarations. Drivers' declarations are stored in a standardised format within the DRD and as such, the DRD is designed to work with any approved EWD. Physically, the DRD is a secure and driver-specific mass storage device (can be read from and written to, but does not allow deletions) based on a Universal Serial Bus (USB) connection. Whilst availability decisions have not been made by Authorities, the DRD can store in excess of 12 months of EWD records resulting from normal operation.

In-Vehicle Unit (IVU)

The IVU processes the driver's work and rest period declarations and stores these onto the DRD. Optionally, the IVU may include features to assist the driver in making declarations such as utilising a Global Navigation Satellite System receiver to provide location and time information. In conjunction with storing the driver's declarations on the DRD,

the IVU stores these records for transmission to the EWD provider. This transmission allows the EWD provider to inspect the records to confirm system operation and to forward these on to the driver's record keeper.

Dependent on the final national policy on EWD systems, the IVU may periodically record the location and speed of the vehicle between driver declarations. This creates an auditable trail of the vehicle's travel which may be used to corroborate the driver's declarations.

System operation

To be able to use an EWD, the driver applies to a DRD issuer to obtain a DRD. Before being issued with a DRD, the driver's identity is authenticated by the DRD issuer. The driver will need to be registered within the transport operator's EWD system and be issued with an identification and authentication method. As this is not required to transfer with the driver across system, this method may be proprietary to the EWD provider's system.

Once registered, the driver will use their DRD with the IVU installed in the vehicle. At the start of the day, the driver will insert the DRD into the IVU and, using their identification and authentication method, declare that they have started work.

On each work and rest change, the driver will use their identification and authentication method to declare their working state. Each time the driver declares their working state, records are written to the DRD and sent to the EWD provider for provision to the record keeper.

If the driver wishes to switch between trucks, the driver ejects the DRD from the current IVU and inserts it into the new

IVU. If the driver is pulled over for a roadside compliance check by an enforcement officer, the driver ejects their DRD and supplies this to the officer. The enforcement officer uses the DRD with a remote data terminal (laptop, PDA or similar) to view records and determine compliance.

If the driver detects a fault with the IVU, the driver contacts their transport operator who then contacts the EWD provider. The EWD provider also monitors the operation of the IVU remotely and may contact the transport operator if a system fault is detected. The EWD provider, with the cooperation of the transport operator, shall rectify the IVU in a timely manner.

Operational pilot

Background/context

On 29 March 2010, the NSW Government announced the \$170 million Road Toll Response Package, a five-year investment to improve road safety. The Road Toll Response Package builds upon the recommendations from a Road Safety Roundtable held in July 2009 which was set up to engage road safety experts and community representatives to examine road safety issues in response to a rising road toll. One of the projects to improve safety for heavy vehicles is the Operational Pilot of EWDs and speed monitoring systems. This pilot has been allocated \$5 million in funding over three years, 2010 to 2013. The pilot is being led by the NSW Roads and Traffic Authority and involves the jurisdictions of Queensland, Victoria, South Australia, Western Australia and the Commonwealth, with the other jurisdictions participating as observers.

Pilot objectives

The operational pilot is intended to thoroughly test and refine the proposed national draft policy and technical specification for the approval of electronic systems and their use for enforcement and business purposes and for better safety, productivity and environmental outcomes.

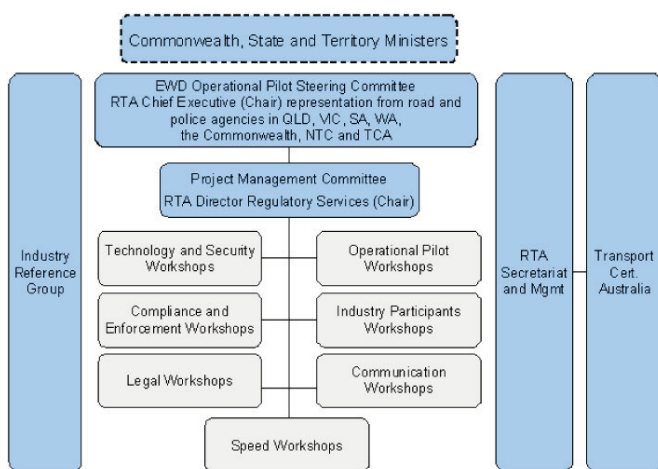


Figure 2. Governance of the EWD pilot

Outcomes - What the pilot will achieve

The outcomes for the pilot include benefits for both industry and authorities. The information generated by the electronic heavy vehicle systems can be used in many more ways than the data from written work diaries. The electronic systems can help drivers to comply with the law, for example, by assisting them in planning their work and rest times.

In addition, the opportunity for an electronic system to generate warnings or reports would significantly help many operators and drivers to comply with their required hours of work and rest and better manage on-road speeds of their drivers and vehicles. For example, an EWD system could notify the driver of the amount of work time remaining before he or she must take a rest break.

It is likely that these electronic systems will provide more efficiencies for transport operators than the current written work diary. At present, written work diaries provide transport operators with minimal assistance in monitoring and managing the work of their drivers. For example, electronic systems can assist operators in responding to on-road events (such as delays in loading) by amending trip schedules, rosters and the planned rest breaks of drivers.

At present many operators have a parallel system in place: both an electronic system and the written work diary. The former is employed for commercial purposes and the latter for adherence to regulatory requirements. If these two structures were combined into one system, a significant amount of administrative work would no longer be required of operators.

The heavy vehicle electronic systems have the potential to reduce the shortcomings of the written work diary and substantially increase compliance with heavy vehicle fatigue and speed laws. A more robust method of recording hours of work and rest will significantly improve the accuracy and integrity of driving and speed records. This will also result in greater confidence in heavy vehicle safety for the general public.

Governance

The governance framework is detailed in Figure 2. The structure includes an inter-jurisdictional Steering Committee of senior representatives of the participating road authority/transport agencies, senior police representatives from these jurisdictions and representation from the National Transport Commission and Transport Certification Australia. The Steering Committee is chaired by Michael Bushby, Chief Executive of the NSW Roads and Traffic Authority, and was established to guide and steer the development and implementation of the Operational Pilot of Electronic Work Diaries and Speed Monitoring Systems.

A Project Management Committee was established to coordinate all activities of the pilot. This includes overseeing a series of workshops to assist in informing specific pilot issues, coordinating all activities of the Industry Reference Group and any other entity as directed by the Steering Committee.

An Industry Reference Group, was set up to ensure that the transport and logistics industry has the opportunity to contribute to the operational pilot, including advising on the operation of electronic systems and the business and commercial matters which impact upon the transport and logistics industry.

The Director of Regulatory Services, NSW Roads and Traffic Authority, chairs both the Project Management Committee and the Industry Reference Group. Transport Certification Australia was contracted by NSW Roads and Traffic Authority to conduct the pilot.

Methodology

The pilot will be conducted in two stages.

Stage 1 is designed to assist in developing the required business systems, processes and procedures for the application, selection, deployment and data collection of pilot systems. Stage 1 will incorporate trialling and refining the proposed processes and procedures designed for the pilot across a small sample of diverse systems.

Stage 2 involves the application of the refined systems, processes and procedures in the pilot. It will incorporate a sample of systems representative of those offered by industry. This stage will include extended periods of field work across Australia and encompass a representative sample of transport operators, vehicles and drivers.

These two stages are detailed below and depicted in Figure 3.

Timeframe

It is anticipated that Stage 1 will commence in July 2011 and Stage 2 will commence in January 2012, subject to the timely development of national technical specifications, a policy framework and support of other jurisdictions and industry stakeholders.

Conclusion

Following direction from the Australian Transport Council in 2008, the NTC and Austroads responded with a draft policy framework and specification for electronic heavy vehicle speed and driver fatigue systems. These were taken to public consultation in late 2010.

An Operational Pilot led by New South Wales with national support has since commenced with the intention to thoroughly test and refine the national draft policy and specification for the approval of electronic systems. This two year pilot will conclude in 2013 and is expected to provide outcomes that benefit both industry and authorities.

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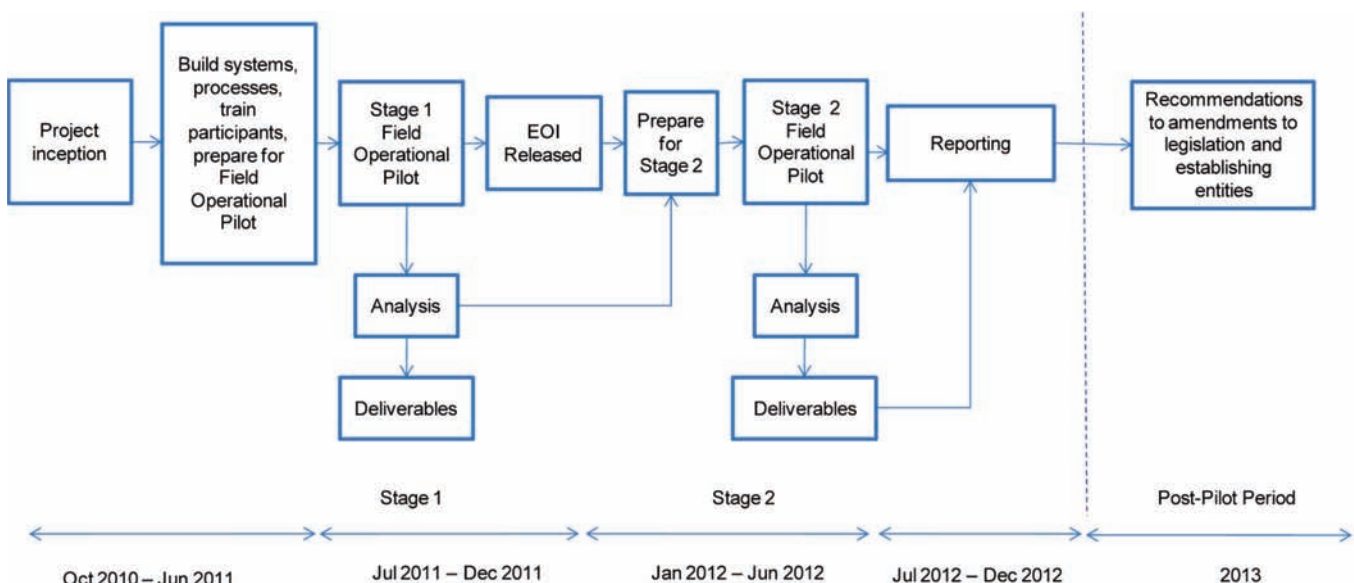


Figure 3. Pilot staging

Heavy vehicle road safety: A scan of recent literature

by SJ Raftery, JAL Grigo and JE Woolley, Centre for Automotive Safety Research, The University of Adelaide

Abstract

The number of registered heavy vehicles (HV) in Australia has risen by 22% since 2005 and, with the national freight task projected to double by 2030, the number of HVs on Australian roads will continue to increase. In the 12 months to the end of June 2010 crashes involving heavy vehicles resulted in 239 fatalities and around one third of all work-related road crash fatalities occur within the freight industry. Heavy vehicle safety for both the trucking industry and the general community remains an important issue. In recognition of this the Australian Trucking Association commissioned the Centre for Automotive Safety Research to undertake a research scan to develop a knowledge base that may be used to guide the strategic direction and development of effective outcomes in the area of heavy vehicle safety. The scan focussed on five key areas: factors associated with HV crashes, road and vehicle design, human and social factors, speed management and enforcement, and the effectiveness of accreditation schemes. Gaps in knowledge were identified and recommendations for future research in the areas of fatigue, seatbelt use, traffic management, and technology are suggested.

Keywords

Heavy vehicle, Truck, Safety, Crashes, Road safety, Research scan

Introduction

Heavy vehicles¹ (HV) are a common sight on Australian roads, be it rural highways or the arterial roads of major cities and towns. Statistics from the Australian Bureau of Statistics (ABS) [1] indicate that to the end of March 2010, the number of registered trucks in Australia has risen to over 536,000 since 2005, an increase of just over 22%. Furthermore, in the 12 month period ending October 2007, heavy vehicles travelled a combined total of 15,856 million kilometres with articulated trucks having the highest average kilometres driven of all vehicle types, as shown in Table 1.

Table 1. Total (in millions) and average (in thousands) kilometres travelled October 2006 to end of October 2007 [2]

	Total kms (x1,000,000)	Average kms (x1000)
Passenger vehicles	157,928	13.7
Motorcycles	1,905	3.7
Light commercial vehicles	37,385	17.1
Rigid trucks	8,644	22.0
Articulated trucks	6,929	93.2
Non-freight carrying trucks	283	14.2
Buses	2,097	31.6
All vehicles	215,171	14.6

Heavy vehicles play an integral role in the transportation of freight throughout Australia. Since 1971 the Australian road freight task has increased by a factor of 6 reaching 184,072 million tonne-kilometres in October 2007 [2], with current projections indicating that the freight task will at least double by the year 2030 [3]. It is clear that the number of heavy vehicles on Australian roads will grow in line with the increasing freight task.

Concomitant with this growth in the freight task and numbers of heavy vehicles are increases in the numbers of other vehicle types on the road network including passenger cars and motorcycles. Table 2 shows the growth in ownership of all vehicle types from 2005 to 2010 as reported in the Australian Bureau of Statistics 2010 motor vehicle survey [1]. With the growth observed across all vehicle types over the five year period it is clear that improving road safety across the entire road network will continue to be a significant issue for all road users, and particularly so for the trucking industry. Heavy vehicle safety can be considered in terms of an Occupational Health and Safety perspective or from a general road safety perspective. Both show that there is still much room for improvement.

Table 2. Growth in numbers of registered vehicles from 2005 to 2010 [1]

	2005	2010	% change
Passenger vehicles	10,896,410	12,269,305	12.6
Campervans	40,693	48,504	19.2
Light commercial vehicles	2,030,254	2,460,568	21.2
Rigid trucks	368,520	431,278	17.0
Articulated trucks	69,723	82,436	18.2
Non-freight carrying trucks	19,962	22,367	12.9
Buses	72,620	86,367	18.9
Motorcycles	421,923	660,107	56.5
Total	13,920,105	16,060,932	15.4

When considering the road freight transport industry itself, Safe Work Australia [4] report that 41 (19%) of the 295 working fatalities recorded in the 2006-07 period were in the road freight transport industry. During this same period the rate of fatal injury among road and rail drivers² was 25.1 per 100,000, the highest rate of fatality observed across all industries. Furthermore, road crashes are the largest cause of fatal injury in the freight industry which also accounts for one third of all work-related road crash fatalities [4]. Improving the safety of heavy vehicle operations will require ongoing attention.

When considering the road network as a whole, statistics for road crashes involving heavy vehicles provided by the Bureau of

Infrastructure, Transport, and Regional Economics [3] indicate that in the 12 month period to the end of June 2010 a total of 239 fatalities were recorded from 194 crashes involving heavy vehicles. As such, a considerable proportion of the nation's road trauma can be attributed to crashes involving heavy vehicles. While there is some evidence that HV drivers are not always at fault [5, 6] the impact of these crashes is borne by both the HV industry and the community in general. Furthermore, the advancement of HV safety (and road safety in general) requires consideration of a broad spectrum of factors of which the attribution of fault is perhaps the least important. This philosophy is consistent with best practice in the area of risk and safety management.

The purpose of the research scan is to develop an overview of current knowledge in order to guide the strategic direction and development of effective outcomes in the area of heavy vehicle safety.

Method

The research scan focussed on six key areas: understanding the factors associated with HV crashes, road design, vehicle design (incorporating interaction between HVs and other road users), human and social factors (including fatigue and licensing issues), speed management and enforcement (including general enforcement), and the effectiveness of heavy vehicle accreditation schemes.

In order to draw on the most relevant and up to date knowledge of heavy vehicle road safety an effort was made to identify peer reviewed journal papers, conference proceedings, technical papers and published reports outlining research conducted within the past decade; older publications were also included where more recent evidence was lacking. Materials were sourced from the Centre for Automotive Safety Research's extensive road safety library and a number of academic databases and industry-related indexes, including:

- **Australian Transport Index (ATRI).** A database of Road transport resources addressing a range of subjects including: road safety, traffic accidents, heavy vehicles, freight, traffic engineering, vehicle design, road design, human factors, speed, and speed limits.
- **Transport.** A database of Transport resources covering the subjects of road safety, traffic accidents, heavy vehicles, and human factors.
- **CASR library catalogue.** A collection of over 25,000 items relevant to the study of road safety, vehicle safety, vehicle design, human factors, speed, and licensing.
- **Academic Search Premier.** A Multi-disciplinary database.
- **PsycInfo.** A database of the American Psychological Association (APA) covering subjects relevant to behavioural science and human factors.
- **Informit.** A Wide range of databases covering subjects including health, business, humanities, social sciences.
- **Compendex.** A Scientific and technical research database. Subjects: engineering.

Internet search engines such as Google and Google Scholar were also utilised to identify publicly available resources on the internet. The websites of key Australian and international trucking and road safety organisations were also searched for publicly available materials relevant to the aims of the research scan.

A research scan differs to a literature review in that where a review offers critical analysis of evidence a *research scan*, on the other hand, seeks only to identify the extent of existing research and the state of current knowledge based on that body of evidence. As such, the present scan provides a summary of findings only, and offers no critical evaluation of the findings presented.

In total 280 publications were identified and included in the research scan; a summary of this work is provided herein. Given the considerable scope of the project and the time constraints governing its completion it is possible that additional, relevant materials may not have been included.

Discussion

The goal of the present research scan was to consolidate existing knowledge with regard to various factors associated with the safety of HVs. Much of this research is concerned with the safety of articulated HVs (e.g., B-doubles) although there is a small body of literature regarding rigid HVs. A brief overview of research findings relating to heavy vehicle crashes, road and vehicle design, human and social factors, speed management and enforcement, and accreditation schemes is provided below. Throughout the research scan a number of knowledge gaps were identified as potential targets for future investigation. In recognition of the impracticalities of undertaking such an extensive research program a number of areas were identified as offering the most benefit to HV road safety. Recommendations for a suggested program of research are made.

Heavy vehicle crash factors

An investigation of factors associated with HV crashes focussed on research providing evidence of causal factors or the identification of factors that contribute to the death or injury of people involved. There is an extensive body of literature examining the characteristics of HV crashes providing a wealth of information with regard to the role of speed, driver factors (such as fatigue, substance use, and general medical condition), seatbelt use, infrastructure issues (e.g., road design, condition, and alignment), vehicle factors (e.g., mechanical condition, type, load, and configuration), and issues associated with vehicle control.

Evidence from Australian and international sources indicates that single vehicle crashes, particularly loss of control type crashes, account for the majority of HV crashes [7, 8]. Further evidence indicated that the majority of fatal HV crashes occur on rural highways during daylight hours and under favourable weather conditions [9, 10]. According to recent statistics published by National Transport Insurance's National Truck Accident Research Centre [7], 37% of HV crashes occur on

designated highways, and the majority of crashes occur when road use is heaviest, with the 11.00am to 2.00pm period being the worst. The causal factors most commonly associated with HV crashes include excessive or inappropriate speed and fatigue [8, 11-13], while the mechanical condition (particularly brakes) and load characteristics of the vehicle are also associated with HV crashes [9, 12]. Statistics published by National Transport Insurance (NTI) [7] also indicate that 32% of HV crashes involve inappropriate speed and 10% fatigue; 42% of crashes involve both fatigue and inappropriate speed.

Road design

An examination of road characteristics relevant to HV safety focussed on evidence related to road infrastructure (e.g., engineering treatments, line markings, and clear zones), road features (e.g., intersections, road alignment, and road condition), and traffic management (e.g., signage and route access).

A number of road design features presenting safety issues for HV drivers were identified. Evidence indicated that road design and infrastructure could be improved to better accommodate HVs, particularly along recognised freight routes in both rural and urban areas. Treatments such as shoulder sealing have been found to provide a simple, cost-effective means for improving safety for all road users [14], while other evidence indicated that the use of truck climbing lanes and lane restrictions for HVs offered safety benefits without major disruptions to traffic flow [15-17]. Aspects of the urban freight route environment that have been identified included signal phase timing, particularly from amber to red, lane width and storage lengths, and kerb radii for turns [18, 19]. Evidence also indicated that the provision of rest areas throughout Australia is inadequate and does not align with established guidelines with regard to both the facilities provided and the frequency of rest stops along individual routes [20].

Vehicle design

The design of HVs is also an important consideration with regard to HV safety for both HV drivers and other road users. A scan of HV design literature focussed on areas related to vehicle features such as underrun protection and safety technologies, and factors associated with HV interactions with other road users.

Following the discussion of road design above, the risks associated with road design features can also be ameliorated through vehicle design and technologies. On-board warning systems can be used in conjunction with Intelligent Transport Systems (ITS) to forewarn drivers of potential hazards allowing them to take proactive steps to reduce those risks [21]. For example, warning drivers that their speed may be inappropriate for an upcoming bend will enable them to slow to a more appropriate speed before entering the curve. Intelligent Speed Adaptation (ISA) technologies can further reduce HV risks associated with speed, while other technologies such as Electronic Stability Control (ESC), Vehicle Stability Systems (VSS), Yaw Stability Control (YSC), and Electronically

controlled Braking Systems (EBS) that improve the stability and control of the vehicle under normal or emergency driving conditions also have the potential to improve HV safety [22-26]. Digital short-range communications (DSRC) also hold significant potential for improving the operational safety of all vehicles on the road network [27]. At present the development of new crash avoidance technologies proceeds apace however, until evaluations of these technologies are conducted it is difficult to state with any certainty their benefits for road and HV safety. It should be noted that many of the technologies identified herein are still in their infancy, as such the safety benefits offered by these has yet to be fully examined (see recommendations for future research below).

The advent of on-board technologies will provide new sources of data that can be used in infrastructure design and management, and may also provide other avenues for enforcement and improving compliance.

The design of HVs has also been found to influence the involvement in, and outcomes of, an HV crash. The aggressivity³ of HVs plays a key role in the injuries of the occupants of other vehicles and vulnerable road users (i.e., cyclists, pedestrians, and motorcyclists) [30], while the generally poor crashworthiness⁴ of trucks has been identified as a significant issue where cabin integrity is compromised during roll over or collision with a fixed object [31].

Human and social factors

There is an extensive body of research pertaining to a variety of human and social factors associated with driving-related and other aspects of human performance. While all of this research is of relevance to the HV industry, a sub-set of HV specific research is also available. A scan of this research focussed on the safety issues surrounding health (including mental health), fatigue and sleep, substance use, and behaviour.

Investigations of HV driver health have revealed that a number of adverse health outcomes are associated with HV driving including obesity, cardiovascular disease, diabetes, and sleep apnoea [32-34]. A limited number of studies have examined the extent of mental health issues for HV drivers, those that have been conducted suggest that the prevalence of mental health issues such as anxiety and depression are in line with those observed amongst the Australian population [35, 36]. This research has also linked mental health issues with an increased risk of crashing and that HV drivers face a number of barriers to obtaining treatment for these issues [36].

Fatigue and sleep-related issues are also an issue of significant concern within the HV industry and have been identified as a risk factor for HV crashes. A general body of research has identified that fatigue has a detrimental effect on performance in terms of attention and reaction times, vehicle control, and deterioration in general performance (for a comprehensive review see [37]). Other research has indicated that HV drivers may have a higher risk of fatigue-related crashes compared to

other road users due to the nature of their work (e.g., shift work, long hours, monotonous activity) and their lifestyle (increased risk of sleep disorders due to medical conditions such as obesity) [38-40]. Sleep apnoea has also been linked with impairments in driving performance and is a significant issue within the HV industry as a confluence of lifestyle factors (e.g., sedentary lifestyle and poor diet) increase the likelihood of sleep apnoea among HV drivers [41].

