



Australian Government

Department of Infrastructure and Regional Development

Bureau of Infrastructure, Transport and Regional Economics

RESEARCH REPORT

140



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Safety

**Impact of road trauma and
measures to improve outcomes**

Bureau of Infrastructure, Transport and Regional Economics

**Impact of road trauma and measures to
improve outcomes**
Report 140

Department of Infrastructure and Regional Development
Canberra, Australia

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ISSN: 1440-9569

ISBN: 978-1-925216-10-3

December2014/INFRA2315

Cover photograph: Barton Highway, Canberra, Tim Risbey.

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An appropriate citation for this report is:

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2014, *Impact of road trauma and measures to improve outcomes*, Report 140, December, Canberra.

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Foreword

This report is the result of a Bureau project that was a Coalition election commitment that tasked the Bureau of Infrastructure, Transport and Regional Economics (BITRE) with undertaking a review of the full impacts of road trauma, including the benefits and costs of measures to encourage safer drivers, build safer roads, and drive safer cars.

The Bureau is grateful for the help of road safety experts who participated in both the survey and workshop to identify new measures with the most potential to further reduce road trauma.

The project was undertaken by Tim Risbey, Jack McAuley and Mark Cregan, with assistance from Peter Johnston and Elly Jung.

Gary Dolman
Head of Bureau
December 2014

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At a glance

There have been impressive road safety improvements over the last 40 years, but road crashes remain a huge cost at an estimated \$27 billion per year. This is the equivalent of 18 per cent of health expenditure and 1.8 per cent of Gross Domestic Product (2012-13).

Significant progress has been made to achieving the National Road Safety Strategy 2011–2020 target of a 30 per cent reduction in casualties. While the numbers of vehicle occupant deaths has trended down, the analysis of trends confirms the relatively high risk for motorcyclists, pedal cyclists, older drivers and remote communities. These trends, combined with population increases, will make the target even more challenging and underpin the search for new ways to further reduce road trauma.

BITRE commissioned consulting firm Jacobs to interview road safety experts to identify initiatives to reduce road injury and deaths. Collectively, over 400 initiatives were suggested (Jacobs 2014). A workshop of road safety experts narrowed this to the top initiatives with the most potential to save lives and reduce injuries.

Three of the top measures suggested by road safety experts—research, management and leadership—are strategic and not amenable to economic analysis. These important strategic issues are addressed in the broader Review of the National Road Safety Strategy (Austroads, forthcoming).

Another top ranking measure, the general enforcement of road rules, is not amenable to analysis.

BITRE's analysis has focussed on four priorities identified by road safety experts: infrastructure, safer intersections, distraction from mobile phones, and autonomous emergency braking (Table 1).

The primary basis of assessment is the expected reduction in road trauma—the avoided loss of life and injuries—compared to what would have happened otherwise (the base case). This base case projects future levels of road trauma taking account of population and economic growth as well as currently planned measures to reduce road trauma, including technologies in passenger vehicles such as electronic stability control, side airbags and autonomous emergency braking.

BITRE's analysis has confirmed that roadside barriers, median barriers and rumble strips are measures that reduce road trauma. However, to maximise road safety benefits they need to be implemented taking account of specific road conditions. Use of the Australian National Risk Assessment Model with Australian parameters and programme benefit-cost analysis would facilitate prioritising these infrastructure investments from a safety perspective.

Lower speed limits can be a valuable option to help achieve improved road safety outcomes where low traffic volumes mean that infrastructure upgrades are not currently economically justified.

Intersection treatments can be very effective. Roundabouts can be particularly effective, reducing casualty crashes by over 70 per cent. However, the safety benefits can be partly offset by traffic impacts and there can be negative impacts on motorcyclists, pedal cyclists and pedestrians.

There is value in a comprehensive mobile phone strategy. While it is difficult to determine how important mobile phone distraction is in real world crashes, mobile devices more broadly may be a factor in 7 per cent of crashes. In 2013, 7 per cent of crashes accounted for 83 deaths and 2300 hospitalised injuries. No specific measures have yet been identified that could be modelled by BITRE to test their effectiveness.

Autonomous emergency braking systems will save lives as they are introduced to the vehicle fleet. The technology in light vehicles is expected to save over 1200 lives and prevent 54 000 hospitalised injuries by 2033. Over 400 of these deaths and 10 000 of the hospitalised injuries prevented are pedestrians and pedal cyclists. However, there is a significant lag before light vehicles with autonomous emergency braking systems comprise a significant proportion of the fleet. A hypothetical scenario of mandating autonomous emergency braking from 2018 suggests that such action could save an approximately 600 lives and prevent 24 000 hospitalised injuries by 2033.