Another human factor that presents a significant issue for road safety is the use of licit and illicit substances. Investigations of substance use among HV drivers have indicated that the prevalence of substance use among this group is comparable to that of the broader Australian population [42]. Evidence also indicated that the most commonly used substances by HV drivers were stimulants (e.g., amphetamines and methamphetamines, pseudoephedrine, and cocaine), which appeared to be predominantly used as a fatigue countermeasure [42, 43]. Given the high prevalence of medical conditions among HV drivers an effort was made to identify literature regarding the effects of prescription medications on HV driver safety. No such research was identified.

Any consideration of human factors must also examine driver behaviours. One of the key issues identified within the present literature is the low prevalence of seatbelt use among HV occupants [44, 45]. Evidence suggested that HV drivers have a number of misconceptions with regard to the comfort and safety benefits of seatbelts that contribute to this lower prevalence [44, 46]. Safety consciousness and enforcement consequences were factors commonly reported by drivers as reasons for always using a seatbelt [44, 47, 48]. The effects of driver training were also examined. Evidence indicated that training in a number of areas (e.g., numeracy and literacy, and safety management) can improve safety of HV drivers [49, 50]. While no evaluations of current driver training practices were identified the evidence questioning the effectiveness of these practices was identified [51].

Speed management and enforcement

Speed and the management of speeding vehicles is one of the most important issues in road safety [52, 53]. As such, research regarding the management of speed and the general enforcement practices of police and other regulatory authorities were also examined as part of the current research scan.

Evidence identified by the scan indicated that speed is an issue for heavy vehicle safety. Inappropriate speed (i.e., driving too fast for the conditions) or driving over the posted speed limit was found to be one of the major contributing factors to HV crashes [8, 11-13]. Evidence also indicated that, due to the proportions involved, low level speeding is a significant safety concern for HVs. There was also some indication that on-board technologies such as speed limiters and ISA can provide safety benefits with regard to the management of HV speed [23].

There was a lack of literature regarding HV-specific enforcement practices however, much of the general traffic enforcement literature was still relevant to HV operations. The majority of this literature discussed the effectiveness of police operations targeting speeding behaviour. This evidence revealed that police enforcement campaigns play an important role in affecting the behaviour of all road users with a variety of strategies found to produce a number of safety benefits. For example, high visibility operations effectively reduced speeds on targeted roads and, to a lesser extent, surrounding roads, although this effect is relatively short lived following the cessation of police operations [54, 55]. Research has also demonstrated that speed cameras also effectively lower average speeds and reduce crashes on roads where they are installed [56]. The use of mobile radars has been found to produce similar effects [57].

As discussed previously the advent of telematics and digital short-range communications (e.g., vehicle-to-vehicle and vehicle-to-infrastructure) has the potential to improve the management of the complex task of HV compliance, creating a more efficient and effective system of enforcement. However, it will be important to resolve a number of issues regarding the use of new technologies, including how these technologies will be used by enforcement agencies and ensuring the reliability and accuracy of both stored and collected data.

Accreditation schemes

Safety accreditation schemes provide an alternative means for ensuring heavy vehicle operator compliance with recognised safe operating standards. These standards address a range of issues including fitness to drive and driver health, training, vehicle maintenance, and the management of transport operations.

Three studies were found that evaluated accreditation schemes. Safety benefits of accreditation within the HV industry was determined by comparing the crash rates of vehicles from accredited operations to those from non-accredited operations. These studies have demonstrated the positive safety benefits to be derived from accreditation. For example, vehicles from accredited HV operations had 50-75% fewer crashes than vehicles from non-accredited operations [58]. Similarly, compliance reviews undertaken as part of the accreditation process reduced HV crashes by up to 40% with this reduction in crashes remaining stable for a minimum of seven years following the review [59].

Recommendations for future research

The consolidation of evidence achieved in the research scan brought to light a number of gaps in the current state of knowledge⁵. While further research is required to fill each of these gaps the following recommendations are offered as a point of departure.

1. Fatigue was identified as a clear issue for the heavy vehicle industry. Given the current state of knowledge it is

recommended that future research seek to improve the management of fatigue within the HV industry. One such line of inquiry should seek to identify HV drivers who may have an increased risk of fatigue related crashes.

2. Indications of restraint use among HV drivers suggested that compliance with seatbelt use is low with estimates ranging from 4-30% [44, 60]. Estimates indicate that the benefits of increasing seatbelt use among HV drivers would effectively prevent 37% of fatalities, 36% of serious injuries, and 22% of slightly injured truck occupants [61]. Research to improve seatbelt use among heavy vehicle occupants should seek to identify the characteristics of HV occupants and other factors related to restraint use that may be amenable to change.
3. International research indicated that lane and speed restrictions for HVs on some road sections have positive effects for road safety in these areas. Research should evaluate the effectiveness of such strategies under Australian conditions. This research could also investigate the effect of these restrictions on traffic flow and productivity of the HV industry.
4. Numerous technologies with potential safety benefits for HVs were identified. Evaluations of the effectiveness of these technologies will assist the HV industry in the identification of those technologies that offer the greatest benefits for HV safety. Such research is important given the rate at which existing technologies evolve and new technologies are developed. It is also important to identify ways in which the most at risk HV drivers benefit most from these technologies.

Closing comments

It should be noted that the leading road safety countries are now transitioning to a systems approach to road safety. This is based on an acknowledgement that humans are fallible and, therefore, the design of transportation systems, including the roads on which people travel, the vehicles in which people travel, and the speeds at which people travel need to accommodate human errors in order to reduce severity of injury outcomes. The approach adopted in Australia is the Safe Systems approach and is becoming an integral part of road safety strategy and action plans over the next decade. Efforts to improve heavy vehicle safety will be considered by road authorities in this context over the next decade. Additionally, the transition to a national heavy vehicle regulator is currently underway and this will provide a further change in context to the way in which heavy vehicle safety will be considered into the future.

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authors and do not necessarily represent those of the University of Adelaide or the funding organisations.

The complete research scan *Heavy vehicle safety: Research scan* is available from <http://casr.adelaide.edu.au/publications/>

Notes

¹The term Heavy Vehicle (HV) refers to rigid and articulated vehicles with a gross vehicle mass (GVM) of 8 tonnes or greater.

² The statistics provided in this paper are, as closely as possible, tailored to the road freight (i.e., HV) industry however, due to the manner in which Safework Australia statistics are collated there may be some crossover with other aspects of the Transportation and Storage industries (e.g., occupations associated with rail and freight management).

³Aggressivity refers to the degree of protection a vehicle provides for other vehicles and road users with which it collides (28). Newstead S, Watson L, Cameron M. Vehicle safety ratings estimated from police reported crash data: 2009 update. Melbourne: Monash University Accident Research Centre 2009. Report No.: 287. In general terms vehicles of higher mass fare better than vehicles of lower mass in a collision (29). Evans L, Frick MC. Mass ratio and relative driver fatality risk in two-vehicle crashes. Accident Analysis & Prevention. 1993;25(2):213-24.

⁴Crashworthiness refers to the protection a vehicle affords its occupants in the advent of a crash. This incorporates factors such as the integrity of the passenger space and secondary restraint features such as airbags and seatbelts (28). Newstead S, Watson L, Cameron M. Vehicle safety ratings estimated from police reported crash data: 2009 update. Melbourne: Monash University Accident Research Centre 2009. Report No.: 287.

⁵An extensive list of research gaps and areas for future research are provided in the full report.

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Investigating the role of fatigue, sleep and sleep disorders in commercial vehicle crashes: A systematic review

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Abstract

Commercial vehicle driving is an occupation in which increasing demands are being placed on drivers as a consequence of economic and trade expansion. Crash rates are high, as is the injury risk to all road users where commercial vehicles are involved. Fatigue and sleep deprivation are of increasing concern, and sleep disorders have been shown in car drivers to increase crash risk. Commercial drivers may have higher crash risk due to exposure and high sleep disorder prevalence; however, reviews thus far have not provided sufficient conclusion. The aim of this systematic review was to investigate the evidence of the role of fatigue, sleep and sleep disorders in commercial motor vehicle crashes. Relevant electronic databases and grey literature were searched and 16 peer-reviewed published studies met the study criteria. Factors found to have an association with crashes were daytime sleepiness (Epworth Sleepiness Scale), and sleep debt. While not employed as a search term, obesity was shown to be a risk factor for sleep disorders, daytime sleepiness and incurring a crash or near miss. Most studies suffered from small sample size as well as specific methodological flaws making generalisation difficult and indicating the need for a large, well-designed study with empirical measures of both risk factors and outcomes.

Keywords

Sleep disorder, Commercial driver, Sleepiness, Crash

Introduction

The commercial motor vehicle (CMV) driver faces a challenging work environment. With increasing demands on the heavy vehicle industry, alongside economic and trade expansion, safety concerns are paramount. Crash rates are high [1], as is the injury risk to all road users [2] where heavy vehicles are involved. While fatigue and sleep deprivation have been recognised as factors critical to the safety and performance of commercial motor vehicle drivers [3,4], there is inconclusive evidence for the interplay and strength of associations of other sleep-related risk factors for CMV crashes including sleep disorders such as sleep apnoea and excessive daytime sleepiness, alongside associated factors such as the drivers' health status.

Systematic reviews to date have included some studies of CMV populations; however, there is no current review investigating the crash risk associated with fatigue, sleep or sleep disorders solely among CMV drivers. Connor et al [5] investigated the role of driver sleepiness across studies of car drivers and highlighted a positive association, albeit based on a paucity of

well-designed studies. Robb et al [6] conducted a review of risk factors for drivers involved in work-related crashes, concluding fatigue and sleepiness to be consistently associated with an increased risk of crashing and Tregear et al [7] more recently reported increased crash risk for both private motor car and CMV drivers with obstructive sleep apnoea (OSA).

Some studies have focused on sleep hours for CMV drivers, considering also the scheduling contribution to reduced sleep. Studies have shown that, on average, CMV drivers sleep 5-6.5 hours per night/day [4,8]. Further, they have been shown to drive for an average of 14 hours per day when not restricted [9], as such leaving limited time for sleep. Beilock [10] described excessive work hours as well as schedule-driven tendencies to speed among this group of drivers. These factors are expected to contribute not only to insufficient sleep with greater sleepiness during the waking hours, but also increased crash risk. While shift work per se is not the subject of this review, the additional effects of circadian rhythm disruption in those drivers working either predominantly at night, or on rotating shifts, should also be considered as a potentially negative contributor to their sleep health.

Sleep disorders such as obstructive sleep apnoea (OSA) have been shown to increase the crash risk of motor vehicle drivers by two- to seven-fold [11], although this has been demonstrated predominantly in symptomatic sleep clinic populations. Given previous research has found CMV drivers to have a higher prevalence of sleep apnoea than the general population [12,13], it may be expected that the crash risk is greater in a CMV population, yet this has not been empirically demonstrated.

Obesity, most commonly measured as a body mass index (BMI) $>30 \text{ kg/m}^2$ is an important risk factor for OSA and has been postulated to contribute to sleepiness. Sufferers of OSA often experience daytime sleepiness, challenging the performance of tasks requiring vigilance and alertness such as motor vehicle driving [14]. Dagan, Doljansky & Green [15] recommended screening all professional drivers, whether or not they report symptoms of OSA, by assessing the drivers' BMI, given their findings that obese drivers are more prone to be sleepy during the day. Few studies have investigated driver performance (of any vehicle, car or truck) and crash outcomes using anthropometric proportions as a covariate measure, and not all studies measuring OSA have concurrently studied the effects of obesity. The replicable estimate of crash risk related to a diagnosis of sleep apnoea, or other measures of or contributors to daytime sleepiness and driver sleep health, has yet to be quantified.

The national freight task in Australia is increasing at approximately 1.21 times economic growth [16]. Projected economic growth in Australia may therefore increase scheduling, payment and delivery pressures on drivers if employers do not adjust their staffing accordingly; it is imperative that the drivers' opportunity for sleep and consequently optimum health is considered equally. The

objective of the current review therefore, is to assess the available evidence investigating the role of fatigue, sleep or sleep disorders in drivers of commercial vehicles that crash.

Methods

A systematic review of the international literature was conducted to identify all peer-reviewed published research and relevant grey literature that quantified the relationship between fatigue, sleep or sleep disorders and a CMV crash. The following electronic databases were searched: Medline, EMBASE, Scopus, Transport and the Australian Transport and Road Index (ATRI) database. The search was restricted to English language articles published from 1950 to 2010 inclusive. Studies were included if they specifically investigated the CMV or bus driver population, using the keyword search terms or Medical Subject Heading (MeSH) terms of "Commercial vehicle" OR "Commercial driver" OR "Truck" OR "Truck Driver" OR "Lorry" OR "Bus" OR "Long Distance" AND "Sleep\$.tw" OR "Obstructive Sleep Apnoea" OR "Tired" OR "Fatigue" AND "Accident" OR "Crash" OR "Collision". The term 'near miss' was not included as a search term; papers considering 'near miss' were only included if they primarily measured CMV crash. Reference lists of all papers meeting the inclusion criteria (below) were searched and hand searching was conducted of relevant journals, namely Accident Analysis and Prevention, Injury Prevention, Traffic Injury Prevention, Epidemiologic Reviews and Sleep journals for a five year period (2006-2010 inclusive).

Definition of terms

1. *Commercial Motor Vehicle*: includes vehicles defined as 'heavy vehicles' (used for commercial transportation), trucks and buses conducting long haul trips. CMV drivers were considered those who drove long distance trips commercially, in heavy vehicles, and included long distance bus drivers.
2. *Fatigue*: There is ongoing scientific debate about the definition of fatigue. For the purposes of this review, papers were included which employed the terms fatigue and/or sleepiness.

Inclusion criteria

Studies were included if they met the following criteria:

1. Study subjects were CMV drivers or, where both CMV and non CMV drivers were included in the study, a separate analysis using only the CMV drivers was performed and data presented.
2. The study must have enrolled at least 20 subjects.
3. Sleep, fatigue or sleep disorder was measured in CMV drivers as an exposure; either by self-report, validated scale such as the Epworth Sleepiness Scale, formal polysomnography or video evidence such as in naturalistic driving studies.
4. CMV crash was the primary outcome of interest; studies were also included if they measured any near miss as a CMV driver, but only if the study primarily measured crashes.

5. Articles were full-length.
6. If the same study was reported in multiple publications, the most complete publication was used as the primary reference.

Exclusion criteria

Studies that focused entirely on 'short distance CMV' drivers were excluded. This exclusion was considered necessary due to the known differences in scheduling and work environment (including regulatory requirements) of the long distance CMV driver compared with the short distance CMV driver; hence the difference in risk exposures that would influence the outcome of crashing differently.

Literature analysis

The search strategy was applied by one author (LN Sharwood) and repeated after three months in order to verify the number of articles identified as well as to identify new publications. Studies meeting the inclusion/exclusion criteria were appraised independently by two authors according to the STROBE guidelines for reporting observational studies [17]. Studies were appraised on their design with consideration of recruitment bias and reporting, sample size, data sources, statistical methods and data presentation, limitations and external validity. Meta-analysis was not attempted due to the heterogeneity of the populations among the studies that met the inclusion criteria and the lack of robustness of the research designs.

Results

Description of studies

A total of 96 papers were identified using the search terms and databases described above. The 85 articles which had their full text written in English were reviewed by title and abstract to determine relevance for full text extraction. Among the full-text articles extracted, 16 articles (published between 1994 and 2010) met the study inclusion criteria and were critically appraised and their results summarised. These studies comprised one retrospective case-control study, 13 cross sectional studies and two naturalistic driving studies. Of the cross sectional studies, there was only one that used a comparison group.

Study settings included workplaces selected from union databases (n=2) marine ports (n=2), company terminal/depot (n=2), weighing stations (n=1), national occupational safety database (n=2), a roadhouse, a central marketplace, a population database and a police reported crash database. Three studies did not describe study settings. Response rates where they were described, ranged from 25% to 67%, and although many sampling frames may have incorporated significant bias, these concerns were not described nor adjusted for in any study.

Outcome measures

The number of crashes and/or near misses as a CMV driver was the primary outcome in 15 of the 16 studies included in the

review, one (a case-control study) [18] examined fatal versus non-fatal crashes. Crash status was self-reported by all studies other than the 2 naturalistic driving studies [8,19] which measured the outcome by observation, plus the case-control study [18] which investigated all crashes in a state police department's collision report database, and compared fatal crashes with injury crashes, determining the influence of driver sleepiness/fatigue and inattention/distraction on the likelihood of fatal outcome compared to non-fatal injury.

Five studies also included the occurrence of a near miss or crash relevant conflict [8,19-22]. The period of time requested for crash history ranged from 6 months to 10 years with one additional study using the drivers' entire driving history. Three studies did not describe the period of crash history requested [23-25].

Measures of sleep disorders and sleepiness

Obstructive Sleep Apnoea as a sleep disorder was empirically measured by three studies [26-28]. Howard et al [26] used a randomly selected subset of their larger questionnaire sample of commercial drivers to conduct 161 polysomnography tests. They found that over half (59.6%) of drivers had sleep disordered breathing (SDB) (five or more respiratory disturbances per hour) and 16% had Obstructive Sleep Apnoea Syndrome (OSAS) - defined as SDB plus an Epworth Sleepiness Score (ESS) of greater than 10. Stoohs et al [27] found 46% of drivers in their study to have SDB, defined as an oxygen desaturations index ≥ 10 . Carter et al [28] similarly used a randomly selected subset of participants from their larger questionnaire sample and conducted 161 polysomnography tests; of this sample, 17% were found to have OSAS.

Daytime sleepiness was measured as a covariate in 11 studies using the self-report Epworth Sleepiness Scale (ESS) [29]. Using this scale the respondent is asked to rate their 'likelihood of dozing off' in eight different daily activities (one of which relates to sleepiness while driving), scoring 0 to 3 for each response, a sum total greater than 10 suggesting daytime drowsiness. In these 11 studies, the mean ESS ranged from 4.75 to 9.6 and the proportion of drivers with an ESS score greater than 10 ranged from 10.5% to 46%. The Pittsburgh Sleep Quality Index (PSQI) [measured by 24, 25, 30] can be used to quantify a person's level of daytime functioning although it was primarily designed to measure their sleep quality. A PSQI greater than 5 suggests impaired sleep; however, it has also been shown to identify sleep disorders. Using this criterion (PSQI>5) Sabbagh-Ehrlich et al [25] found 21.3% of their sample to have poor sleep quality, De Pinho et al [24] found 46.3% of drivers to be poor sleepers, and 35.4% of drivers studied by Souza et al [30] reported poor sleep on their PSQI.

Nine studies questioned the drivers directly about their tendency to fall asleep or feel drowsy while driving [8, 19, 21-23, 25, 28, 31, 32], some finding incongruence between these responses and those measured with the self reported ESS or

PSQI. Perez-Chada et al [21] for example, found 56% of CMV drivers in their study to report tiredness while driving, yet only 14% of them had an ESS score over 10. In the study by Sabbagh-Ehrlich et al [25], the drivers seemed to self-report lower levels of fatigue than those suggested by the fatigue component of their PSQI scores.

Sleep quantity was also a measure used by 6 studies [8, 23, 24, 28, 30, 32], with 'insufficient sleep' measured by various methods and showing an association with crashes or critical incidents in the following three studies. Hanowski et al [8] in their naturalistic driving study, compared the sleep in the 24 hours prior to the crash/critical incident to the drivers overall mean sleep. Carter et al [28] attributed a 'sleep debt' to those drivers reporting a difference between the number of hours they actually slept and the number of hours they 'want(ed) to sleep'. Tzamalouka et al [32] measured the number of hours slept in the week prior to the crash as an exposure.

Related findings

Anthropometric proportions were measured (either by investigators or self-reported) in 13 of the 16 included studies. Mean BMIs reported ranged from 26.9kg/m² to 29.29kg/m², and the prevalence of obesity (BMI>30) in CMV driver populations ranged from 15% to 53.4%. Where all categories of BMI were presented [19, 21, 25, 26, 30], those drivers with a BMI>25 (overweight and obese) ranged from 52.5 to 81%. High BMI is assessed against the outcome of crash in two studies. These relationships are described below.

Exposure-outcome relationships

Considering first the relationship of a sleep disorder diagnosis to a crash outcome, Howard et al's drivers [26] with SDB did not have significantly increased self-reported crashes compared with drivers not having SDB. However, the study was not powered to detect this. Stoohs et al [27] found drivers with SDB had had twice as many crashes as those drivers without SDB (adjusted for mileage); however, this was not statistically significant. Drivers with OSAS in the study by Carter et al [28] reported no greater crash rate than others in the sample, perhaps because their crash report time frame was very long (10 years prior).

Secondly, the relationship of sleepiness (as measured by an ESS score greater than 10) to self-reported crash was considered by seven studies [21-24, 26,30,31]. In all seven studies positive ESS was related to a significant increase in crash risk; five studies described significance with odds ratios ranging from 1.91 to 2.98 (adjusted) and two studies using chi squared tests. Sleepiness indicated by positive PSQI (score>5) was not found to be significantly associated with self-reported crash by either De Pinho et al [24] or Souza et al [30]. However, all drivers with a history of crash in the study by Souza et al had a positive PSQI.

Thirdly, the findings of all studies which measured the relationship of sleep quantity to crash risk were consistent,

despite having measured sleep quantity in different ways.

Hanowski et al [8] found reduced sleep to be significantly predictive of critical incidents including crashes; Carter et al [28] combined sleep debt with an ESS>10 and found this variable significantly related to the risk of a work-related crash, with an adjusted OR of 2.1 (95% CI 1.1-3.9). For Tzamalouka et al [32], the number of hours slept the week prior to this incident was a significant independent predictor (adjusted) for drivers both falling asleep at the wheel or having a crash. The majority of drivers reporting sleepiness related crashes in the study by Leechawengwongs et al [31] identified insufficient sleep as the cause although the researchers did not measure sleep quantity.

Finally, crash or near miss was predicted by BMI in the study by Wiegand et al [19] who investigated the relationship of BMI to fatigue and 'safety critical events'. The odds of involvement in a crash or near miss for an obese driver were 1.37 compared with non obese drivers (CI = 1.19–1.59). Sabbagh-Ehrlich [25] revealed a strong association between BMI and sleep quality, assessed by the PSQI, such that increasing BMI predicted poorer sleep quality.

Discussion

Main findings

Regulation of the heavy vehicle industry has been the subject of considerable scrutiny in recent decades with the objective of reducing CMV crashes, in part due to the recognized stresses the CMV environment places on the health and safety of the driver. Obstructive Sleep Apnoea as a crash risk in this population has been empirically measured by three studies, none of which found significant relationships between this disorder and self-reported crash risk. However, sample sizes were too small to establish any effect. In the study by Stoohs et al [27] for example, with sample size of 90 participants, this finding of a non-significant but elevated risk may be due to Type II error; further, all drivers were from one long distance trucking company. One study [28] also reported the incidence of crashes with an exposure time spanning 10 years. Having a significant time lag from exposure to outcome such as this makes determination of any association quite tentative. Tregear et al [7], in a recent systematic review, described OSA as a significant contributor to non-commercial motor vehicle crashes, recognizing the lack of sufficient evidence in the CMV population.

This review also describes seven studies which found positive associations between excessive daytime sleepiness (measured by ESS) and CMV driver crash risk, with adjusted odds ratios ranging from 1.91 to 2.98. Further, three studies presented a relationship between sleep debt experienced by CMV drivers (using varied measurement methods) and their risk of having a crash or near miss, the sleep debt experienced in the days just preceding the incident being the most critical. These are, however, tentative associations given the limitations described below.

It is of particular importance to describe the findings regarding BMI, driver sleepiness and the crash risk of CMV drivers because excess body weight seems common among the CMV drivers studied in developed countries. BMI was measured in 11 out of the 16 studies reviewed, with most studies ($n=9$) suggesting a prevalence of obesity in CMV drivers that is likely to be considerably higher than in the general population. For example, a recent population-based study of Australian men found a prevalence of overweight and/or obesity of 64% across all ages; this was no different for the age bracket 40-49 years and, at 70%, slightly higher for those aged 50-59 years [33].

Wiegand et al [19] described obese drivers as more likely to be fatigued while driving and involved in a 'safety critical event' compared with non-obese drivers. However, they did not empirically measure OSA. Obesity has been previously described as a contributor to daytime sleepiness and fatigue [34], even in patients without OSA. While it seems likely that a high BMI is a risk factor for daytime drowsiness and sleep disorders, it is not well understood to what degree BMI is an effect modifier on the risk of crashing. There has been sufficient interest in this health concern, however, that the Federal Motor Carrier Safety Administration in the United States recommended in 2008 that CMV drivers with a $BMI \geq 30$ should have compulsory testing for OSA. Previous studies have not provided sufficient evidence on the link between lifestyle (health choices, health conditions and work schedules), fatigue and the risk of CMV crashes or critical driving incidents.

Limitations

The overriding limitation relates to the study design adopted for the majority (81%) of the studies, namely, a cross sectional survey. Such a design is limited in its ability to identify causal relationships and the interplay of risk factors of interest and the outcome. The predictor variables have strong collinearity which is difficult to analyse without more rigorous methodology. Further limitations include small sample sizes of as low as 90 (median sample was 308.5) and although all studies described unique hypotheses and related their analyses to these, none of these studies performed any pre or post hoc power calculation.

Self-report data, as used for both predictor and outcome variables in most studies, adds significant limitation to their strength. Most studies ($n=13$) made use of self-reported crash history which may be subject to considerable recall bias. As is the concern with any self-reported data, trying to obtain accurate estimations of the extent of fatigue in CMV drivers is fraught with difficulty. Most drivers today are heavily regulated with respect to their working hours, so are likely to under-report having been fatigued, falling asleep while driving, or other symptoms of sleep disorder. This has been seen in a USA study [35] where 1443 CMV drivers were screened using a combination of data to identify OSA or related symptoms in which 190 (13%) were identified as having a high risk of OSA and needing further testing. However, none of the 1443 drivers

completing the medical form required for licensure reported they had a sleep disorder or, pauses in breathing while asleep, daytime sleepiness or loud snoring. It has also been found that sleepiness is often denied by drivers as a causal factor in their truck crashes [36]. With respect to sleep disorders, many sufferers are unaware of their own symptoms and therefore do not accurately self-report symptoms such as sleepiness. Previous research has suggested that asking for bed partner validation for self-reported sleep disorders can be of significant assistance [37].

Height and weight data, for the purpose of calculating BMI, was also predominantly self-reported, and as such subject to the measurement error previously reported [38]. Given the likelihood of higher BMI being under-reported, it is plausible that in the absence of adjusting for BMI when investigating the association between sleep and commercial vehicle crashes, the reported association would be weakened, thus biased toward the null.

The ESS was originally validated in a Caucasian, symptomatic population and has been since validated for use in several other languages/cultural settings. The limitations of self-reported fatigue have been highlighted through cross validation. This is evident where the self-reported daytime fatigue while driving differs significantly from fatigue levels found by the ESS, highlighting the difficulty of measuring sleepiness. Polysomnography is the gold standard of objective measures to diagnose sleep apnoea. This was used in three studies only and in a smaller sub-sample of drivers - no doubt given the cost and difficulty of application to all drivers.

In the studies included in this review, participant recruitment methods were either poorly described with respect to sampling frames, or simply suffered from small response rates (some as low as 25%), therefore introducing the possibility of selection bias. While study settings varied, some researchers limited their study populations considerably by using only one transport company [24], or only one recruitment location [21]. Three studies did not describe their sampling methods at all. The key bias in most studies related to how they quantified covariate measures such as sleepiness and similarly the outcome measures of crash or near miss. The ability of the research findings to be generalised beyond the study populations is severely hampered by the significant methodological limitations of the studies.

Conclusion

Commercial motor vehicle drivers spend long hours behind the wheel of the largest vehicles on the road, and therefore particularly need sufficient time for quality sleep, and to eat well to maintain a healthy BMI. The risk of a crash or even drowsiness while driving has significant implications for all road users. This review has highlighted potential associations between the quantity of a CMV driver's sleep, their body weight, levels of sleepiness during the day and their risk of crashing. Most studies thus far, however, have used measures

based on self-report or the driver's perception (e.g. of their fatigue); self-report data are known to be limited in comparison to empirical measures. With these and the other limitations described, the current literature to date is restricted in drawing conclusions in relation to sleep and CMV driver crashes. This paper has described the findings and limitations of previous studies of the risk posed by fatigue, sleep and sleep disorders for commercial vehicle crashes. There remains inconclusive evidence as to the direction and strength of associations of risk factors for CMV crashes, particularly for sleep disorders including sleep apnoea, health status and the role of shift scheduling. These

factors are limiting the much-needed understanding of how preventive measures can be developed to further reduce the risk of crashing among this group of drivers. In the Australian context, it is clear that policy makers are attempting to manage fatigue-related risk in this population. However, there is a need for empirical pre- and post- intervention research to determine the accuracy of regulatory change. The interplay of sleep, health and work-life factors on the risk profile of the long distance commercial vehicle driver must be incorporated into a well-designed study that can further overcome the limitations of the research to date.

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Safety in the transport industry

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Abstract

Workers compensation statistics show high rates of fatalities, traumatic injuries and musculoskeletal disorders occur in the transport industry, particularly the road transport sub-sector. Safety initiatives and innovation are occurring although they tend not to be shared between operators. The Transport Strategy Group, Workplace Health and Safety Queensland is engaging with the industry, especially the heavy freight road transport sector, using action research to learn more about the health and safety systems in the industry and concurrently to improve health and safety outcomes. Industry networks are being established using concepts of collaborative governance to break down barriers, improve sharing of issues and solutions and to improve work health and safety outcomes.

Keywords

Transport, Road freight, Work health and safety, Collaborative governance, Action research

Introduction

Queensland workers compensation statistics show that the transport industry, and particularly the road transport sub-sector, is a high risk industry with workers compensation claims well above the all-industry wide rate [1]. The Transport and Logistics Industry Skills Council, in their 2010 Environmental Scan [2 p.3], observe ‘...there are widely held views that the industry is dangerous, fatiguing and has little potential for career development. The high profile of accidents and fatalities involving transport drivers compounds this image.’

It was against this backdrop of higher than average fatality and injury statistics that Workplace Health and Safety Queensland (WHSQ) established the Transport Strategy

Group (TSG) in 2010. The aim of the TSG is to provide focus and strategic direction on health and safety issues affecting the transport industry through evidence-based and innovative programs [3].

The TSG is developing an approach which recognises that many of the problems confronting the industry are broader societal issues that defy a single jurisdiction- or government-imposed solution. This approach includes:

- leading relationships between WHSQ and transport industry partners (including other government agencies)
- assisting in the development of information and education strategies to enhance health and safety
- seeking to influence legislation and standards including those in other portfolio areas which have the potential to impact health and safety outcomes within industry
- developing WHSQ’s internal capabilities in this area.

The TSG is also addressing the shortcomings or insufficiencies of a formalistic legal paradigm. Over the last two years WHSQ has been improving the impact and effectiveness of inspectorate services through better targeted enforcement activity, a more advisory approach and emphasising interventions with a multiplier effect. Regulatory support and, when required, regulatory compulsion, are critical. However, more is required to move the industry beyond laws and a culture of minimal compliance and avoiding litigation to one which creates new values, norms, practices and culture around health and safety.

One of the priorities of the TSG is an engagement program aimed at identifying and understanding safety management in the industry and, over time, encouraging continuous improvement. This is progressed by facilitating cross-industry

relationships and networks that create positive environments to identify barriers to safety, to share ideas, develop and test solutions, and learn from evaluating those experiences. In short, the program embodies an action research approach in which the TSG seeks to study the system while working collaboratively with transport industry stakeholders for change.

This paper provides the theoretical basis and research methodology which underpins the engagement program. It also provides some of the preliminary findings.

Description of the transport industry

In terms of employment, the transport and storage industry in Queensland is the second smallest of the major industry sectors in the state. In 2009-10, this industry employed almost 120,000 people, or 5.6 per cent of all people employed in Queensland [1]. Road Transport is the largest sub-sector, employing 50,000 workers, and as at 30 June 2010 there were almost 90,000 trucks registered in Queensland [4]. Transport support services and rail transport are the next largest employing sub-sectors. In the medium to long term, Queensland's transport industry is expected to see fairly strong employment growth – around 20% to 2017-18. Some sub-sectors such as road transport and rail are predicted to reach over 30% [5].

The heavy freight road transport industry is complex, with many sub-sectors dominated by small and medium-size businesses, complex sub-contracting arrangements and a high degree of economic pressure [6, 7]. Profitability of owner-operators is very low and owner-drivers work long hours for low remuneration [7]. The potential flow-on effects to poor safety outcomes are recognised and a system to ensure that pay rates are not adversely affecting safety has been proposed [8].

The industry has the challenge of a constantly changing workplace and work environment. Truck drivers spend most of their working time on their own driving in their trucks. Although there are times - during queuing, loading, unloading and infrequent breaks – that drivers interact face-to-face with others, for most of their working hours they are on their own with limited communication. This engenders a unique culture characterised by a strong sense of independence, coping with isolation and working alone [9].

Work health and safety injury and fatality data

In 2008/09 there were 64 compensated fatalities in Queensland. The transport and storage industry recorded 15 fatalities, or a rate of 12 per 100,000 workers. This is significantly down on the 2007-08 rate of 32 per 100,000 workers. However, it is still well above the National Occupational Health and Safety Strategy targets and the all-industries fatality rate of

3 fatalities per 100,000 workers. Fatality data shows not only on-duty road traffic incidents; many fatal incidents are happening in the depots, involving loading and unloading, crush injuries and falling objects [1].

In relation to non-fatal compensated claims, the transport industry was responsible for about 9% of Queensland's 30,500 claims in 2008/09. However, as a rate, transport and storage recorded 21.7 compared to the all-industry average of 14.5 per 1,000 workers. This rate was exceeded only by the manufacturing industry which recorded a rate of 32.4 per 1,000 [1].

Over 70% of compensated injuries were musculoskeletal disorders and these types of injuries, particularly trauma to joints and ligaments, are increasing over time. Over the longer period 2005 to 2009, muscular stress while lifting and handling, falls on the same level and falls from height were the most common mechanisms of injury. Vehicle incidents and contact with moving plant/objects are significantly further down the list of injury mechanisms.

This data shows that while the transport and storage industry is the second smallest industry sector in terms of employment, it has the second highest incidence rate for workers compensation. Drivers have a high rate of injury, ill-health and stress. Owner-drivers tend to have more negative work health and safety (WHS) outcomes than small-fleet drivers or, especially, large-fleet drivers [7]. Fatalities and serious injuries occur in other contexts besides on-road, and improving health and safety performance is dependent upon overcoming the challenges of these industry aspects [3].

Regulatory Space

Safety issues in the transport industry, particularly in the heavy freight road transport industry, have a greater impact on the general public and wider community than for most other industries. Failure of safety, when it occurs on-road, can result in a traffic crash or incident. Due to the vehicle types involved (truck versus car), the consequences for the member of the public can be far worse than for the truck driver [5].

This has given rise to large volumes of regulation covering [10]:

- road rules
- vehicle standards and safety
- vehicle registration
- licensing
- fatigue management
- mass, dimensions and loading
- dangerous goods.

Unlike other industries, the heavy freight road transport industry operates under significant and obvious surveillance - by transport inspectors and police, and by remote technology such as speed cameras, safe-t-cams and red light cameras. Global Positioning System (GPS) tracking is increasingly being used by companies and regulators to monitor where, when and how heavy vehicles are being operated [11].

Not only is this a congested regulatory space, it is also one which is rapidly changing. The introduction of chain of responsibility legislation was a major shift for the industry from prescriptive and driver-targeted rules to more performance and

principle-based regulation. New on-road requirements have also been introduced covering fatigue, mass loads, load restraints and speeding. There is increased focus on prosecuting the corporate chain who are responsible for creating the conditions or placing pressures on drivers. Consignors, consignees, packers, loaders and receivers, who create conditions which lead to drivers contravening road transport laws, can be prosecuted under this legislation [12]. The establishment of a National Heavy Vehicle Regulator and associated legislation will bring further changes. There is also the possibility of safety regulation through industrial relations law, with the Federal Government recently releasing a ‘Safe Rates, Safe Roads’ discussion paper [13].

Changing regulation can be perceived as ‘more’ regulation in an already heavily regulated environment. The perception of an increased regulatory burden can cause an adversarial relationship between the regulator and businesses, fostering a relationship that, in some instances, is ‘dismissively defiant’ with the industry distrustful of any overture from the regulator [14]. Wallace [9] notes the existence of such a relationship between government and the transport industry, and the difficulties that exist in breaking it down. This distrust extends not only to the road traffic regulator but other regulatory agencies, such as for occupational health and safety.

Regulating work health and safety – multiple approaches

An awareness that traditional deterrence-focussed regulation was creating an adversarial climate - one that stifled innovation and, at best, maintained minimum standards rather than allowing best practice to evolve - has led public agencies to investigate other forms of governance [15]. Occupational health and safety has, since the 1970s, been moving away from prescriptive controls towards models of ‘self-regulation’ and responsive enforcement [16].

The ‘new’ approach to regulation, directed by both legislative change and maximising limited regulatory resources, recognises that different organisations will respond differently to different approaches by the regulator. It also recognises that it is essential to ensure a balanced approach across the encouragement-persuasion spectrum [17].

In the last few years, Workplace Health and Safety Queensland [18] has moved to adopt the attributes of a modern regulator characterised by:

- client focus, reflecting and evolving with the community’s needs and concerns
- use of regulatory powers in a constructive, accountable, transparent and effective manner
- experienced and well trained people who are empowered, professional and capable of dealing with each situation on its merits
- a proactive and positive approach – identifying and focusing resources on the areas of greatest risk and impact
- engaging with people to help them be on the right side of the law by showing them how to comply

- ensuring there are fair and swift consequences for those who do the wrong thing.

It is vital that a modern regulator goes beyond the ‘expert knows best’ model in order to change behaviours and build effective intervention programs [19]. ‘Expert knows best’, or command and control models, are not as effective as a combination of collaborative, distributed and dialectic leadership roles, although potentially there are higher regulatory costs for the latter [20 pp.1-2]. Governance arrangements which support these leadership roles will assist a modern regulatory approach.

Collaborative governance is defined as:

‘A governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented and deliberate and aims to make or implement public policy or manage public programs or assets’ [15 p.2].

Ansell and Gash [15 pp.8-11] have developed a collaborative governance framework that suggests effective engagement and collaboration may be impacted by factors such as power/resource imbalances, the incentives for stakeholder participation, and any prehistory of antagonism or cooperation (Figure 1). However, they argue that such factors may be overcome or managed through facilitative leadership stewarding the process (building trust and facilitating dialogue, as well as embracing, empowering and mobilising stakeholders), institutional design (the basic protocols and ground rules that establish procedural legitimacy), and the way the collaborative process is administered (face-to-face dialogue, building collective understanding and trust, and celebrating small wins) [15 pp.12-19].

Collaborative approaches are based upon the formation and maintenance of relationships. They require a facilitative style to manage behaviours, activate the right people, coordinate their interfacing and set out operating rules within which they may deal with complex situations [21 p.445].

When properly applied, this partnership approach has benefits for all stakeholders. It is more likely to result in sustained behaviour change and to create ‘behavioural norms’ that legitimise the adoption of good safety practice. Simply put, if you have the key actors working together for an agreed common goal they are more likely to take action and to see the action as the ‘way we do business around here’ [14, 22]. Critical to the success of these partnerships is having the right people ‘at the table’ but foremost are the skills of the broker or facilitator. They have to be credible, able to build relationships, develop trust, sustain communication and develop processes and plans in concert with the stakeholders [15, 20, 21].

The health and safety performance of the industry, the regulatory space and theoretical approaches outlined above were used to inform the TSG strategy. This strategy combines a focus on engagement and a research approach in order to learn more about the system to be influenced.

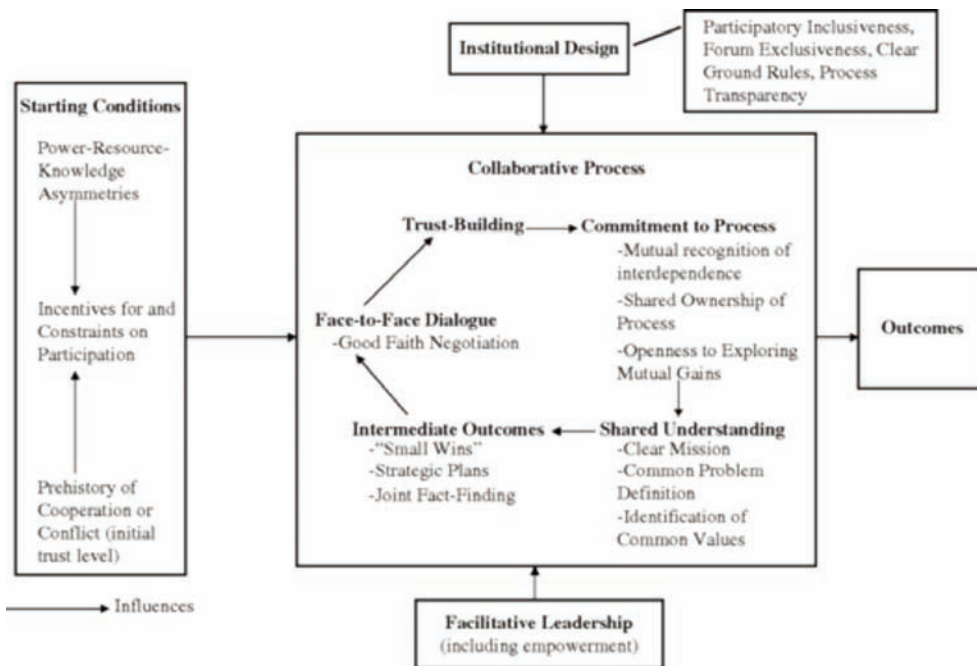


Figure 1. A model of collaborative governance [15 p.8]

Putting it into action

The initial work of the Transport Strategy Group built on a previously established stakeholder framework. Collaborative arrangements are included in the *Workplace Health and Safety Act 1995* with formal arrangements required for Industry Sector Standing Committees (ISSC). The Transport and Storage ISSC was integral to the development of the Transport and Storage Industry Action Plan (IAP) 2008-10 [23]. Initiatives under the IAP led to the staging of a Transport Industry Summit in 2009. The Summit was organised to establish an entry point with the transport industry and to seek industry comment on the most significant occupational health and safety issues facing industry, including stakeholder views on how to address them. It was clear during this consultation that industry felt:

- over-burdened by sometimes conflicting regulation from government agencies
- ready to embrace improved health and safety practices (but without understanding how to do this in practical ways).

With the establishment of the TSG in January 2010, an engagement strategy was developed. This encompassed the principles of Action Research: '... a flexible spiral process which allows action (change, improvement) and research (understanding, knowledge) to be achieved at the same time' [24]. This process of diagnosis-planning-action-evaluating-learning is outlined in Figure 2. Put simply, this is a process of *'learning by doing'* - a group of people identify a problem, do something to resolve it, see how successful their efforts were, and if not satisfied, try again' [25].

Part of this engagement strategy was a series of interviews with senior management and executives of transport companies. The

participants came mainly from the heavy freight road transport sector. Selection of participants was by purposeful sampling. From a list of major transport operators a subset of 20 were contacted initially, consisting of Chief Executive Officers and State Managers [26]. These were followed up with 80 additional operators through a process of identification and referral.

In order to foster an atmosphere of trust and confidentiality, a semi-structured interview process was adopted to explore a number of key themes. It was important to differentiate this approach from legalistic interactions by appointed inspectors acting under conferred powers. It was stated at the start of each interview 'I am not here to conduct an audit of your safety management system. I am sure that on paper it would look fantastic, but what I am really interested in is how safety is being managed through practical application at the coal face in your workplace'.

The basic information asked for by the researcher was:

- what safety meetings they held within their company
- what the highest level of management in attendance was at those meetings
- how often they held each of those meetings
- what initiatives (if any) they had in place to address any safety concerns/issues that were raised at those meetings
- how they managed safety when using contractors and at customer sites
- whether they were aware of any barriers or gaps to improving safety in the industry
- whether they wanted to make any additional comments.

The interview process was also used to gauge interest in the companies becoming involved in WHSQ's Zero Harm at Work Leadership forum [27] and regional transport networks.

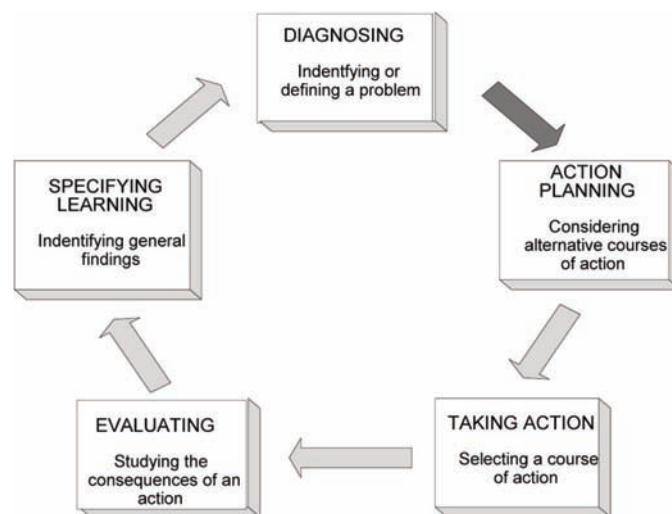


Figure 2. Detailed Action Research Model, (adapted from Susman 1983) [25 p.3]

Records of conversation were made for the first 20 interviews and these were reviewed by those interviewed to ensure that they faithfully captured both the content and meaning of the information provided [26]. The 80 subsequent interviews, conducted to date, were not individually documented but the key themes, ideas and initiatives were recorded. Researcher notes and reports de-identified interviewees and companies to ensure confidentiality.

Thematic analysis was employed and the development of emerging themes is incremental. As themes are identified the methods of questioning require adapting and changing. For example, the early interviews were conducted using a number of questions that had been developed in advance; however, during the interviews the participants raised issues that had not emerged previously. After carefully considering what had been said the words were analysed and the discussions were refined to include these issues for further interviews.