Table 1 summarises BITRE findings relating to the specific measures examined in detail. It shows all measures would save lives and reduce the number of hospitalised injuries, and that all measures are warranted on economic grounds with benefits exceeding costs. For example, upgrading the National Land Transport Network, as modelled, returns more than \$3 for every dollar invested.

Table 1 Summary of measures, Australia

Measure	Potential reduction		Average cost (millions) ^a	Indicative benefit-cost ratio (BCR) ^a	Notes
	Deaths	Hospitalised injuries			
Upgrade national land transport network: 85% 3 stars or above, 20 year timeframe	86/year	2,259/year	\$236.6/year	3.5	Australian Automobile Association fatality and BITRE hospitalised injury estimates.
• Centre median	46/year	1,195/year	\$116.4/year	3.8	Australian Automobile Association costs and BITRE BCR estimates.
• Roadside barriers	13/year	353/year	\$26.1/year	5.0	
• Rumble strips	10/year	253/year	\$37.3/year	2.5	
Reduce speed limits on national land transport network roads	–17 per cent^c	–17 per cent^c	negligible	1.9	For a hypothetical rural highway with high crash risk.
More roundabouts	–72 per cent^b	–79 per cent^b	\$0.1–0.6/site	11.3 (3.0)	Higher BCR compares safety benefits with implementation costs. Lower BCR includes possible traffic impacts. Negative impact for some road users.
Eliminate filter turns	– (d)	–58 per cent^d	–	2.6	BCR includes traffic impacts
Require Autonomous Emergency Braking in all light vehicles, 16 year timeframe	37/year	1,506/year	\$339.8	1.3	Scenario: Autonomous Emergency Braking with vulnerable road user protection by 2018 and high speed Autonomous Emergency Braking by 2020.
Note	There was insufficient data to identify sites/sections where speed limit reductions, roundabouts and filter turn measures would apply. It is therefore not possible to calculate expected national reductions in road trauma and the associated total costs.				
a	Discounted to present values using a real, risk-free discount rate of 4 per cent, consistent with Department of Infrastructure and Regional Development (2014a) guidelines for calculating benefit-cost ratios.				
b	BITRE 2012b, Table T6.T01 p.72.				
c	BITRE estimates based on Austroads (2010) and an average mean speed reduction of 4.25 kilometres/hour. BITRE has assumed the same proportional reduction in hospitalised injuries.				
d	Chen and Meuleners (2013) found a reduction of 58 per cent in serious injury crashes, but was not able to estimate the reduction for fatal crashes.				
Source	BITRE estimates				

Chapter 1 Review of the full impacts of road trauma

The National Road Safety Strategy 2011–2020¹ (NRSS) commits federal, state and territory governments to a national collaboration on road safety improvement, presenting a 10-year plan to reduce the annual numbers of deaths and serious injuries on Australian roads by at least 30 per cent.

The NRSS acknowledges that the level of trauma reduction that can actually be achieved by 2020 will depend on the costs and policy changes that the community is prepared to accept in return for a safer road transport system.

As part of agreed NRSS implementation processes, Austroads has undertaken a comprehensive review of road safety priorities and actions over the next three years.²

BITRE's review of road trauma was announced in *The Coalition's Policy to Improve Road Safety* which states that "As a first step to developing more effective and more targeted approaches to improving road safety, we will task the Bureau of Infrastructure, Transport and Regional Economics (BITRE) with undertaking a review of the full impacts of road trauma. The review will evaluate the benefits and costs associated with the different road safety approaches adopted by various jurisdictions, both domestically and internationally." (The Coalition 2013)

BITRE's review provided a timely review of new or incremental ways that road safety experts believe have potential to further reduce the road toll, and their expected benefits and costs.

In addressing the Government's brief, BITRE analysed the benefits and costs of specific measures identified by Road Safety Experts as having the most potential to reduce future levels of trauma, to work out which might give the best outcome for society. The outcomes of BITRE's Road Trauma Review helped inform the Austroads Review of the NRSS.

On 7 November the Transport and Infrastructure Council (2014) welcomed the findings of the Austroads review of the NRSS, and agreed that the Safe System principles, 10-year targets and strategic objectives set out in the NRSS should continue to guide national efforts to improve road safety.