Results and Discussion

A number of key themes emerged from the interpretive analysis of the records of conversation of the interviews and supplementary information from the additional 80 interviews. These themes are indicative of the type of practice likely to be encountered in more than 50% of the businesses interviewed. As such, they do not apply to all businesses interviewed. The themes are generalised and language used by the interviewees was subject to the interpretation of the interviewer. Discussion of each theme grouping and the implications for a collaborative governance approach is presented below. Quotes (text in bold), selectively drawn from the report produced after the first 20 interviews, are used to illustrate the theme [26].

Consultative arrangements

- Companies have active safety committees at a site level.
- They hold safety meetings including tool box talks within the company structure.

- They have safety as a standing agenda item at every meeting.
- They employ a full-time OHS and/or Compliance Officer .
- Management attend meetings appropriate to the level that the meeting is convened at.
- Safety meetings are held on a monthly basis with State Managers in attendance whenever possible.

“Our company has a strong belief that awareness defeats complacency.”

- Tool box talks are held on a needs basis rather than a regularly scheduled systematic approach.
- Employers are realising that the engagement of the workers in the decision making process is key to improving safety in the transport industry.

“Inclusion of the workers in the decision making process achieves the desired change.”

“Consultation is the key to good safety management.”

“You can have all of the safety processes in the world but the real key to safety is how the drivers apply them.”

- Literacy skills among drivers are improving; however there is a need for clear and concise information about safety. This needs to be delivered as simple messages designed specifically for the targeted audience.

“The best way to communicate important messages to drivers is sharp, short and direct to the point.”

“The way to improve safety in the industry is by bringing the message to the worker in the format necessary for them to understand it.”

“It is important to simplify the message(s) and to identify the audience.”

“The method of delivery of a new idea is crucial.”

“How an idea is delivered is the most important aspect of change management.”

Health and safety management within transport companies is showing signs of taking a consultative and collaborative approach and it is apparent that some of the basic communication mechanisms required for effective health and safety management systems are commonly used. This not only means that the fundamental structures for sharing information between employees and managers are in place but also there is a demand for information and ideas to ensure that meetings are interesting and informative. Participation in wider collaborative mechanisms, such as the local transport networks, could be an effective way of meeting this information need.

Contractors and supply chain

Measures to improve control over safety in the use of contractors and at customer sites are in the process of being implemented. In some companies, contractors are treated the same as direct employees with respect to safety and are included in internal training programs and safety meetings.

“There should be a compulsory element of safety in contract procurement.”

Reporting of issues by drivers is a key component to addressing those issues. In some cases, drivers are being encouraged to report safety concerns at their customer and delivery sites through a simplified *‘Driver Hazard Identification Form’* which is kept in the cab of the vehicle.

“The key to making the workplace safer is encouraging the reporting of near misses. That’s where we can make a real difference.”

“No blame reporting encourages a high level of reporting and if we know what is going on we can address the problem.”

It is clear that the industry recognises that the supply chain is a critical component of health and safety. This recognition is the start of awareness that all health and safety issues cannot be addressed in-house, and that wider communication would be beneficial. This provides the opportunity for WHSQ, through the collaborative governance framework, to facilitate cross industry discussions.

Safety initiatives

Throughout the interview process, a number of ‘low cost/ high impact’ safety initiatives were identified. Highlights include:

- **Safety Cuffs/Chains** – metal cuffs on a short chain that can be clipped onto the outside of container doors prior to opening, allowing a driver to safely open the doors to check and see if the load has moved during transport
- **Mobile Flashing Unit** - a mobile unit that any employee must keep within a defined range, when working in the vicinity of a forklift, in order to alert the forklift driver that there is a person/pedestrian in the area
- **Safety Walk** – once a week an employee is chosen to conduct a safety walk to identify any ongoing safety issues and/or concerns so that these issues can be addressed. The

policy is that names of employees are not relevant unless there is a significant safety breach identified.

Whilst there is a significant level of innovation in the industry, many of the solutions identified are viewed by the industry as simple and not worthy of being shared. Breaking down this perception and encouraging the industry to share and collectively implement effective low cost initiatives could result in significant health and safety improvement in the industry.

Cost of safety and other barriers

- The most commonly identified barrier to the improvement of health and safety is cost although it was recognised that it is part of doing business. Some companies can only afford the bare minimum or basic requirements.

“If you can’t afford safety then you shouldn’t be able to get a licence to operate a transport company.”

- Other significant barriers to improved health and safety are the problems associated with the ageing workforce, and an embedded culture with a level of acceptance that if you work in the transport industry you will probably get hurt.
- Factors external to the company, such as roadside facilities and the behaviour of other road users, were seen as important.

“An increase in the number of change-over stations at appropriate places would help to improve the health of line-haul drivers by having them home every night.”

“There is no respect for truckies on the road.”

Professional drivers drive the equivalent of 10 years driving every year (based on the average person driving 20,000 km/yr)."

“The industry is in desperate need of a traineeship program.”

“All road users would be safer if general licensing included education in relation to sharing the roads with heavy vehicles.”

“Actually looking in the mirror and seeing the distance to the back of the vehicle would provide a better understanding of heavy vehicles.”

The risk of being directed to implement potentially costly rectifications is a significant disincentive for business to seek professional advice or, especially, advice from the regulator. Awareness that other businesses have or have had the same issues and, in some cases, have implemented cost-effective solutions, is a significant incentive for participation in the local industry networks. Realisation by industry that facilitation by WHSQ can lead to practical cost-effective solutions is a significant step in building trust and breaking down the perception of an adversarial relationship between business and regulator.

The emphasis that the road transport industry has on external factors, and perceptions that certain aspects are beyond their control, indicate the need for support mechanisms which emphasise the advantages of the industry expanding their collective sphere of influence.

Conclusions

The opportunity to share the information gathered from one employer to another is a powerful tool and an opportunity for WHSQ to influence the way that the transport industry is managing safety. By facilitating this information exchange, the TSG is more easily able to provide the necessary guidance and assistance to improve health and safety outcomes in the industry.

This is also the opportunity to facilitate employers working together to improve health and safety, and the TSG is encouraging this through the establishment of a series of industry networks. The first regional transport network was established in Rockhampton in September 2010; an early indicator of success was their decision to hold bi-monthly meetings rather than the quarterly meetings suggested by the TSG. Toowoomba was scheduled to have their first meeting in March 2011; however, this was delayed due to the Queensland flood disaster, and occurred in May 2011. Workshops, the first step in commencing the networks, have now taken place in Ipswich, Townsville, Cairns and Mackay. There are also plans for networks in Logan, Gold Coast, North Brisbane, Nambour and Bundaberg by December 2011. In effect, these industry networks will become the vehicles through which action research continues.

The industry networks being established by the TSG are consistent with collaborative governance. The role of WHSQ in the networks is one of facilitation and guidance rather than as an expert giving direction. This will be 'hands on' and will focus on building trust, facilitating dialogue and embracing, empowering and mobilising stakeholders. The aim is for the networks to be self-sustaining with drive and enthusiasm generated by focussing on issues and solutions which can be addressed locally. This will be supported by encouraging the right foundation through the availability of systems, guidance, tools on the WHSQ website and access to health and safety professionals at the network meetings. The networks provide the opportunity to share experiences and expertise and come up with the best health and safety solutions and most practical solutions to make workers safe in their workplaces. WHSQ will utilise the opportunities provided by the networks to disseminate information that is critical for the improvement of safety in the industry as a whole.

The 'low cost/high impact' solutions identified in this paper represent only a few of the many solutions which are available to be shared. These solutions can be developed into information to be shared more widely among other networks and on WHSQ's website. The information available becomes dynamic, improving as better guidance and solutions are developed by the stakeholders. This approach of partnership and engagement encourages ownership of problems and risks. It also demonstrates to stakeholders that they can be effective in addressing problems and having successes. This, in turn, builds confidence and promotes an increased level of trust and participation.

There are challenges in taking this approach. Firstly, there is a significant challenge in overcoming the suspicions created by an overcrowded regulatory space which is often referred to by industry as 'turkey nesting': each additional requirement is dealt with as quickly as possible but isn't necessarily understood, 'just scratched in a pile with all the rest of them'. Regulatory fatigue, overcoming inertia, engaging the unengaged or hard-to-reach (owner-operators and workers) are all associated problems. Secondly, external forces which have impact on the transport industry and government - such as the 2010-11 flood and cyclone disasters in Queensland - create a challenge of maintaining focus on issues that are considered less immediate and therefore less important. Lastly, there are the challenges associated with reliably measuring the impact, particularly in relation to outcomes and benefits. Effective ways to measure and evaluate progress need to be developed.

WHSQ and the TSG do not underestimate these challenges. However, given the positive industry response to date, including strengthened relationships with other regulators, there is good reason to be optimistic about the future.

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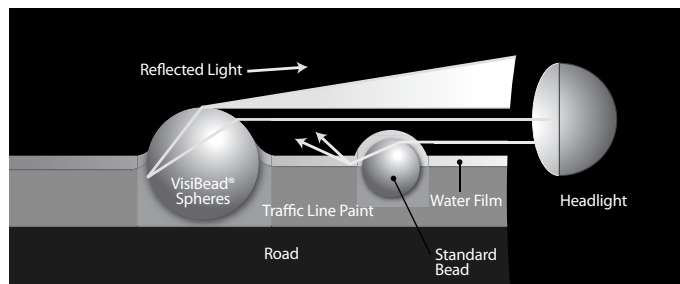
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Contributed Articles

Recent ARRB research on heavy vehicle safety

by M Tziotis, Group Manager – Safe Systems, ARRB Group, 500 Burwood Highway, Vermont South, Victoria 3133

Abstract

Deaths from heavy vehicle crashes represent 16% of the national road toll, with an estimated cost to society of \$2 billion per year. The future will see a significant growth in road freight transport, and so this problem is likely to increase. This paper presents key findings from a research program on heavy vehicle safety undertaken by ARRB and funded by Austroads. Projects include the safety of heavy vehicles in urban areas, and in rural and remote areas; the interaction between heavy vehicles and the road system; and heavy vehicle driver gap selection at intersections. Future research directions are also provided.

Keywords

Heavy vehicles, Road safety, Urban, Rural, Gap selection

Introduction

In Australia, deaths from heavy vehicle crashes represent 16% of the national road toll, with an estimated cost to society of \$2 billion per year. During the 12 months to the end of September 2010, 250 people died from 209 crashes involving heavy trucks or buses. The majority of these crashes (60%) involved articulated trucks, followed by heavy rigid trucks (32%) and buses (8%).

The future will see a significant growth in road freight transport. The capacity of urban and rural road systems to cope with this increase safely and efficiently will be fully tested. The development of measures to improve the safety of heavy vehicle travel is an important part of the road research program undertaken by ARRB and funded by Austroads¹. ARRB's recent research for Austroads in this area has focused on the following issues:

- the safety of heavy vehicles in urban areas, and in rural and remote areas
- interaction between heavy vehicles and the road system
- heavy vehicle driver gap selection at intersections.

An outline of the aims and findings of these projects follows.

Improving the safety of heavy vehicles in urban areas

It is estimated that by 2020 road freight travel in Australia will be more than double that of 2000. While there are differing

views on the future magnitude of the freight task, there is acknowledgement that freight activity in Australia will increase substantially in a relatively short timeframe. The freight forecasts indicate that the greatest increases will occur in urban areas. It is expected that the freight growth will occur mainly near and/or between ports, inter-modal freight terminals, and outer metropolitan industrial areas where large warehouses and distribution centres are located.

If the high levels of projected growth are realised, there will be significant safety implications, particularly as heavy vehicles need to share an increasingly constrained and congested road network with other road users.

The project sought to establish the issues relating to heavy vehicle operations on urban roads, and to develop effective measures to improve safety. The study examined:

- the magnitude, severity, characteristics and trends in crashes
- current knowledge regarding road-based causes
- safety improvements with an emphasis on intelligent transport systems (ITS) and other new technologies.

The study approach included crash data analysis, a literature review, consultations with key stakeholders, and a review of the *National Heavy Vehicle Safety Strategy 2003–2010* and the associated action plans.

It confirmed that most heavy vehicle casualty crashes in urban areas in Australia occur in 60 km/h zones. However, articulated truck crashes are more frequent in 70, 80 and 100 km/h speed zones. This reflects the very small proportion of travel that is undertaken by articulated vehicles on non-arterial roads in urban areas.

The literature review highlighted a range of measures to improve heavy vehicle safety in urban areas such as developing safer roads (e.g. separate truck facilities), achieving more alert and compliant road users (e.g. increased enforcement) and encouraging safer vehicles (e.g. under-run protection for heavy vehicles). The focus of the study, however, was on ITS solutions and some of the technologies for which crash reductions have been demonstrated include:

- electronic braking systems
- intelligent speed adaptation (particularly speed limiting systems)
- lane departure warning systems
- road geometry warning systems.

A number of technologies are promising and are being trialled, but require further evaluation to establish their contribution in actual operation.

Heavy vehicle safety in rural and remote areas

About 60% of road fatalities in Australia occur on roads in rural and remote areas. While there have been substantial reductions in crashes in urban areas, in general these have not been matched in rural and remote environments.

The objectives of the study were to update trends and undertake a detailed investigation of crashes in rural and remote areas in order to identify:

- existing measures which could be used more widely or more efficiently
- new and cost-effective measures
- improvements to current road design and traffic engineering practices
- locations and parts of the road network that will come under pressure from increased freight movements.

With the predicted increase in freight activity, it can be expected that heavy vehicle crashes will also increase unless effective safety measures are undertaken. A review of the likely growth in the freight task identified that the key short and long interstate haul routes between capital cities are expected to experience sustained growth of 3% to 4.6% per year up to 2020.

Site investigations of a representative sample of heavy vehicle crash locations identified a range of road factors involved. Information on these factors was subsequently used to identify remedial works. Major crash factors included:

- Intersections – poor sight distance, delineation either not provided or inadequate (i.e. linemarking, raised reflective pavement markers, edgelines and guide posts), unsealed or only partially sealed shoulders, insufficient or poorly positioned signing, roadside hazards located within the clear zone (e.g. poles, culverts and steep embankments), safety barriers either not provided or inadequate, insufficient advisory/warning signs (e.g. of curves, intersection ahead, advisory speed).
- Road segments – poor road pavement (i.e. not well maintained, inadequate drainage, too narrow), unsealed or only partially sealed shoulders, unexpected transition between roads of varying standard, poor sight distance for overtaking, insufficient or poorly positioned signing, roadside hazards located within the clear zone (e.g. trees, poles, culverts).

Safety improvements can be undertaken either as part of a maintenance or a capital works program. The approach adopted should focus on high volume arterial roads, freight routes, the level of crash risk, and rates of increase of heavy vehicle activity.

Road maintenance programs should ensure regular attention to:

- road delineation features (i.e. edge, lane and centre-of-the-

road linemarking, raised reflective pavement markers, chevron alignment markers, guide posts)

- regulatory, advisory and hazard warning signs (including placement and positioning)
- road shoulders and road surfaces
- sight distance at intersections (e.g. removal of obstructing vegetation).

Capital works programs should include:

- expanding the provision of passing lanes
- installation of safety barriers designed for heavy vehicles at locations where there is a high run-off-road risk
- installation of median barriers (including wire rope barriers) and increased separation of opposing lanes of traffic (e.g. wider barrier lines, increased spacing between double barrier lines)
- provision of sealed road shoulders on freight routes
- improvement of sight distances at major road intersections
- improvement of the delineation and conspicuity of intersections (e.g. linemarking, guide posts, raised reflective pavement markers and islands)
- provision of clear zones (e.g. removal of hazard, flattening of batter slopes).

Road authorities should continue to invest in improvements at heavy vehicle crash sites at intersections and road segments with both mass action programs and blackspot treatments. These programs are highly effective in reducing crashes at locations that have inherent safety problems.

Improving the interaction between heavy vehicles and the road system

The project evaluated the interaction between heavy vehicles and the road system in order to identify issues related to heavy vehicle crashes and develop proposals to improve the road system on heavy freight routes. The approach involved:

- an overview of heavy vehicle crash characteristics
- identification of freight routes with safety problems
- development of a draft strategy to improve route safety
- identification of revisions to the Austroads *Road Safety Audit* guide to take better account of heavy vehicle safety issues.

An analysis of crash data indicated that the characteristics of heavy vehicle crashes matched those for all types of crashes, at least for some of the variables investigated. However, they differed in some respects; for example, 'same direction' crashes account for a higher proportion of heavy vehicle crashes.

Inspections of heavy vehicle crash cluster sites along selected freight routes identified the road and road environment factors which may have contributed to the crash or its severity. These included poor delineation, narrow lanes, limited sight distance and clear zone hazards.

Treatments which could form part of a strategy to address heavy vehicle safety on major routes in the short term and the longer term were identified. Some of these confirmed measures

are already in the *National Heavy Vehicle Strategy 2003-2010*, such as the clearance of roadside hazards, shoulder sealing, provision of passing lanes, and programs to minimise the risk posed by utility poles.

Further investigation of other promising measures such as the use of barriers to reduce the risks posed by roadside hazards, audible edgelineing for heavy vehicles, and improved delineation was required. Other longer term measures warranting support include skid-resistance treatments and greater lane widths.

Heavy vehicle driver gap selection at intersections

The project sought to measure the gap sizes selected by drivers of heavy vehicles for a number of turning/crossing manoeuvres at intersections. Driver gap-taking decisions were analysed at six sites. Four were located in Melbourne and two in Brisbane; four sites were T-intersections and two were cross-intersections. The sites consisted of standard intersection geometry which satisfied ARRB selection criteria. Road-mounted traffic counters and video cameras were placed at each site, and data was recorded continuously for a period of approximately seven days.

The five heavy vehicle classes analysed in this study were:

- medium rigid truck
- heavy rigid truck
- semi-trailer
- truck-trailer
- B-double.

Data were only analysed during daytime hours (approximately 7.00 am to 5.30 pm), when the road was dry and when the driver of a subject vehicle made a complete stop before performing the entry manoeuvre.

It was found that the gap size chosen by the driver for the five vehicle classes increased in line with the size of the vehicle, namely medium rigid, heavy rigid, semi-trailer, truck-trailer and B-double.² This was an expected result as the latter vehicle classes have a longer length and a larger mass. The B-double vehicle class had a significantly larger gap size than the other classes. Gap sizes for the medium rigid, heavy rigid and semi-

trailer vehicle classes were very similar for the majority of manoeuvres.

Further measurement of driver gap selection at night, during wet weather, and with laden and unladen vehicles would also provide valuable information on driver behaviour.

Future research directions

Heavy vehicle safety will remain an important area of research for Austroads and ARRB. The directions for future research are likely to include:

- assessment of the most promising vehicle technologies with an emphasis on intelligent transport systems
- investigation of representative heavy vehicle crash locations in order to identify the causes and risk factors
- development of measures in support of the national heavy vehicle safety strategy and action plans
- review of speed limits in relation to road standards and roadside development
- improvements in road design and traffic management practice which take greater account of their interaction with heavy vehicles
- the suitability and application of safety barriers to reduce the risk for heavy vehicles from roadside hazards
- review of the design of intersections on key freight routes to accommodate heavy vehicles more safely.

Notes

¹Austroads membership comprises the Australian state and territory road transport and traffic authorities, the Commonwealth Department of Infrastructure and Transport, the Australian Local Government Association, and the NZ Transport Agency. Its purpose is to contribute to improved transport operations including the fostering of research in the road sector.

²The gap range for each vehicle was found to be: medium rigid (4.6 to 8.6 seconds), heavy rigid (5.2 to 7.2 seconds), semi-trailer (6.6 to 9.6 seconds), truck-trailer (5.0 to 9.6 seconds) and B-double (7.8 to 12.0 seconds).

Large truck crash avoidance

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Abstract

Large truck and other commercial vehicle crash causation can be conceptualized by a risk-cause timeline and model. Different types of risk factors interact continuously to raise or lower crash risks, though crashes are usually precipitated by a discrete driver error or other failure. Enduring individual differences in driver risk are strong, with personality and related risk attitudes as a

major source. Roadway characteristics (e.g., divided vs. undivided roads) are comparable to driver differences in their effects on risk. For motor carriers, a distinction can be made between risk *reduction* (i.e., improving drivers and vehicles) and risk *avoidance* (reducing exposure to risk). Both can be effective strategies.

Keywords

Crash causation, Crash risk, Crash risk reduction, Crash risk avoidance, Driver risk, Divided roadways, Commercial motor vehicles, Truck safety

Introduction: What is crash risk?

At any given time on the highway, many different factors interact to affect commercial motor vehicle (CMV) crash risk. Traditionally, crash risk factors and causes are classified as either *driver, vehicle or environmental*, with the latter including both the roadway and weather. Figure 1 is a schematic of these interacting factors, with some elaborations [1]. In regard to the truck driver, it is helpful to consider two general types of human factors. The first of these are from the driver's constitution: physical, medical, psychological, or other *enduring personal* risk factors. The second type of driver factor includes all the *temporary personal* risk factors that affect people in their daily lives. This includes last night's sleep, time awake, circadian status (peaks and valleys), recent meals, recent caffeine, and temporary emotions like anger and frustration (perhaps associated with delivery schedule pressure). Traditional terms for these two categories of human factors are *traits* and *states*.

Influences from *outside* the truck driver can be considered *situational* factors, with vehicle and roadway environment as major subcategories. Vehicle factors include the vehicle's basic configuration (e.g., single-unit vs. combination, trailer and cargo type), its mechanical condition, and its safety-related

features. Roadway environment factors include road type, traffic density and patterns, surface condition, and weather. Thus, a simple taxonomy of the crash risk factors operative at any time during driving is as follows:

- Driver
 - enduring characteristics (traits)
 - temporary characteristics (states)
- Situational (outside the driver)
 - vehicle
 - environmental (eg., roadway, weather, surface condition)

In recent convenience-sample surveys [2, 3] of US motor carrier safety managers and other experts, driver traits and driver states were regarded by respondents as the two most important factors affecting crash risk. These two factors were regarded as far more important than vehicle factors (equipment and condition), roadway characteristics, and weather conditions. Findings from the US Large Truck Crash Causation Study (LTCCS) and many other studies also find driver factors to predominate in crash causal scenarios [4].

Not seen in Figure 1 below are the many prior and 'macro' influences on driving safety which are less apparent in driving scenarios but operative nonetheless. Most notably, carrier practices 'create' many of the driver, vehicle, and roadway environmental elements seen in Figure 1. Government policies and practices form another overlay to driver-vehicle-roadway interaction and resulting crash risk. The following list highlights six categories and numerous specific crash risk factors.

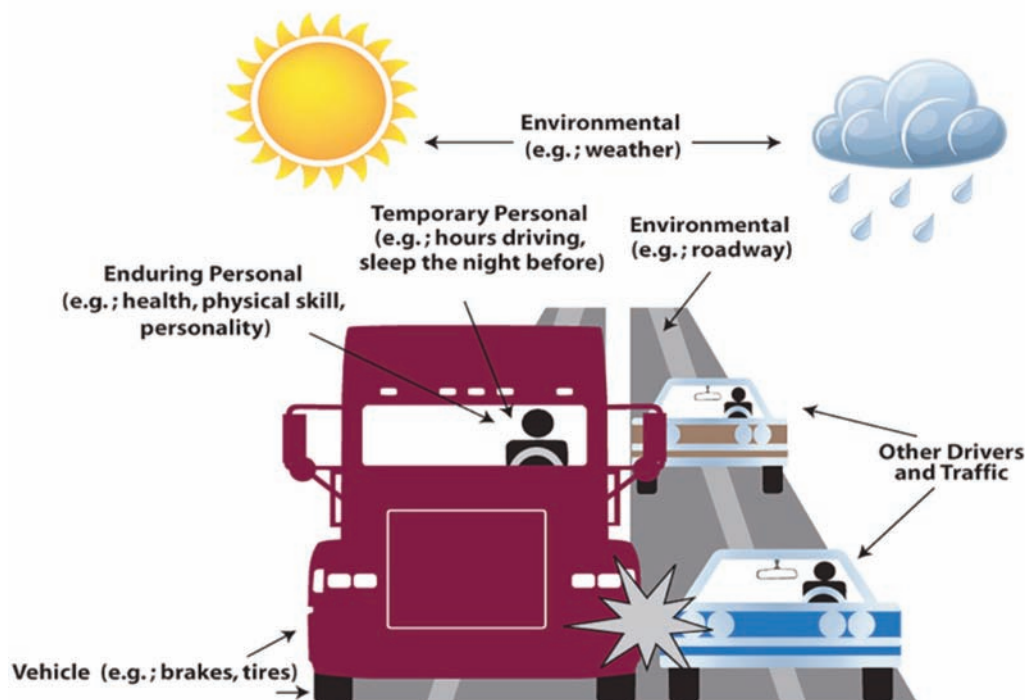


Figure 1. Multiple interacting factors in large truck crash involvement. Reprinted from [1]

Potential crash risk factors

Enduring Driver Factors

- Demographics; e.g., age, gender
- Driving knowledge & skills
- Personality; e.g., aggressiveness, sensation-seeking, stress level
- Risk perception & attitudes
- Psychomotor skills; e.g., reaction time
- Medical status & conditions, including fatigue susceptibility
- Behavioural history
- Mental abilities

Temporary Driver Factors

- Recent sleep
- Time-of-day & circadian rhythms
- Time awake (e.g., > 16 hours)
- Time-on-task (hours working & driving)

- Short-term illnesses
- Moods & recent stress
- Recent food & fluids
- Drugs, medications, & alcohol
- Familiarity with road

Vehicle

- Vehicle design & configuration
- Mechanical condition
- Safety features & technologies

Roadway & Environmental

- Mileage exposure in general
- Divided vs. undivided roads
- Level of access/types of intersections
- Traffic density
- Curves & ramps
- Intersections
- Lane restrictions

- Construction zones
 - Weather & road surface condition
- ### Carrier Operations & Management

- Organization & operation type
- Driver selection
- Fleet-based driver training
- Communications & dispatching
- Driver performance monitoring & evaluation
- Rewards & discipline
- Pay & benefits

Government Policies & Practices

- Driver qualifications & licensing
- Hours-of-Service
- Enforcement practices
- Information & education programs.

If you came upon a truck crash and wondered how it happened, you would probably not think about all the factors listed in the textbox. Instead, you would likely ask what driver error (mistake or misbehaviour) or other failure (vehicle, environmental) was the immediate or ‘proximal’ trigger of the crash. Examples include driving too fast, following too closely, failure to see another vehicle, falling asleep at the wheel, or vehicle brake failure. In the LTCCS, the term *Critical Reason* (CR) was used for proximal crash causes [4]. Most were driver errors of various types, but they also included vehicle failures and extreme environmental conditions like icy roads and wind gusts.

Figure 2 shows a conceptual crash timeline encompassing predisposing risk factors and proximal causes [1].

Risk factors set up a situation where driver errors or other failures are more likely to occur or to have greater consequences. Multiple risk factors can exist at the same time, and have compounding effects on total risk. For example, a driver with aggressive, risk-taking tendencies (driver risk factors), pulling a top-heavy load (vehicle risk factor), enters a sharp curve (roadway risk factor), is going too fast (proximal cause or Critical Reason), and rolls over (crash).

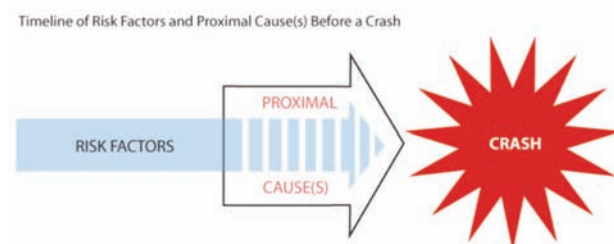


Figure 2. Timeline of risk factors and proximal cause(s) before a crash. Reprinted from [1]

Though simplistic and general, the above risk model views multiple risk factors as interacting in potentially complex ways. It does not seek a ‘root cause’ [5] but rather sees a multitude of interacting factors which can each raise or lower risk to various degrees. All of these set up conditions for a proximal error to trigger a crash. In the model, proximal causes are distinguished from risk factors by the fact that they are more discrete triggering behaviours or other events, as opposed to pre-existing driver, vehicle, or environmental conditions. The model is heuristic in that it frames analyses of crash and naturalistic driving data as well as safety interventions at the fleet level.

Differential driver risk

‘Metaprinciples’ of human nature and behaviour [6] include:

- individual differences: each person is physically and psychologically unique
- behavioural consistency: each person behaves relatively consistently over time and in different situations.

These two ‘metaprinciples’ are different sides of the same coin: people are different from each other, and these differences may permeate life. Many personal dimensions affect driving styles, performance, and behaviour. Driver individual differences are of great potential concern in CMV transport because of the high mileage (and, therefore, risk) exposure of many commercial vehicles and because of the high potential severity of their crashes. The *paradox of large truck safety* [1] is the fact that, even though long-haul trucks are generally driven safely and have generally low crash rates, there is a high premium on making trucks and their drivers safer. This is because of their inherent high exposure and crash severity risks. The same

principle applies to long-haul bus operations, with the added concern for commercial vehicle passengers as well as for the motoring public.

Studies of both commercial and non-commercial drivers consistently show that risk among drivers is neither random nor evenly distributed [1, 7]. Rather, within almost any group of drivers, some will show greater likelihood of involvement in at-fault incidents whereas most others will show relatively low involvement rates. With relatively infrequent events such as crashes, such variation *could* be due to chance alone. To distinguish true differences in underlying risk from variations due to chance, one needs more data. Naturalistic driving studies quantify individual risk by capturing many incidents, not just crashes. In these studies [8-9] trucks are instrumented with multiple cameras and sensors. Volunteer drivers drive them in regular operations for an extended period, typically several months. Driving data is recorded by an onboard computer, and incidents (e.g., a crash, hard braking, or other sharp manoeuvre to avoid a crash) are captured and analyzed. Comparing incident involvement to exposure allows researchers to quantify the relative risk (e.g., odds ratio) associated with any measured factor, including different drivers.

Figure 3 gives an example from a large truck naturalistic driving study conducted by the Virginia Tech Transportation Institute [9] and sponsored by the US Federal Motor Carrier Safety Administration (FMCSA). In the study, 95 drivers were rank-ordered by their frequency of involvement in at-fault (preventable) incidents. The average driver had about seven at-fault events. At the extremes, the worst driver had 43 while, at the other extreme, 18 drivers had *zero* at-fault incidents in several months of driving. When exposure (hours of driving) was compared to incident involvement, the worst 19% of drivers (i.e., those with the highest rates) were found to be associated with 53% of all observed at-fault incidents. The risk ratio for incident involvement versus exposure for the high-risk drivers versus the rest of the drivers was 4.9. In other words, hour-for-hour, the high-risk drivers were 4.9 times riskier than were other drivers.

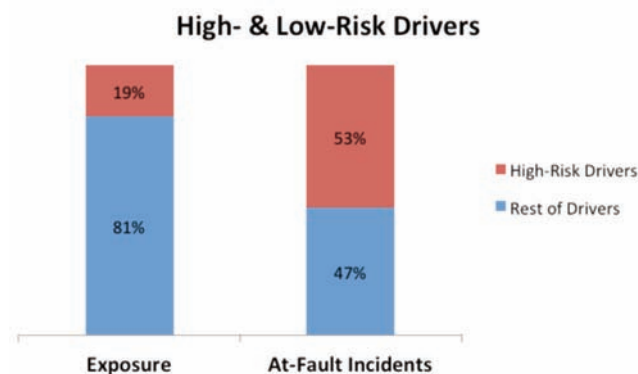


Figure 3. Exposure (hours of driving) and at-fault incidents for worst drivers and rest of drivers in truck naturalistic driving study. Data from [9]

A principal object of commercial driver selection for hiring, and assessment in general, should be to identify as many as possible of these high-risk drivers [2, 7]. They should be excluded from the fleet to *avoid* the risk that they create, or remediated (e.g., through training, rewards, or discipline) to *reduce* their risk to acceptable levels.

Naturalistic driving study results have their caveats [1]. They are not controlled experiments but rather detailed observations of driving in the real world where confounding factors may be operating. It is possible that some drivers are assigned more difficult routes or otherwise are exposed to greater risks than others. Also, few of the incidents captured are actual crashes. More typically, they are hard-braking or other sharp avoidance manoeuvres to avert a crash. No studies have been conducted over years of driving, but most of the study time periods have been long enough (e.g., two months) to reliably discern individual driver patterns. While empirical data on the long-term stability of driver risk is hard to come by, most carrier safety managers and other experts believe that relative CMV driver risk is generally consistent from year to year [7].

Distribution of 51 ESC activations among 18 drivers:
16, 16, 10, 3, 2, 2, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0.

More recent data corroborating differential risk among commercial drivers comes from a Field Operational Test [10] of Electrically Controlled Braking Systems (ECBS) and Electronic Stability Control (ESC). These systems were installed on 18 long-haul trucks, each with a dedicated driver. After a six-month baseline period, each driver drove his or her ECBS/ESC-equipped vehicle on daily runs of roughly 500 miles for another six months. ESC activations occurred when a vehicle was experiencing yaw or roll instability indicative of potential loss-of-control. During the six-month test period there were a total of 51 ESC activations among the 18 drivers and trucks, for an average of about three activations per driver. There was only one 'average' driver however. Instead, the distribution of ESC activations (indicative of potential loss of vehicle control) was as shown in the textbox. Three drivers with 16, 16, and 10 events accounted for 42 of the 51 events (82%). The other 15 drivers together accounted for 9 events (18%). These data further demonstrate differential risk among drivers. They also attest to the value of employing Onboard Safety Monitoring (OBSM) of driver behavior along with prevention systems like ESC to record system sensor data and activations for driver evaluation and remediation.

What enduring driver factors underlie differential driver risk? All of those listed in the textbox can contribute. No one has sorted out the relative influence of various factors quantitatively, but it appears that driver personality and risk attitudes are most central [1-2, 7, 11]. In contrast, variations in psychomotor skill seem to affect driving safety only in extreme cases [2]. Medical conditions like obstructive sleep apnea and cardiovascular illness cause performance failures triggering crashes, but many more

crashes are triggered by misbehaviours like speeding and tailgating [4]. The general rule in driving safety is ‘Behaviour trumps performance.’

Roadway, traffic and operational risk

A survey mentioned earlier [2, 3] found roadway and traffic factors to be regarded by carrier safety managers and other experts as having less influence on crash risk than do driver factors. Naturalistic driving data suggest that the effects are comparable, however. That is, a ‘bad’ road raises crash risk about as much as a ‘bad’ driver does. In the same naturalistic driving study described above [9], analysts classified the road type in each incident video and in randomly selected driving periods. The random periods captured overall exposure to the two road types. Only 10% of tractor-semitrailer driving was on undivided roadways, but 38% of incidents occurred on them. This is shown in Figure 4. Here the risk ratio was 5.3. In other words, driving on undivided roads had 5.3 times the incident risk of driving on a freeway or other divided road. This is not too surprising when one considers the risk differences between divided and undivided roads. On divided roads, vehicles are all traveling in the same direction at relatively uniform speeds. On undivided roads, there usually are traffic signals, stops and starts, crossing vehicles, turning vehicles, pedestrians, many opportunities for distraction, and little margin-of-error [3]. Undivided roads probably carry even greater relative risks for trucks than for cars because of these small margins of error.

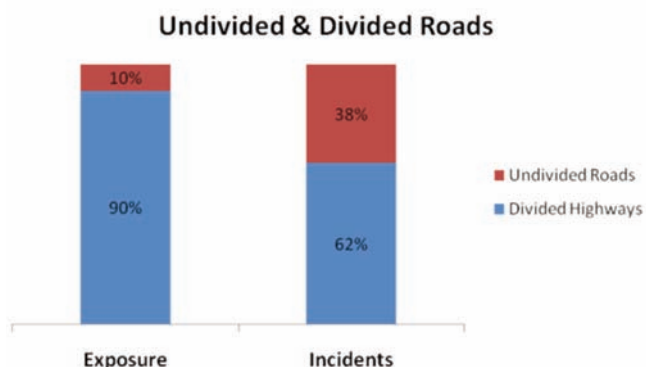


Figure 4. Exposure (percent of randomly selected time periods) and incidents for undivided and divided roadways in truck naturalistic driving study. Data from [9]

The same analysis approach finds that dense traffic, compared to light-to-moderate traffic, has very similar relative risk effects. Driving in work zones elevates relative risk even more. In the same study [9], 0.7% of driving was in work zones, but 6.0% of incidents occurred there - an odds ratio of 8.5. Work zone risks were also highlighted by the LTCCS, where 13% of all its crashes (all with serious injuries or fatalities) occurred in work zones [4]. Like most crash investigation studies, the LTCCS had no accompanying exposure data, but if one accepts the

naturalistic driving exposure estimate of 0.7%, the resulting estimated relative risk of serious truck crashes in work zones compared to normal roads is more than 20.

From an operational perspective, risk avoidance means planning truck trips to minimize exposure to undivided roads, dense traffic, work zones, and similar higher risk locations. Generally speaking, such risk avoidance strategies are also operational *efficiencies*; that is, they make transport faster as well as safer. Other CMV operational efficiencies with apparent safety benefits include reducing empty backhaul ('deadhead') trips, minimising loading/unloading delays, optimising routing and navigation, optimising travel times (with evening travel appearing to be best), assigning familiar routes to drivers, avoiding adverse weather, and using higher productivity (i.e., larger) vehicles when possible [3]. In general, efficiency means safety, as long as 'efficiency' is achieved by proactive planning rather than by applying pressures for faster speeds and tighter schedules [3, 12].

Most carrier safety interventions may be considered risk reductions – they are efforts to improve the safety performance of individual drivers and vehicles. This includes proven methods like driver training, rewards and discipline, safety technologies on vehicles, and sound maintenance. Others may be conceived as risk avoidance, that is, proactively reducing or eliminating a risk factor. Differential driver risk is one ever-present concern in risk avoidance. Improved driver selection, with follow-up assessments of employed drivers, is paramount. Roadway and traffic risks can be avoided through proactive planning to make operations more efficient and decrease exposure to known travel hazards.

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The influence of speed on concrete agitator vehicle stability

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Abstract

Concrete agitator vehicles have a relatively high centre of gravity and are therefore exposed to a risk of rollover. The stability of concrete agitator vehicles is also affected by the movement of the concrete in the rotating barrel. This report describes a study into the influence of speed and load on concrete agitator vehicle stability, using vehicle testing and computer based modelling.

It was found that (a) a rotating barrel decreased performance of the concrete agitator vehicles in static rollover threshold and load transfer ratio performance measures when compared to a stationary load, and (b) speed, modelled with the vehicle travelling through a roundabout, had a significant influence on the likelihood of rollover.

Keywords

Rollover, Stability, Heavy vehicle, Truck

Introduction

As with most heavy vehicles, the concrete agitator vehicle has a relatively high centre of gravity (COG) and is therefore exposed to a risk of rollover. The stability of the concrete agitator is also affected by the movement of the concrete in the rotating barrel. Holcim, a supplier of cement and aggregates, wished to assess the stability of their concrete agitator vehicles and investigate the effects of the moving concrete load in order to maximise the roll stability of their concrete agitator vehicles. This would minimise the chance of rollover and thus improve the overall safety of the vehicle fleet, with the aim to meet the company's commitment to zero harm.

The stability of a rigid vehicle is dependent upon many factors. Some of these factors are inherent in the cab chassis as supplied by the manufacturer, while others depend on the body fitted or use of the vehicle during operation, and others on the load condition.

The key factors that contribute to vehicle stability are:

- centre of gravity height
- mass
- load distribution
- suspension properties
- axle track width
- chassis and mounting restraint and rigidity
- characteristics of load (i.e. moving load)

Holcim engaged ARRB Group Ltd (ARRB) to conduct an investigation into the stability of their concrete agitator vehicles. As part of the investigation, ARRB was engaged to:

- perform static testing of a concrete agitator vehicle with the barrel rotating (completed for dry, medium and wet concrete mixes)
- determine the SRT (Static Rollover Threshold) via computer simulation
- conduct LTR (Load Transfer Ratio) analysis for a concrete agitator vehicle travelling through a roundabout via computer simulation.

Method

Static testing of vehicle with barrel rotating

The static testing of the concrete agitator vehicle was conducted at the Holcim batching plant in Bayswater, Melbourne, in

November 2006. The aim of the testing was to gain a better understanding of the influence that concrete moving in the rotating barrel has on the stability of the vehicle. This was achieved through observation and by acquiring data from sensors fitted to the vehicle.

The test vehicle was an Iveco Acco 8x4. Observations of the cement mixture moving inside the barrel were made from an overhead gantry. The vehicle was fitted with sensors to measure longitudinal acceleration, lateral acceleration, vertical acceleration and roll rate. The data acquisition system comprised a Panasonic CF-29 Toughbook, National Instruments Daqpad 6020E interface and Labview data logger software (Figure 1).



Figure 1. Instrumentation fitted to test vehicle

Tests were conducted using the following concrete mixes:

- '10 slump' – a dry mix often used to form kerbs
- '40 slump' – a medium mix often used for driveways
- '80 slump' – a wet mix often used for garage floors.

Tests were conducted with the engine speed between 600-1500 rpm and the barrel rotating at approximately two revolutions per minute. Two barrel revolutions per minute is typical of the rotation speed experience when driving on road.

With the barrel rotating, data was logged for a period of 1-2 minutes at a sample rate of 100 Hz. The data acquired during testing provided a quantitative measure of the forces transferred from the rotating barrel to the vehicle chassis and suspension.

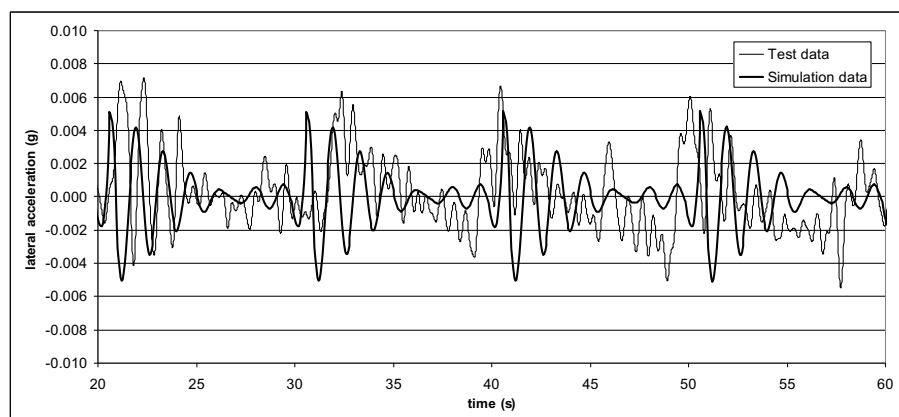


Figure 3. Calibration of vehicle model

This data was then used to determine the 'worst case' concrete mix, where the mix would be most detrimental to the rollover stability of the vehicle.

Vehicle modelling

Holcim selected a 10x4 concrete agitator vehicle for assessment via simulation. The vehicle properties were based on information supplied by the vehicle manufacturer, including vehicle centre of gravity (COG) height, mass, load distribution, suspension properties and vehicle dimensions.

The vehicle was modelled at maximum axle weights, being 11 tonnes on the steer axle group and 20 tonnes on the drive axle group.

A computer model of the 10x4 vehicle with rotating barrel was created and the data collected during testing of the 40 slump (medium) mix was used to characterise the movement of the load in the rotating barrel. ARRB completed this assessment using modelling techniques developed in-house and validated in numerous field tests and comparative studies over the last 12 years.

An example of validation of the computer model against test data can be seen in Figure 2, where there is a close relationship between the yaw rates measured during a field test of an innovative multi-combination vehicle and the yaw rates determined in the simulations.

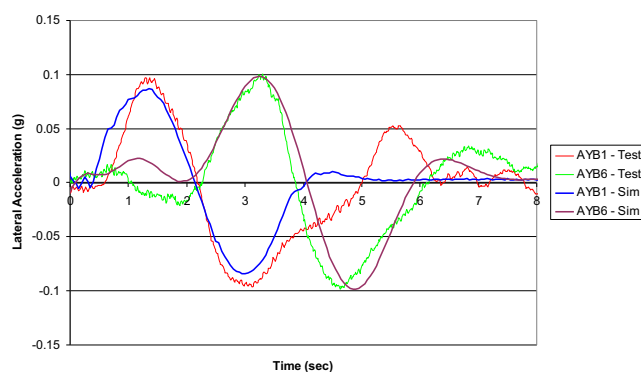


Figure 2. Example simulation validation

The behaviour of the '40 slump' (medium) mix concrete load in the rotating barrel was modelled using computer simulation and compared to the test data. The input parameters of the model were calibrated against the test data and adjusted to closely match the behaviour measured during testing. Figure 3 shows an overlay of the simulation and test data outputs.

Simulations were completed for the 10x4 vehicle (subject vehicle) loaded to maximum axle weights with a rotating barrel at 2 rpm and a moving concrete load. The characteristics of the moving concrete load were based on the '40 slump' test data. The performance of this vehicle was compared to the 10x4 vehicle with the same dimensions and properties except that the barrel and load were stationary at all times (i.e. the barrel was not rotating and there was no slosh effect from the concrete load).

Static rollover threshold

Simulations were completed to determine the Static Rollover Threshold (SRT) of the vehicle as well as the Load Transfer Ratio (LTR) when negotiating a roundabout.

A common measure of rollover stability is SRT which is the level of lateral acceleration that a vehicle can sustain without rolling over during a turn. The SRT is expressed as a fraction of the acceleration due to gravity in units of 'g', where 1 g is an acceleration of 9.807 m/s^2 corresponding to the force exerted by the earth's gravitational field. High values of SRT imply better resistance to rollover and hence better stability.

ARRB completed the SRT analysis in accordance with the National Transport Commission (NTC) Performance Based Standards (PBS) Rules (2008). The nationally accepted performance target for SRT, adopted under the NTC's PBS is 0.35 g for heavy vehicles and 0.40 g for buses and dangerous goods vehicles. The value of 0.40 g roughly equates to the 62 degree stability angle required of dangerous goods vehicles. The result of the SRT analysis, therefore, provides a measure of the vehicle's roll stability which can be directly compared against a recognised national standard. The SRT analysis modelled the subject vehicle with a moving load as well as a stationary load.

As the proposed vehicle is still within prescriptive dimension limits for a rigid truck, there is currently no enforced stability requirement that this vehicle must satisfy.

Load transfer ratio

Load Transfer Ratio (LTR) is a measure of the amount of load transfer from one side of a vehicle to the other in a dynamic manoeuvre. An LTR of 0.0 indicates straight line travel (i.e. no load transfer), while an LTR of 1.0 indicates that all of the vehicle's mass is supported by the wheels on one side (i.e. complete wheel lift-off on the other side, rollover is imminent).

An LTR of 0.6 is considered, on the basis of ARRB's experience, to be the maximum safe level while travelling around a roundabout, bend or corner, which means that 60% of the vehicle mass usually carried by the inside tyres when travelling around a corner has been transferred to the outside tyres.

ARRB completed a LTR analysis for the subject vehicle negotiating a roundabout. ARRB selected road geometry suitable for assessing the vehicle stability during a manoeuvre, which would likely be encountered during normal driving conditions. The road geometry selected for the LTR analysis was the roundabout located at Baxter-Tooradin and Dandenong-Hastings roads and represents typical roundabout road geometry. The roundabout comprises varying negative crossfall with an average value of 2% and an approximate horizontal radius of 20 m (to road centre line). This road geometry can result in a vehicle rollover if negotiated at high speed. A 3D environment that accurately represents the actual road surface (including crossfall, elevation, curvature and position of the road) was created. Figure 4 shows an example of a 3D environment created from the measured road geometry data.

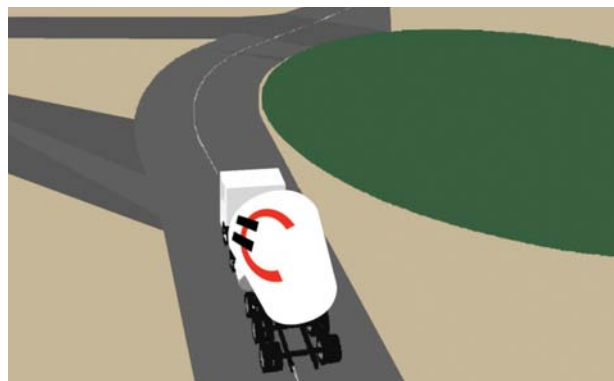


Figure 4. 3D computer model of roundabout road geometry

The vehicle's approach and negotiation of the roundabout were analysed using computer simulation. The speeds simulated ranged from 25 to 35 km/h. For each of the speeds simulated, the LTR was recorded during the manoeuvre. Simulations were completed for both the subject vehicle (moving load) and baseline vehicle (stationary load).

Results

Static testing of vehicle with barrel rotating

From the static testing of a vehicle with the barrel rotating at a speed of 2 rpm, the effect of the rotating barrel and moving concrete load on vehicle roll stability was quantitatively measured for three variations in concrete mixes. It was shown that:

- The effect of the rotating barrel and moving concrete load on vehicle roll stability was quantitatively measured for three variations in concrete mixes.
- The '40 slump' (medium) mix resulted in the highest recordings of body roll rate.
- The '10 slump' (dry) mix resulted in the next highest recordings of body roll rate.
- The '80 slump' (wet) mix resulted in the lowest recordings of body roll rate.
- The '40 slump' (medium) mix was considered to be the least stable load condition.

- The magnitude and frequency of '40 slump' (medium) was determined and the test data deemed suitable for simulating and assessing vehicle stability when driving on road with the least stable load condition (worst case scenario).

Static rollover threshold

Table 1 shows the results obtained from the simulation for the 10x4 concrete agitator vehicle.

Table 1. Results of SRT simulation

Vehicle	PBS Performance target	Performance achieved
Subject vehicle		
(with '40 slump' moving load) ≥ 0.35 g		0.36 g
Baseline vehicle		
(with stationary load) ≥ 0.35 g		0.38 g

The 10x4 concrete agitator vehicle simulated with a rotating barrel and moving load achieved a SRT value of 0.36 g and 0.38 g with a stationary load. The simulation results indicate that the 10x4 vehicle with a rotating barrel and moving load is less stable than if the barrel and load were stationary.

Both vehicles achieved a SRT value that satisfies the NTC's PBS target of ≥ 0.35 g.

Load transfer ratio

Figure 5 shows the variation of LTR with distance travelled at various speeds. The LTR plot exhibits minor variation during the vehicle's approach to the roundabout (Section A) due to small variations in crossfall on this section of the road. The LTR then increases to a peak value as the vehicle negotiates the

apex of the curve (Section B), then falls as the vehicle exits the roundabout (Section C).

When travelling at 25 km/h the subject vehicle reaches a peak LTR of approximately 0.5 as the vehicle negotiates the bend then reduces to less than 0.1 as the vehicle exits the roundabout. This result indicates that 25 km/h is a safe speed for this vehicle to negotiate this roundabout.

When travelling at 30 km/h the vehicle exceeds the recommended safe LTR of 0.6, reaching a peak of 0.75 for the subject vehicle (moving load) and 0.70 for the baseline vehicle (stationary load). The LTR then reduces to less than 0.1 upon exiting the roundabout. This result indicates that negotiating this roundabout at a speed of 30 km/h puts the vehicle at risk of rollover. At this speed, the difference between the subject and baseline vehicle is more obvious, with the 10x4 vehicle with the rotating barrel and moving load at a greater risk of rollover.

When travelling at 35 km/h the subject reaches a LTR of 1.0 and subsequently rolls over. The baseline vehicle (stationary) does not rollover, but is highly unstable reaching a peak LTR greater than 0.9.

Discussion

The behaviour of the concrete moving inside the barrel was observed and recorded during the testing process using three different slump types, being dry ('10 slump'), medium ('40 slump') and wet ('80 slump').

With the barrel rotating at approximately two revolutions per minute – simulating the typical barrel rotation speed of the vehicle on the road – data was logged to provide a quantitative

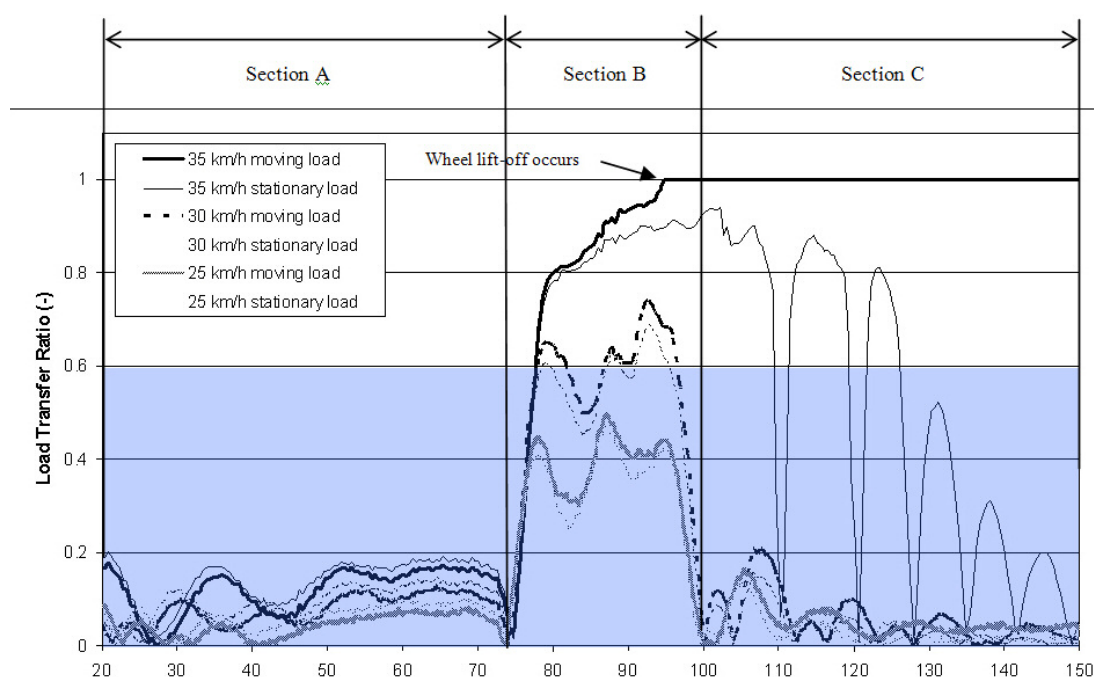


Figure 5. Load Transfer Ratio against distance travelled

measure of the forces transferred from the rotating barrel to the vehicle chassis and suspension.

The following observations were noted:

- Large masses of the 40 mm slump mix were observed to stick to and climb up the inside of the barrel then fall in slabs as the concrete mass approached the top of the barrel, and resulted in the highest recordings of body roll rate.
- The 10 mm slump mix did not bind together nor climb as high inside the barrel and tended to crumble and fall and resulted in the next highest recordings of the body roll rate.
- The 80 mm slump mix did not stick to the inside of the barrel and exhibited a self-levelling behaviour, and resulted in the lowest recordings of body roll rate.

The SRT analysis showed that having a moving load destabilised the vehicle and resulted in a poorer SRT performance than the same vehicle with a stationary load. While the vehicle under both loading conditions was able to meet the required performance level, this indicates that the moving load decreases the stability of the vehicle, and makes the vehicle have a higher likelihood of rollover.

From the LTR analysis using the simulated model with a rotating load and the dimensions of the particular roundabout it was observed that:

- The vehicle was able to negotiate the simulated path through the selected roundabout at 25 km/h* and remain below the recommended LTR of 0.6 (Table 2).
- At only 5 km/h faster (30 km/h), the vehicle exceeds the recommended safe limit. This result indicates that negotiating this roundabout at 30 km/h momentarily puts the vehicle at risk of rollover.
- At another 5 km/h faster (35 km/h), the vehicle reaches a LTR of 1.0 and subsequently rolls over.

Table 2. Effect of speed on peak LTR through a roundabout

At speed of 25 km/h	5 km/h faster (+5 km/h total)	5 km/h faster (+10 km/h total)
Below LTR of 0.6	Above safe limit	Truck rolls over

** It should be noted that a safe speed is very variable and is dependent upon the environment (such as crosswinds), the load characteristics and the truck type.*

Table 3. Effect of load condition on peak LTR through a roundabout

Load case	At speed of 25 km/h	5 km/h faster (+5 km/h total)	5 km/h faster (+10 km/h total)
Subject vehicle (stationary load)	0.47	0.70	0.95
Baseline vehicle (moving load)	0.50	0.75	1.00

The LTR analysis was also able to determine the effect that the moving load had upon the stability of the vehicle as it passed around the roundabout (Table 3). The LTR increased

(decreased in performance) when the moving load was modelled over the case where a stationary load was modelled, further indicating that a moving load and rotating barrel will destabilise a vehicle and increase the risk of rollover.

Conclusion

Simulations were completed for a 10x4 concrete agitator vehicle loaded to maximum axle weights with a rotating barrel at 2 rpm and a moving concrete load. The characteristics of the moving concrete load were based on the '40 slump' test data. The performance of this vehicle was compared to the 10x4 vehicle with the same dimensions and properties except that the barrel and load were stationary at all times (i.e. the barrel was not rotating and there was no slosh effect from concrete load).

ARRB completed the SRT analysis in accordance with the Performance Based Standards Rules (NTC 2008).

From the SRT analysis it was concluded that:

- The vehicle achieved a minimum SRT value of 0.36 g (rotating barrel and moving load) and 0.38 g (stationary load - simulated with the barrel not rotating and no slosh effect from concrete load).
- This result means the SRT value of the 10x4 subject vehicle is better than the recommended ≥ 0.35 g and therefore satisfies the SRT requirements of PBS (NTC 2008).
- As the proposed vehicle is still within prescriptive dimension limits for a rigid truck, there is currently no enforced stability requirement that this vehicle must satisfy.

ARRB completed a LTR analysis for the subject vehicle negotiating a roundabout. ARRB selected road geometry suitable for assessing the vehicle stability during a manoeuvre, which would likely be encountered during normal driving conditions and represents typical roundabout road geometry. The roundabout comprises varying negative crossfall with an average value of 2% and an approximate horizontal radius of curvature of 20 m. This road geometry can result in a vehicle rollover if negotiated at high speed.

From the LTR analysis it was concluded that:

- The vehicle with a stationary load (simulated with the barrel not rotating and no slosh effect from the concrete load) was able to negotiate the selected roundabout at a higher speed than the vehicle with a rotating barrel and moving load.
- The rotating barrel and moving load reduces the stability of the 10x4 subject vehicle and puts it at a higher risk of rollover.
- The subject vehicle is able to negotiate the simulated path through the selected roundabout at 25 km/h and remain below the recommended load transfer ratio of 0.60.

The assessments show that some small variations in slump type, load condition or speed can result in significant changes in performance, and most importantly, regardless of the vehicle or the load, too great a speed through a bend, roundabout or corner will result in the vehicle rolling over.

It does not take much to cross the line of safety as the road variables such as road camber and crosswinds as well as vehicle parameters such as slump type can change frequently. Drivers need to adopt a very conservative speed - less than they think is the maximum safe speed - so as to maintain a greater safety margin when approaching, entering, driving through or departing a bend, roundabout or corner.

The findings of this safety study have been used by Holcim to produce a training video. The video aims to provide drivers with a better understanding of the influence of speed and moving loads on vehicle stability. Subsequently, videos relevant to other types of truck have been produced - all with the aim of improving understanding and reducing the risk of truck rollovers.

Acknowledgements

This safety study was a collaborative effort between ARRB Group and Holcim. For the purpose of the study, Holcim made available their facilities, staff, vehicles and drivers and funded the safety study to be completed via the testing and simulation methods employed by ARRB Group.

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Australian major accident investigation report on 2009 NTI Data: Heavy vehicle losses > \$50,000

by Owen P. Driscoll, National Manager – Industry Relations, National Transport Insurance, Director – TruckSafe Pty Ltd – Australian Trucking Association, National Coordinator – National Truck Accident Research Centre

Introduction

Fundamentally, truck crash research is a prerequisite for achieving sustainable improvements in road safety, with benefits not only for customers but for all transport operators who share the road.

This report continues a unique series of longitudinal studies involving the tracking of Australian heavy vehicle crashes where National Transport Insurance (NTI) is the insurer, since 1998. These studies are undertaken every two years by the National Centre of Truck Accident Research.

NTI provides insurance, risk appraisal, claims and accident management services to the road transport and earthmoving industry. It currently insures more than 131,000 items of plant and equipment having an insured asset value of \$9.4 billion. Since 2002, NTI has settled 41,000 notified losses (per item) with claims payments exceeding \$570 million (AUD).

The research into major losses in 2009 follows quantitative studies completed on major truck crash incidents reported during 2003, 2005 and 2007. Since the initial study conducted in 2003, NTI-insured equipment numbers has grown by 48% whilst major crashes over (>) \$50,000 have increased marginally by 7%. There was a 1% decrease in the number of major incidents reported, when compared to those investigated for the prior period, the average financial loss per incident increased by 6.2% to \$136,472. For the duration of the 2009 period, 323 major incidents were reported at a total cost of \$44 million.

Methods

This research focuses on primary data specifically reviewing major heavy truck crashes managed by the National Claims

Centre. Such incidents have an aggregate cost greater than (>) \$50,000. The loss per incident includes property damage, crash scene repatriation, load transshipment, salvage, recovery and towing outlays. Losses in relation to freight on-board and personal injury are not included. This research concentrates on heavy vehicle accidents in the hire and reward freight sector with vehicles having a payload exceeding five tonnes where National Transport Insurance (NTI) is the insurance underwriter.

Findings

In terms of portfolio growth, during 2007, NTI insured 113,526 items that increased to 120,567 by the end of 2009. Representing a growth of 6.2% in numbers, the crash frequency rate, in relation to major incidents > \$50,000, improved to 2.7 incidents per 1000 units. Figure 1 shows rates in years 2003, 2005, 2007 and 2009.

Information compiled and analysed in the 2009 study found the worst day of the week to be Monday with 18.9% of major incidents occurring within this 24 hour cycle (Figure 2). This was slightly down on prior results; nevertheless, Mondays and Tuesdays still accounted for 37.5% of crashes. This is consistent with earlier studies.

Otherwise, excluding Saturdays and Sundays, crash rates progressively decreased during each week before a marginal increase on Friday. Irrespective of the fact that for various freight tasks the working week may commence on different days, it could be argued that there is a correlation with a driver's fitness for duty, or lack thereof, where they have not worked and not had sufficient rest throughout the weekend.

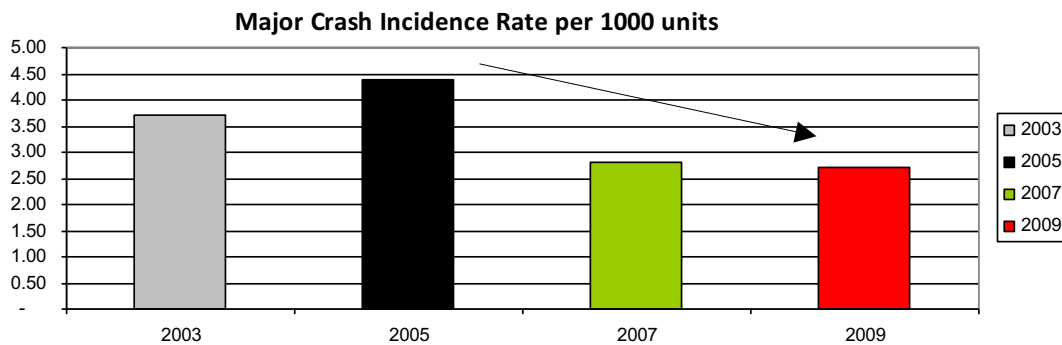


Figure 1. Crash rates of NTI-insured vehicles per 1000 units

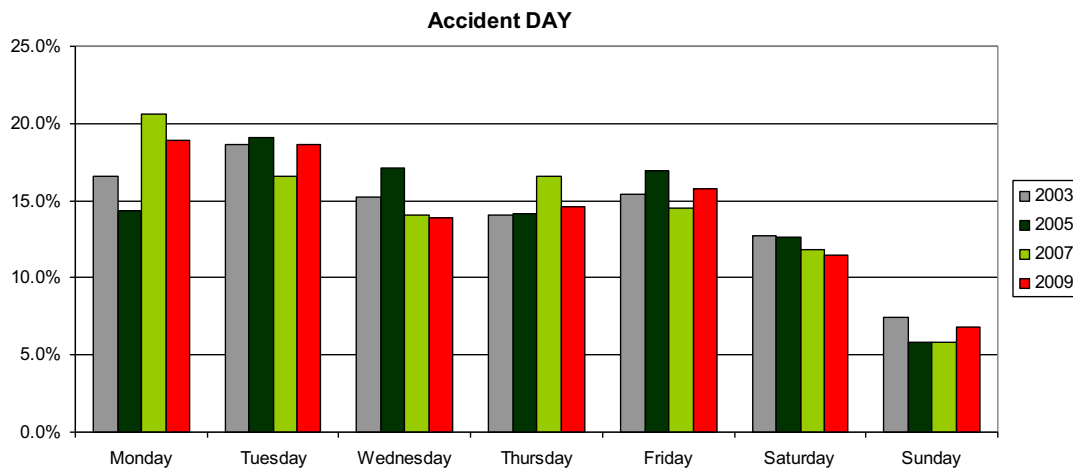


Figure 2. Per cent of crashes by day of week

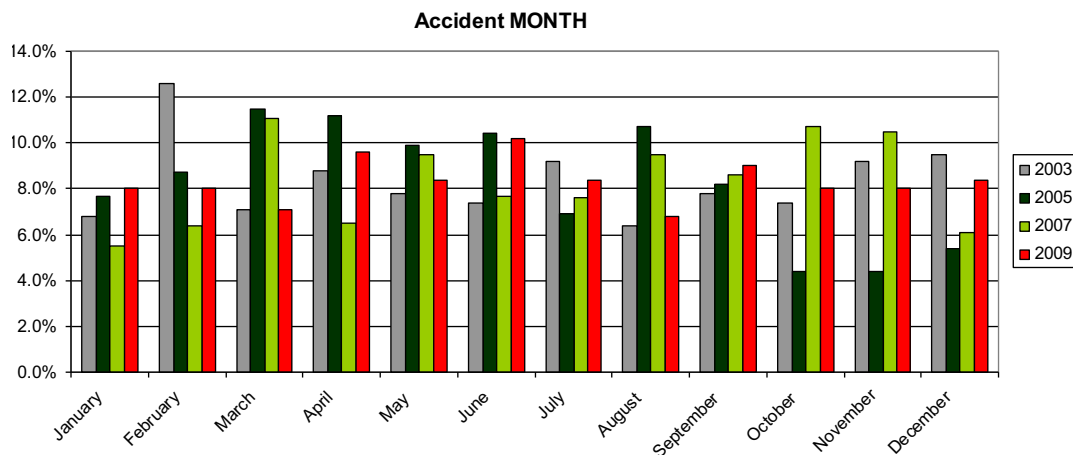


Figure 3. Crashes by month for years 2003, 2005, 2007 and 2009

It was also found that of single vehicle accidents (SVAs), 54.5% occur during the 3-day period Monday to Wednesday, with 27.5% between midnight and 0700. The question of increased pressure on the freight task during this period of the week is relevant.

A further investigation with regard to driver fatigue and day of week is detailed later in this report.

Data reviewed in the 2009 study found that the worst month was June with 10.2% of major incidents occurring in this

period. Further, April incidents grew substantially when compared with previous studies (Figure 3). Unseasonal autumn weather conditions, particularly in central and eastern regions may have contributed to a marginal increase in crash incidents during this period.

Whereas in the past, accidents increased noticeably during the months of October through November, this was not apparent in the 2009 research.

Information processed and analysed in the 2009 study found yet again that the worst time of day was between 11.00 – 14.00 hours. This was consistent with findings in the 2005 and 2007 reports although these results differed from the 2003 study that found the predominant period to be between 04.00 – 06.00 hours. Taking into account all studies, it was evident in the 2009 research that incidents between the hours of midnight and 06.00 fell significantly.

It is further noted that there was a spike between the hours of 15.00 and 18.00 with fewer incidents reported between 20.00 and midnight.

Indisputably, the research consistently finds that most major crashes occur when most traffic is using the network. Further reference to the impact of fatigue and crash times is made later in this report.

Research into major incidents in 2009 again noted that New South Wales continued to dominate major crashes (36.5%), reporting 36.5% of crashes. However, this was lower than the 2007 result (30.7%) which had been an improved result on 2005 (35.4%) and 2003 (43.1%). Arguably the most recent research is

a more indicative result of the NSW performance. However, 33.8% of road freight travels through or within NSW [1] thus putting the result into perspective. Statistically, the results for Queensland & WA result remained unchanged, whilst major incidents had decreased in Victoria, Tasmania and the ACT. South Australia experienced a marginal increase in major truck crashes. Figure 4 overlays the amount of freight carried through each state and territory, with percentages of crashes occurring in each state or territory.

With respect to crash location, the 2009 research highlights a worsening situation on Australia's National Highway 1. In earlier published studies, one in six major truck crashes had taken place on this segment of the network whereas this recent research concluded that almost 23% of major crash incidents occurred on the national highway. The previous study in 2007 identified an improvement on the Pacific Highway NSW; however, that outcome was not sustained, with 2009 showing an increase in major truck crashes in this research period (Figure 5).

It is noteworthy that losses on the Hume Highway have dropped substantially since 2003. No doubt this can be attributed to the duplication of the Hume in Victoria and more

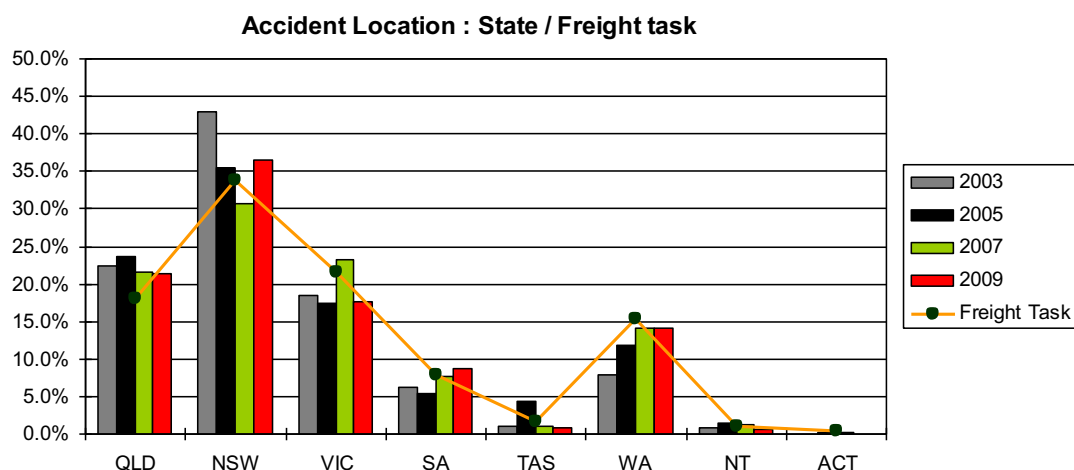


Figure 4. Crashes and freight movements by state

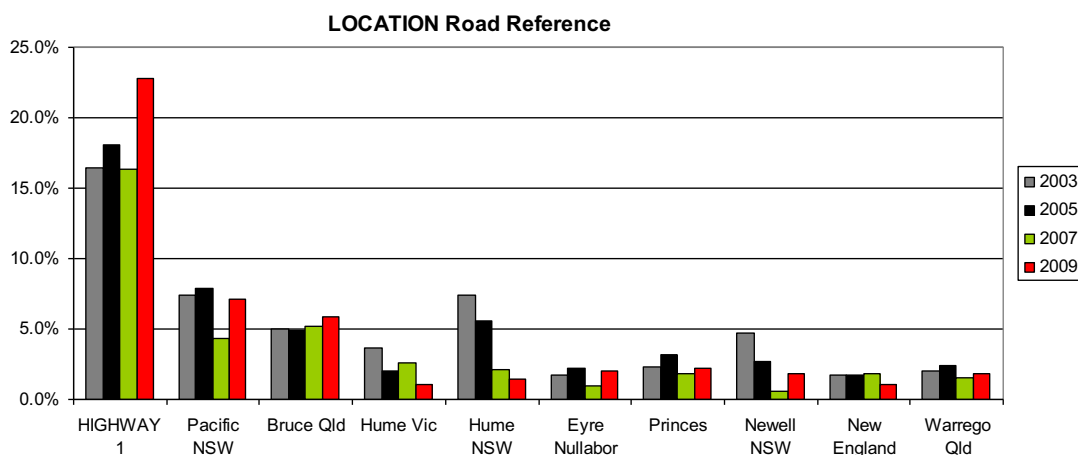


Figure 5. Location of crashes by highway names

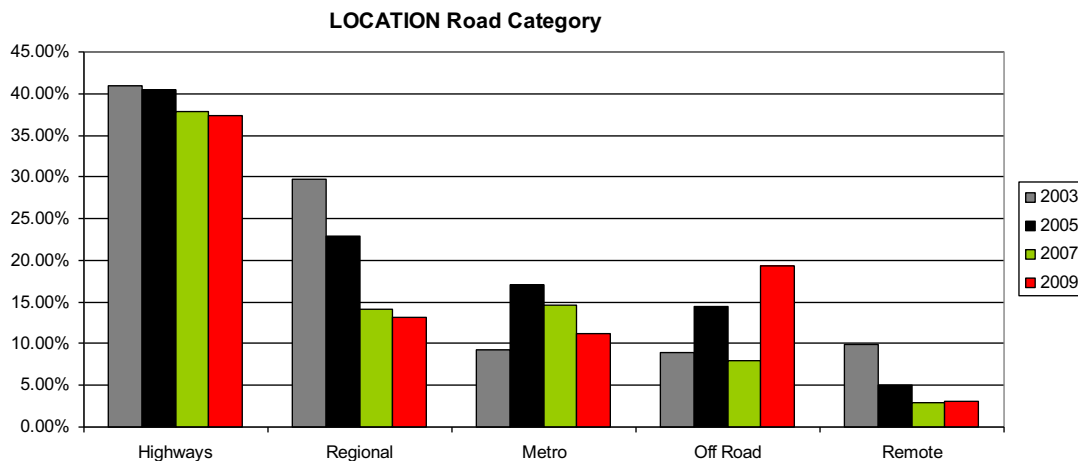


Figure 6. Location of crashes by road category

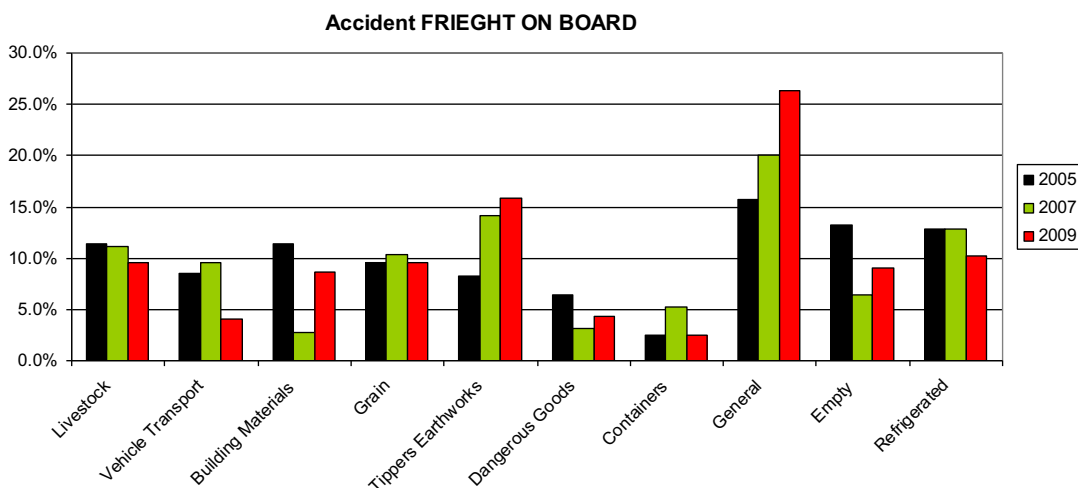


Figure 7. Crashes by freight carried

recent works from Wodonga to Woomargama, Holbrook, Kyemba, Gundagai and Coolac in NSW. Queensland's Bruce Highway experienced no improvement and remains as one of the most dangerous highways on the national network for all road users.

Overall, 37% of major crash incidents occurred on designated highways with improved results in metropolitan, regional and remote areas (Figure 6). The newest concern is that of accidents which have been identified as 'off road' and therefore outside the ongoing monitor of road enforcement agencies. Such losses were associated with vehicle theft, malicious damage or fire, food processing installations, road works or mine sites.

The 2009 research found that vehicles with general freight on board at the time of loss accounted for 26% of major incidents. There was a marginal improvement in grain haulage and livestock each of which accounted for 9.6% of major truck crashes (Figure 7).

The crash rate of bulk tippers, specifically working locally on earthworks, increased to 15.8% of major incidents. This result is up from 5.6% in 2005 and is evidence of the expanding fleet in metropolitan operations. Refrigerated goods and car/carrier

hauliers, however, showed improved results.

Vehicle configurations, as shown in Figure 8, were introduced into NTP's research into major incidents in 2005. Such criteria were appropriate given the expected growth in the Australian freight task with an escalation in the size of articulated trucks and the augmented uptake of larger articulated truck combinations leading to a higher utilisation of multi-combination equipment. Factors contributing to the growth in the road freight task include improvements in inter-urban road infrastructure, increased demand in time-sensitive freight services and increased average vehicle carrying capacity.

The freight task (excluding rigid vehicles), based upon (articulated) loaded tonne-/km travelled, is shared between semi-trailers carrying 38% of all (artic) freight, with B-doubles carrying 46% and the rest being transported by roadtrains and an assortment of multi-combination units [2].

The share of freight carried by B-doubles continues to grow at 2.2% per annum [3]. The number of B-doubles has increased substantially since 2000, but their average annual kilometres have not increased at the same rate [4].

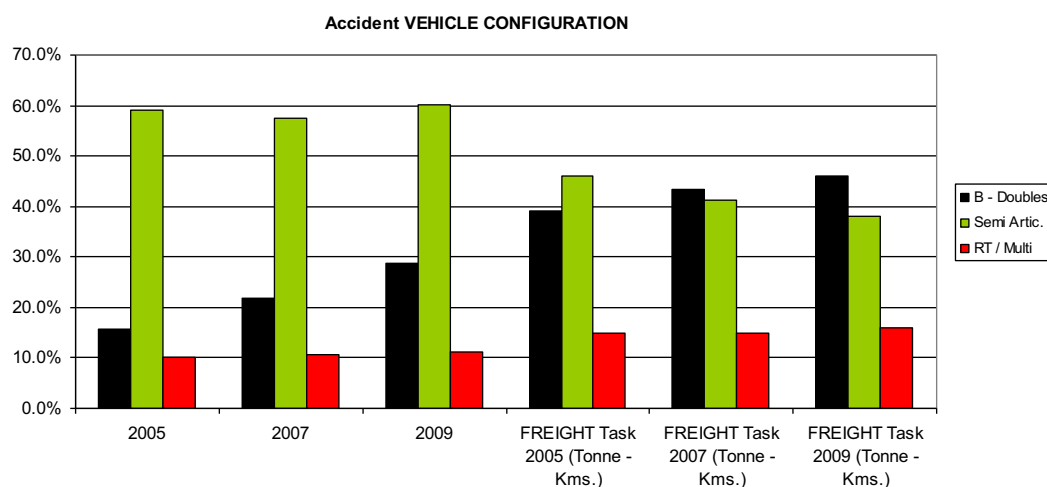


Figure 8. Crash percentages by vehicle configuration

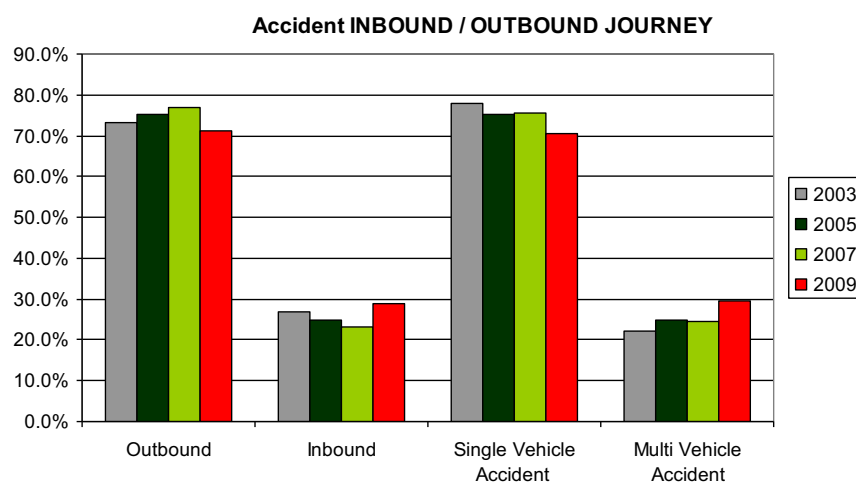


Figure 9. Crashes by inbound and outbound journeys, and by single and multi-vehicle crash

In 2009, semi-trailers were disproportionately over-represented with 60.1% of major incidents. This result has marginally worsened since the prior study irrespective of the fact that the freight task in this configuration has decreased to 38%. As previously reported, this result is to be expected given the fact that in many instances, this configuration operates on the worst of the network, with ageing equipment and drivers with less experience.

Importantly, with market pressure for higher capacity equipment, the result again confirms that the larger the vehicles, the safer they are. B-doubles now carry 46% of freight and accounted for 28.8% of major truck crashes. This followed the 2007 result where B-doubles were better performers with 21% of losses. This of course can be attributed to the fact that B-doubles are newer, better-maintained vehicles, with experienced and highly-trained drivers using the best of the road network.

Research into the aspect of whether a journey is inbound or outbound from home-port assists with fatigue management and provides indicators of the general health and wellbeing of drivers during the course of their work program (Figure 9).

Confirming past studies, it has again been established that a high proportion of crashes in 2009 occurred on the outbound leg (71.2%). Historically, the vast majority of severe incidents occur on outbound trips and, ironically, not on the return journey where the expectation would be that the driver has become fatigued during the journey.

Given that such incidents are found to occur on outbound legs, from a risk management perspective the driver must be required to satisfy management that he or she is 'fit for duty' at the commencement of the task. Additionally, stress created at the commencement of the trip through inefficient loading practices, late departures and unachievable time slots ultimately leads to driver fatigue. It is to be expected that the 'Chain of Responsibility' legislation will influence this current result.

Yet another indicator that fatigue influences major crash incidents is that of research findings into single vehicle accidents. Again it is noted in Figure 9 that seven out of ten major truck crashes are incidents where no other vehicle was involved. The 2009 result is an improvement on previous results; however, there was an increase in multi-vehicle incidents.

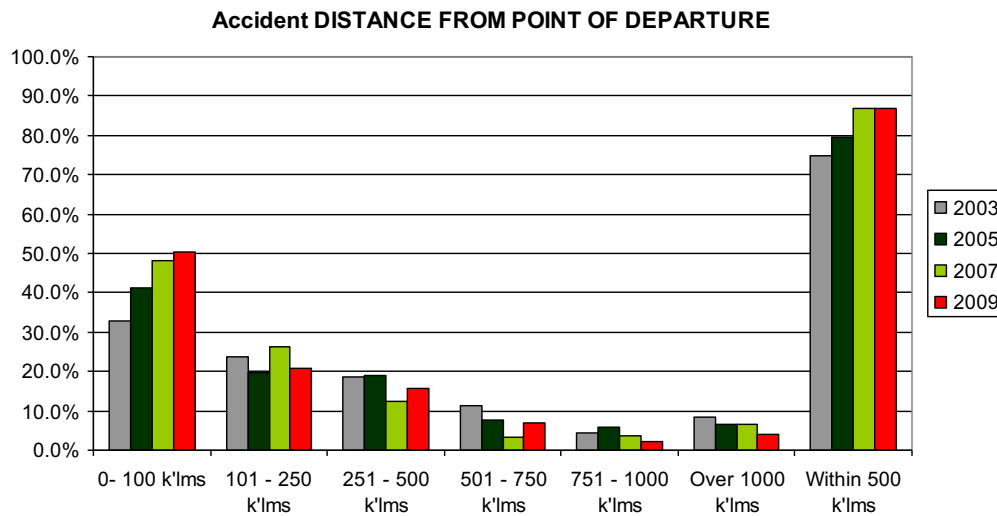


Figure 10. Crashes by distance from point of departure

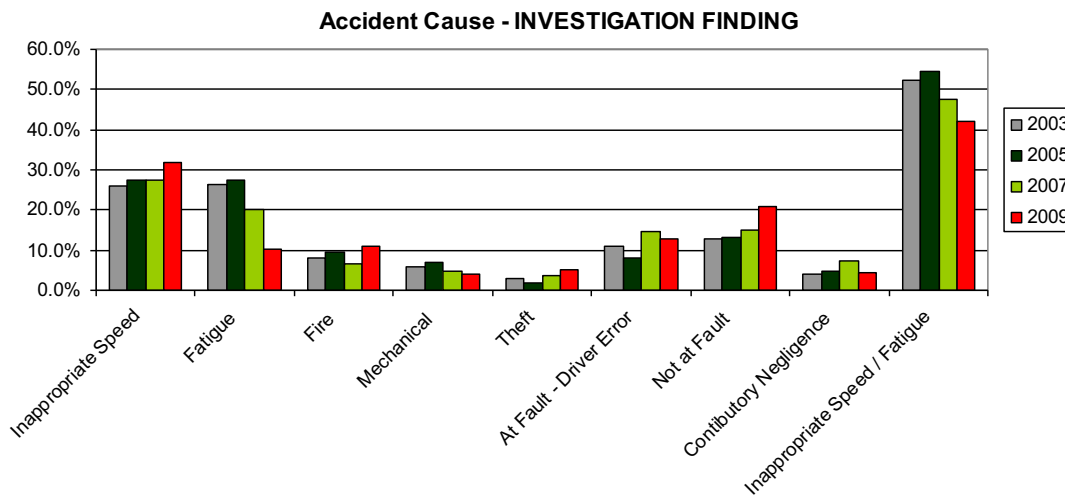


Figure 11. Crash cause involvement assigned by NTI investigations

Furthermore, in cases of serious multi-vehicle crashes, it was found that the driver of the heavy vehicle was negligent 44% of the time. In fatal crash incidents involving more than one vehicle, the other driver was at fault in 82% of cases. This report questions the relevance of road safety agencies highlighting the increase of fatalities involving heavy vehicles given that in most cases the driver of the goods-carrying vehicle is not responsible. Undoubtedly there needs to be an increased safety focus on all road users, particularly those sharing the roads with heavy vehicles.

The 2009 evaluation established that 86% of major crash incidents occurred within 500 kms of point of departure, irrespective of whether the journey was outbound or on the homeward leg. This is an identical result to prior research. Further, more than 50% of incidents occurred within 100 kms of the point of commencement of the journey (Figure 10). The greatest exposure is within the initial five to six hours of a journey, hence the importance of strictly monitoring 'fitness for duty'.

Figure 11 shows the risk factors that were determined by NTI investigators to be involved with the crashes, irrespective of those alleged by the driver at the time of the incident. This most recent research found that inappropriate speed for the prevailing conditions accounted for 31.8% of crashes. This was an increase on past findings. However, whilst it was established in the 2007 report that fatigue was the cause in 20.3% of major crashes, this improved substantially to 10% in 2009. No doubt this improved result may be attributed to a range of reasons not limited to the 2008 introduction of driving hours reform.

This improved result reduced the combined speed/fatigue factor to 41.9% although all of the gain here was in the fatigue result. These two causal factors remain a major concern, even though there is strong evidence of improvement. Inappropriate speed for the conditions is a training and vehicle management issue.

Vehicle theft continued to be insignificant and there was a marginal increase in losses attributed to fire. There were less incidents involving mechanical failure.

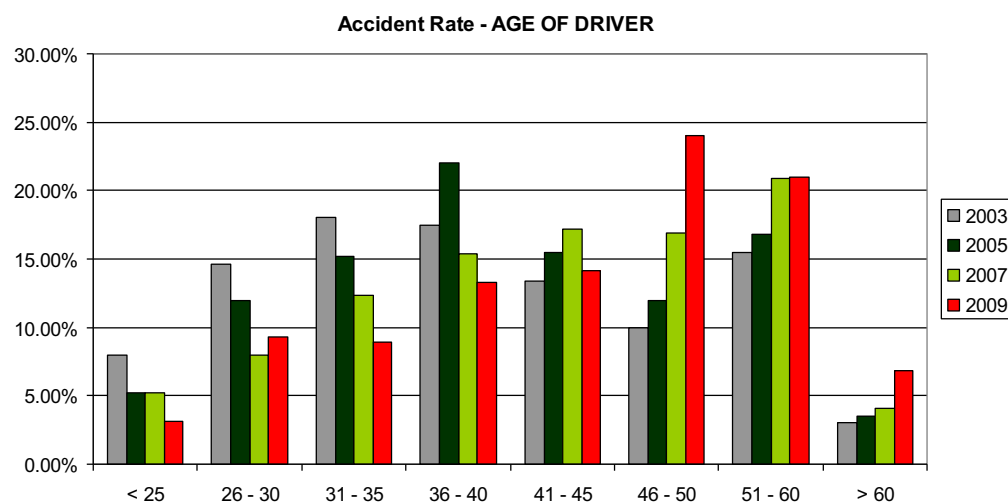


Figure 12. Crash rates by age of driver

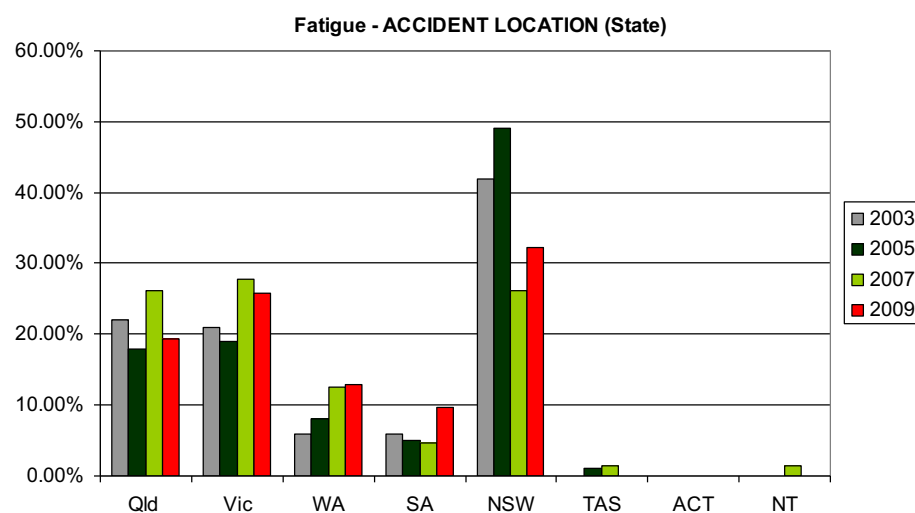


Figure 13. Fatigue-involved crashes for each State and Territory

The 2009 study found that drivers under the age of 45 were involved in considerably fewer accidents proportionally than was found in the investigations conducted in 2003, 2005 and 2007 (Figure 12). Again, drivers over the age of 45 were involved in higher proportions when comparing the studies, but this could obviously be attributed to the fact that the average age of all heavy vehicle drivers continues to escalate. Consequently, the average age of drivers involved in major truck crashes continues to increase: from 38.5 years in 2003, to 40.5 years in 2005, 43.2 years in 2007 and 44.8 years in 2009. Further, the 2009 research found that in 27.8% of serious truck crashes, the driver was over 50 years of age.

Although it could be argued that many insurers desist from the practice of accepting drivers under the age of 25 years, NTI for some time has guardedly supported the acceptance of younger drivers which would suggest that those accepted under 'managed and monitored' apprenticeships are returning improved results. In 2009, as in prior research, there was no evidence of drivers under the age of 25 years being at increased risk of involvement in major truck crashes.

In 10.1% of major incidents in the 2009 study, fatigue was found to be a significant cause. This was an improved result as stated earlier in this report. Although results improved in Queensland and Victoria, there was a notable deterioration in NSW and SA after a substantial improvement in 2007. The Western Australian result worsened marginally at 12.9% of large crash incidents reported in that state. There were no reported incidents in Tasmania, the ACT or the Northern Territory (Figure 13).

The 2009 study also establishes that 80.06% of fatigue-related incidents occurred within 500 km from commencement of the journey, either outbound or on the homeward leg. This finding was a substantial increase on 2007 (72.3%). Some 81% of major crashes found to be attributed to driver fatigue occurred on outbound journeys within 500 km of the point of departure. This result followed the 2007 finding of 89.3%. This finding raises obvious concerns about driver management and particularly fitness for duty. The average age of fatigued drivers involved in these incidents (44.3 years) continues the trend of

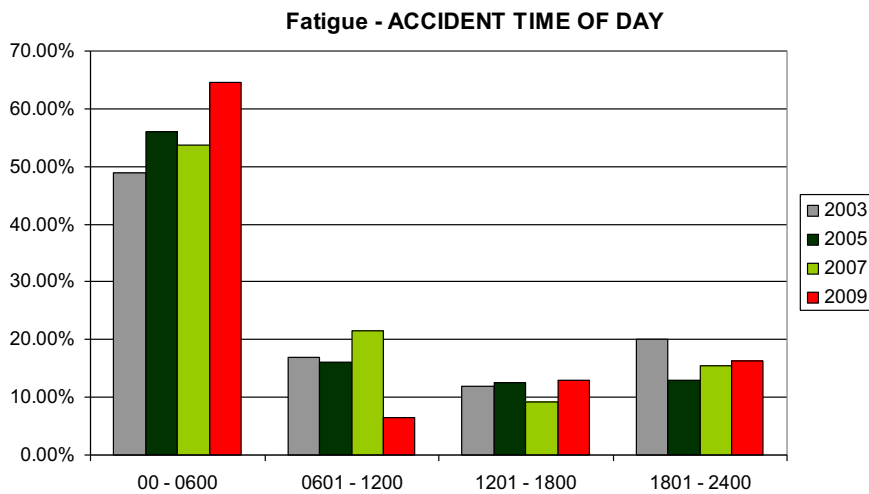


Figure 14. Fatigue crashes by time of day

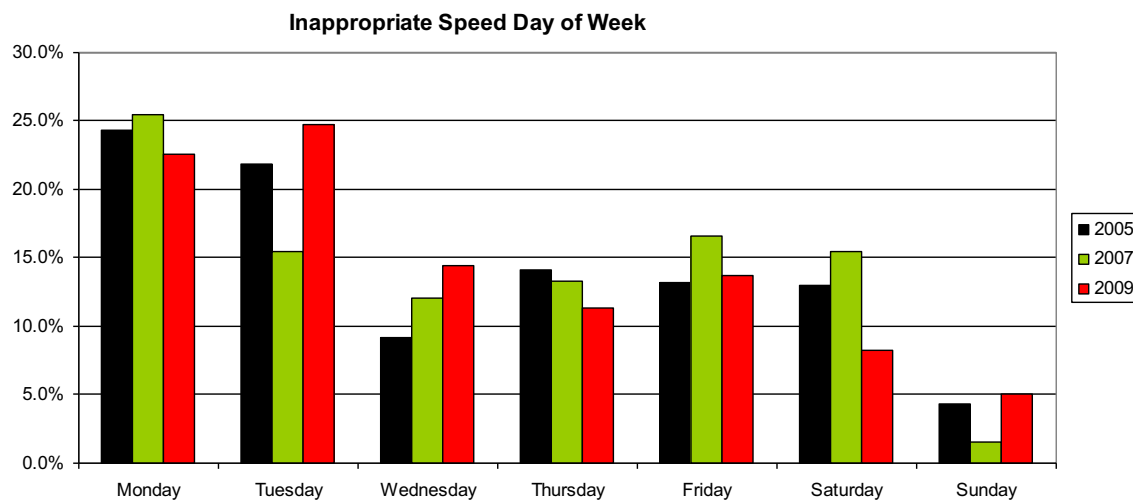


Figure 15. Crashes involving inappropriate speed by day of week

earlier findings: 36.75 years in 2003, 40.56 years in 2005 and 42.5 years in 2007, confirming that the driver pool is ageing.

Although this research established less fatigue-related serious heavy vehicle crashes, 64.5% of accidents deemed to be fatigue-influenced were reported between the hours of midnight and 06.00. This followed the 2007 finding of 53.8%, with 56% in 2005, and continued to be a serious concern for those operations continually working through these hours. As seen in Figure 14, there was a substantial improvement in the period from 06.01 hours to midday.

Inappropriate speed for the conditions continues to be the predominant cause for heavy truck crashes in Australia. The 2009 study found that 31.8% of reported incidents could be attributed to inappropriate speed, particularly when altering direction. Although showing a marginal increase since prior studies, this result was comparable with previous years: 27.4% of major accidents attributable to inappropriate speed in 2007, 27.3% in 2005 and 26.1% in 2003. Travelling during the early

part of the week presents the most risk: as seen in Figure 15, Mondays and Tuesdays accounted for 47.3% of losses attributed to inappropriate speed.

Summary of Findings 2009

The key findings from an analysis of the 2009 NTI crash data are:

- Inappropriate speed for the conditions continues to be the predominant cause for heavy truck crashes in Australia. The 2009 study found that 31.8% of reported incidents could be attributed to inappropriate speed, particularly when altering direction.
- Fatigue and inappropriate speed were found to be responsible for almost one in two serious truck crashes (41.9%).
- Fatigue-related serious truck crashes had reduced by 50%.
- 1 in 4 serious truck crashes occurred on Australia's National Highway 1.

- Since 2002, there has been a 27% decrease in serious truck crash incidents reported (damage > \$50,000). When comparing the 2009 result to crashes investigated in the 2007 period, the average financial loss per incident increased by 6.2% to \$136,472.
- With 18.9% of losses, Monday was found to be the worst day. Mondays and Tuesdays account for 37.5% of serious crashes.
- June and April were the worst months for major incidents.
- The worst time of day is 11.00 – 14.00 hours.
- NSW, with 36.5% of major truck crashes, experienced deterioration since the 2007 study. This could be attributed to an increase in crash incidents on the Pacific Highway.
- It is noteworthy that losses on the Hume Highway have dropped substantially since 2003 from 11.1% to 2.5% of major truck crashes.
- Semi-trailers are over-represented with 60.1% of major crashes, though only responsible for 38% of the articulated freight task (loaded tonne- /- km).
- B -Doubles are the safer alternative, carrying 46% of the freight task with only 28.8% of major accidents.
- In 7 out of 10 serious truck crashes, no other vehicle is involved.
- In 86% of serious truck crashes, the vehicle was within 500 km of point of departure. 50% of incidents occurred within 100 kms.
- In 71.2% of serious truck crashes, the vehicle was involved in an outbound journey from home base.
- In 29.5% of serious truck crashes where another vehicle was involved, the truck driver was totally responsible in 44% of the incidents.
- In fatal crash incidents involving another party, the other driver was at fault in 82% of incidents.

Conclusions

The Australian road freight sector remains in transition. Fundamentally, the freight task is in growth; nevertheless, weak trading conditions on the high volume eastern seaboard are being experienced as demand contracts. Operations without a specific niche and long term, well- established customers are further exposed to fluctuations in the cost of doing business. Environment, equipment finance and safety compliance outlays remain a growing concern for the foreseeable future with expected long term ramifications.

Be that as it may, road transport safety in Australia continues to maintain a high standard and, as evidenced in this research, results continue to improve particularly with regard to the frequency of serious truck crash incidents. Road quality and infrastructure, particularly rest areas and parking bays, are an ongoing concern in regional areas and of an improved standard on new motorways; however, in country areas and some major highways, road quality is sometimes severely affected by lack of funding and poor maintenance.

During the course of these studies since 2003, the insurer's portfolio (vehicles insured) has increased by 48% whilst major crash incidents have increased marginally by 7%. In the 2009 research, the overarching finding is that there were fewer major truck crashes recorded. However, such losses have increased by 6.2% in average cost of claim when compared to prior research.

Fatigue-related crash incidents have reduced substantially during the period since 2003.

On a case-by-case basis, to ensure consistency of the comparable model, the National Centre of Truck Accident Research reviews all truck accidents where material damage exceeds \$50,000. This study of major truck accidents focuses on claims settled during 2009. This is the fourth in a series of quantitative evaluations conducted every two years tracking the behaviour of a cohort of Australian heavy vehicle operators.

Acknowledgement

The National Centre of Truck Accident Research is an independent research facility wholly funded by National Transport Insurance in Australia & New Zealand. NTI supports the analysis of its data and other available data with the view that effective research focusing on current information is crucial to a greater insight into serious heavy vehicle crashes.

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Editor's note: This is an edited (slightly abridged) version of the NTI Report. The full report can be viewed at www.nti.com.au, as can previous reports referred to in this article.

Occupational road safety 2020: Using PESTELED analysis to understand the work- related road safety context

by Dr Will Murray, Research Director, Interactive Driving Systems
Visiting Fellow, Loughborough University and CARRS-Q

Introduction

Since the formation of the coalition government in the UK there has been increasing focus on, and debate about, cuts in the road safety budget. Such cuts will have many knock-on effects for road safety, including the work-related or fleet sector. This means that it is increasingly important for all sectors of the fleet industry, and its suppliers, to fully understand the external context in which they find themselves, particularly when trying to make long term plans. Work-related road safety is influenced by external economic, legal and political factors which operate at local, national and international levels. These factors influence organisational changes such as management structures, which in turn influence work context and job characteristics at organisational and individual levels. When developing a work-related road safety program - for all vehicle types from heavy trucks and buses, right down to couriers on two wheeled machines - it is vital to understand and allow for such external factors.

During the 1980s, a PEST (political, economic, social and technological) analysis was developed as the way to do this. Then in the 1990s, this concept expanded into a PESTEL (political, economic, social, technological, environmental and legal) analysis. Now the tool has further evolved into a PESTELED (political, economic, social, technological, environmental, legal, ethical and demographic) analysis.

PESTELED explained

So what is a PESTELED analysis, and why is it important for organisations to undertake one in relation to work-related road safety in these interesting and potentially challenging times?

PESTELED analysis is defined as a management technique to enable an analysis of external factors that may impact the performance of an organisation. Originally designed as a business environmental scan, PESTELED examines the external macro environment ('big picture') including political, economic, socio-cultural, technological, environmental, legal, ethical and demographic forces within which businesses operate and which act on them.

PESTELED is a useful tool for understanding the 'big picture' of the environment in which businesses are operating, and the opportunities and threats that lie within it. By understanding the external environment, organisations can take advantage of the opportunities and minimize the threats. With significant future growth expected in road freight transport in Australia

and other countries, this tool should prove useful in highlighting a range of safety issues, and making a contribution to improving safety in the commercial heavy vehicle and transport industry.

The following provides some initial thoughts on the current issues affecting the fleet and fleet supply industry.

Political factors affecting work-related road safety

- change of government in UK, with some moves toward Euro Scepticism amongst British politicians – particularly around the debt crisis in the Eurozone, and significant cuts occurring in road safety budgets and other government spending
- increasing EU interest in work-related road safety including clarification that Framework Directive EC 89/391 does categorise vehicles on the road as a workplace
- lobbying power of motor industry and suppliers forcing safety investment into technology rather than driver development or improved mobility management
- occupational road safety discipline growing
- movements around environment and corporate social responsibility
- impact of Decade of Action for Road Safety, Moscow ministerial declaration and the recent United Nations resolution on road safety
- managing the government's own substantial fleet and leading by example.

Economic factors affecting work-related road safety

- government cost-cutting and the impact on road safety and training
- recession and the need for cost saving, high value solutions, needs-based approaches, detailed business cases and outcomes evaluation
- increasing need for budget protection supported by well thought out purchasing, cost, finance sourcing and risk financing models
- promoting the importance of fleet safety as a brand enhancement, reputational and money- saving opportunity
- focus on use and safe management of contractors, sub-contractors and freelancers to cut costs
- impact of rationalisation, downsizing and other negative changes on safety
- sustaining safety and engaging drivers and managers in hard times.

Social factors affecting work-related road safety

- role of government and the government fleet, and its importance to business
- using the road for work and commuting – remains the biggest injury and fatality risk faced by most people
- road safety campaigns
- road Safety week and community-corporate social responsibility
- fleet safety as conduit for general road safety
- embracing the systems-based approach to safety.

Technological factors affecting work-related road safety

- maximising the benefits of telemetry and other technology such as vehicle-based cameras
- electronic licence and criminal records bureau (CRB) checks. Note: in the UK organisations can obtain such data electronically directly from the government agencies involved as long as they have the informed consent of the driver, and can prove the security of their systems for data transfer, storage and retrieval
- data linkages/warehouses – national and organisational – linking collisions, risk assessment, fuel, telemetry and licence check data – leading to needs-based targeted training programs
- need for data-led systems based approach.

Environmental factors affecting work-related road safety

- safety and environment links
- focus on green, carbon, fuel
- systems-based approach.

Legal factors affecting work-related road safety

- globally – impact of ISO39001 standard on Road Traffic Safety, framed by the systems-based approach
- relevant European and other regional regulations such as the Certificate of Professional Competence (CPC) for large vehicle drivers, EC89/391 covering health and safety, and the Working Time Directive
- UK health and safety regulations including vehicle as part of workplace under Health and Safety law, corporate manslaughter and vicarious liability
- Eastern Europe – importance of the Labour Code in engaging organisations
- Australia – Chain of Responsibility rules for heavy vehicles; all vehicles irrespective of type, size and ownership being seen as part of workplace under Health and Safety law, and, Fatigue Management regulations
- US – Negligent Entrustment, ANZI 15 standard and Hours of Service
- Germany – workers compensation, social insurance and the role of the Berufsgenossenschaftens (regional social insurance organisations)
- Sweden – Vision Zero, engaging suppliers through building safety into purchasing, interpretation of EC89/391 and government leadership on vehicle safety features

- New Zealand – Chain of Responsibility rules, the Accident Compensation Commission fleet guide and vehicle as part of workplace under Health and Safety law
- South Africa – road safety regulations called Administrative Adjudication of Road Traffic Offences (AARTO), including substantial fines for organisations operating vehicles illegally
- In the emerging or BRICK economies (Brazil, Russia, India, China and Korea) the number of road fatalities have typically been increasing in line with development. Currently there appears to be limited legal process in place for work-related road safety in the BRICK economies, even though vehicles being driven for work are involved in about 70% of road fatalities in such regions according to the Global Road Safety for Workers project (see www.virtualriskmanager.net/niosh).

Ethical factors affecting work-related road safety

- growing importance of data protection and privacy as fleet safety and driver training become increasingly data-led, based on risk factors such as collisions, licence checks and telemetry
- the road safety versus mobility trade-off
- the question of investment in vehicle safety features or journey management.

Demographic factors affecting work-related road safety

- ageing population, requiring different interventions
- young drivers joining workforce bringing higher risks
- health and wellbeing
- driver life cycle – driving for life from cradle to grave
- land use planning issues linked to population decentralisation.

Summary and lessons for work-related road safety research, policy and practice

Overall, in these interesting, changing and challenging times, it is vital for the fleet industry and its suppliers to understand the context in which they operate when making plans for the short, medium and long term future.

PESTELED is a good framework for achieving it - to allow a better understanding of the potential market opportunities and threats to the industry. Interested readers are encouraged to spend 10 minutes undertaking a PESTELED review of the road risks in their organisations, and to send your feedback via email to will.murray@virtualriskmanager.net. A 'Gap Analysis' is also recommended as a good starting point for a work-related road safety program, using the freely available 10 and 30 question tools at www.fleetsafetybenchmarking.net.

National Logistics Safety Code

by Duncan Sheppard, Director - Communications and Policy, Australian Logistics Council

Introduction

All players in Australia's logistics supply chain must take responsibility to ensure safety is given the highest priority. Unfortunately, due to complex regulation, it is often confusing for parties to be certain of their responsibilities. The National Logistics Safety Code (NLSC), developed by the Australian Logistics Council (ALC) is an industry-based code clearly setting out all participants' responsibilities when they control or influence the movement of freight in the supply chain, particularly road transport laws and OH&S legislation.

"The National Logistics Safety Code can trace its origins back to 2006 when the Retail Logistics Safety Code was launched with five original signatories – Woolworths, Coles, Metcash, Toll and Linfox," according to ALC Chief Executive Officer, Michael Kilgariff.

"Two years on from that we harmonised the RLSC with the Steel Code to form the National Logistics Safety Code which in effect created a single national code designed to improve and maintain safety across the supply chain."

Mr Kilgariff said the National Logistics Safety Code is all about industry leading safety. "It's a voluntary scheme which encourages industry to take responsibility for complying with relevant safety rules and regulations," he said. "The Code sets out all participants' responsibilities when they control or influence the movement of freight. In so doing, it produces a clear and equitable alignment of responsibilities for the carriage of goods. The features of the NLSC are its flexibility, its consistency, and the Code's ability to be adapted to meet the needs of any mode or industry sector," Mr Kilgariff said.

The NLSC was developed to suit a changing logistics landscape. Traditionally, the movement of freight between Consignors and Consignees in the supply chain was characterised by distinct responsibilities being understood by each party with regard to points of control within the chain and the safe movement of freight.

In the past, suppliers retained control of the delivery task using their own fleets or outsourced carriers to deliver the product to the consignee. Within this simple model, the carriers had responsibility for transporting the freight under conditions of safety. Relevant regulations and standards were directed at them, while suppliers, consignors and consignees were relieved of formal responsibility for these aspects of their business (unless, of course, they used their own fleets).

The last decade saw major transformations to these comparatively straightforward and discrete relationships between the players in the chain. Major Australian logistic chains have followed the path of their counterparts in many comparable countries and have begun to assume the leading

management role within their supply chains. While in some cases suppliers continue to make the arrangements for the delivery of freight to their customers, in others consignors/consignees have set up their own facilities and have largely taken control of the storage and movement of freight along the supply chain.

This blurring of the traditional lines of control has naturally had an impact on freight carriage operations. The scheduling of freight movements is controlled, sometimes by the supplier (especially in the case of primary freight moved between the supplier and the consignor/consignee's facility) or by the consignor/consignee (especially in the case of goods moved between the major parent and satellite facilities).

In addition, trucks are often loaded and sealed within the premises of the consignor. As a consequence, depending on who controls the conditions under which freight is loaded and scheduled for delivery, the carrier often has little control over key facets of the safe and secure transport of freight, yet may be held formally responsible for breaches under relevant regulation and standards.

The National Logistics Safety Code is designed to ensure that all participants are aware of their responsibilities in the supply chain when they control or influence the safe and legal carriage of freight. It produces a clear and equitable alignment of responsibility for the carriage of goods within the chain against the relevant standards and regulations, and also induces higher standards of accountability and good practice within the industry.

How the National Logistics Safety Code works

The Code is aimed at establishing enforceable operational guidelines covering logistical interaction between those in the NLSC in relation to the carriage of freight by heavy vehicles.

It prescribes minimum levels of operational behaviour to assist those bound by the code to manage their obligations under the relevant road transport laws and occupational health and safety legislation.

The Code has two classes of signatory. First, participants in the NLSC have the status of participating signatories and assume obligation under the Code. Second, industry bodies or associations, such as the ALC or the Australian Food and Grocery Council, have the status of endorsing signatories without assuming any direct obligations under the Code but will endorse and support the principles of the Code.

The Code applies to the wide range of activities within the supply chain including:

- legal compliance and chain of responsibility
- OH&S risk assessment and compliance
- fatigue (scheduling, time slot flexibility, waiting time, queuing, loading or unloading)
- communication
- safe loads (preparation, restraint and containment, mass container weight declarations, dangerous goods)
- speed management
- equipment
- driver health/drug and alcohol
- subcontractor assessments
- operational infrastructure.

In addition to the specific freight carriage requirements covered under the relevant road transport laws, participants in the NLSC are expected to abide by all relevant regulation concerning driver fitness. Signatories are required to ensure that their actions, inactions or demands do not result in pressures being brought to bear on the transport task that would result in a breach of the legislative requirements of the States or Territories through which the goods are transported.

The Code is intended only to assist all parties to identify issues related to chain of responsibility compliance and to give guidance in the management of that compliance. Compliance with the Code will not necessarily guarantee compliance with the diverse range of regulation throughout Australia. Participants in the NLSC must identify the relevant regulation applicable to their operations and comply with it.

This Code:

- does not require any signatory to exchange any information or participate in any discussions concerning customers, suppliers, prices, products, geographic areas of operation or any other such matters
- is not intended to be an 'industry code' for the purposes of Part IVB of the Trade Practices Act
- becomes effective after each signatory has satisfied itself that there are no trade practices concerns
- is not intended to prevent the signatories from acting in a commercially competitive manner
- is not intended to be anti-competitive in any way.

Supply chain points of control

A Responsibility matrix has been developed which identifies different roles each party may play in the NLSC. The Chain of Responsibility (COR) means that all those who control transport operations – not just the drivers – can be held responsible for breaches of road laws and may be made liable. The matrix can be viewed in full at www.austlogistics.com.au.

The fundamental principle embodied in the matrix is promoting safety and compliance with all relevant road transport laws. This principle is to be observed in practice by organisations and individuals who control or influence all functions in the National Logistics Safety Code including the planning, consigning, packing, loading, driving, operating and receiving of freight.

Auditing

A feature of the NLSC is an audit system that measures members' regulatory compliance.

Audits are carried out by a third party, accredited by the independent accreditation body, Registrar Accreditation Board of the Quality Society of Australasia (RABQSA).

There are three types of audit:

- an entry audit to review a participant's processes and procedures
- an annual compliance audit to review whether participants are conforming with the Code's required elements
- a partnership audit review (PAR) following each audit.

For further information, visit the Australian Logistics Council website www.austlogistics.com.au, or contact the author on (02) 6273 0755 duncan.sheppard@austlogistics.com.au.



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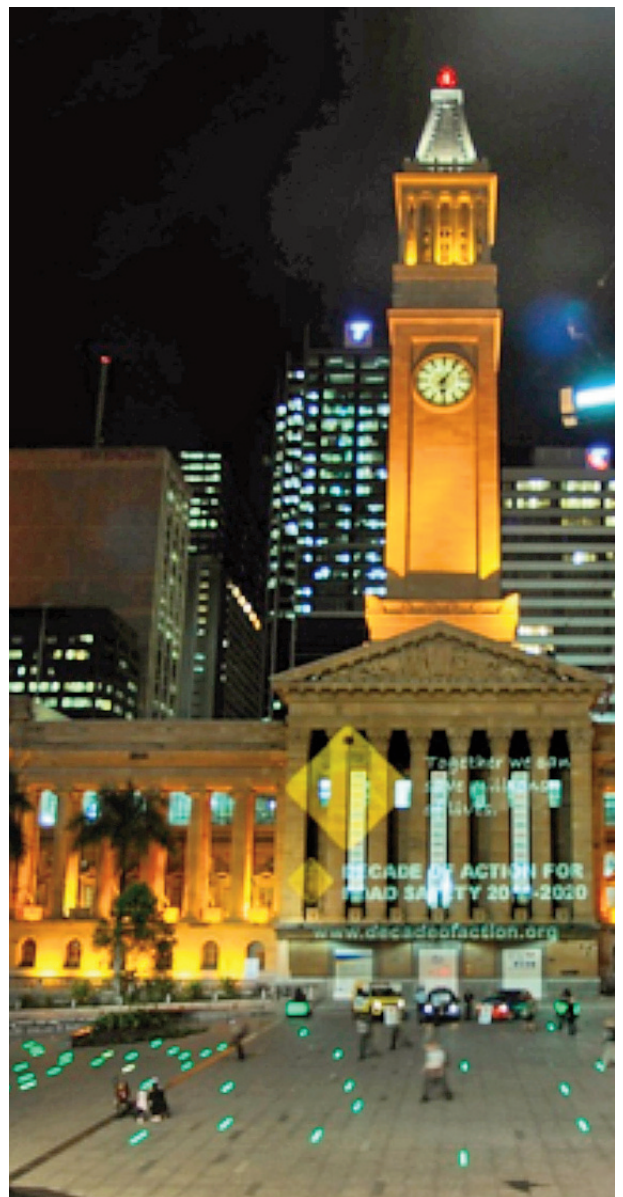
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