The Council endorsed the NRSS Action Plan 2015-17 developed in response to the Austroads review findings. The Action Plan sets out a range of agreed priority initiatives to support long-term improvement in the safety of Australia's road transport system, with a focus on strategic investment in infrastructure safety and improvements in the safety of our vehicle fleet.

¹ The NRSS 2011-2020 was released on 20 May 2011 by the former Australian Transport Council. It is now overseen by the Transport and Infrastructure Council.

² The NRSS required a review in 2014 of progress in implementing the "First Steps" agenda and the implementation of the other proposed initiatives. The main aims of this broad NRSS Review by Austroads were to assess progress: in implementing the NRSS action agenda; towards the NRSS objectives in each cornerstone areas (Safe People, Safe Vehicles, Safe Roads, Safe Speeds, and Safe Systems); and towards the NRSS casualty reduction targets. In January 2014 an Austroads project was awarded to assist with this first review of the NRSS (Austroads, forthcoming).

Different road safety approaches

The brief for BITRE's review included "evaluate the benefits and costs associated with the different road safety approaches adopted by various jurisdictions, both domestically and internationally."

International approaches

In 2008, International Transport Forum (ITF)/Organisation for Economic Co-operation and Development (OECD) published a research report [*Towards Zero: ambitious road safety targets and the Safe System approach*](#), which was the first international effort in defining and promoting the adoption by all countries of a Safe System approach as the main framework for road safety policies (OECD/ITF 2014b).

This Safe System vision is based on ambitious targets and the aspiration to progressively eliminating all fatalities and serious injuries. A Safe System approach is based on the underlying principles that:

- human beings can make mistakes that can lead to road crashes;
- the human body by nature has a limited ability to sustain crash forces; and
- it is a shared responsibility between stakeholders (road users, road managers, vehicle manufacturers) to take appropriate actions to ensure that road crashes do not lead to serious or fatal injuries.

A Safe System approach is at the core of the Plan of Action of the UN Decade of Action, which states that for all countries, whatever their level of development, the guiding principles underlying the Plan for the Decade of Action are those included in the "Safe System".

Sweden, the Netherlands and Australia were the precursors in the late 1990s in the adoption of the Safe System approach. **Box 1** summarises Sweden's approach. While there is reticence among some countries about establishing a vision zero or a "zero" target, several have adopted this principle since the publication of the 2008 report (OECD/ITF 2014b).

In International Traffic Safety Data and Analysis Group (IRTAD) countries the annual number of road deaths fell nearly 40 per cent between 2000 and 2012. This period saw robust road safety strategies with well-defined and targeted measures (such as speed management, alcohol limits and seat-belt use) introduced in many countries for the first time (OECD/ITF 2014a). Across IRTAD countries there are a number of key learnings from international experience (**Box 2**). The major influences on the past reductions in road fatality rates were:

- Seat belt legislation and enforcement/wearing rate
- Blood alcohol legislation and enforcement (random breath testing)
- Speed limit legislation and enforcement (speed camera checks)
- Vehicle safety technology and standards
- Drug limit legislation and enforcement (random drug testing)
- Youth-specific legislation.

OECD/ITF (2014a) finds more limited success in saving lives among vulnerable road users. Reductions in pedestrian, cyclist, and motorcyclist fatalities have levelled off, and in some cases increased, and the share of fatalities among elderly road users is slowly increasing in many countries.

Box 1 Vision Zero in Sweden

Since 1990, Sweden's road fatality rate per 100 000 population has decreased by 67 per cent while the number of vehicles per 1000 population has increased by 16 per cent. In 2013, the road fatality rate reached a record low of 2.7 deaths per 100 000 population. All user groups with the exception of motorcyclists have benefited from this reduction in the fatality rate.

The lack of progress for motorcyclists is explained by the doubling the motorcycle fleet between 1996 and 2012. In response, in April 2010 the Swedish Transport Administration presented a new national strategy on motorcycle and moped safety. The main focus of this new strategy is on anti-lock brake systems (ABS) and increased speed compliance for motorcyclists, and proper helmet use for moped riders.

Critical success factors in the Sweden were:

- A sense of urgency
- Vision Zero as a concept: ethical standpoint, distribution of responsibility, and the accident model (view of human error, focus on injuries and a systems approach)
- Political consensus and leadership: unanimous decision in Parliament in 1997, which still has broad political support
- Quantified interim targets as milestones towards Vision Zero.

Approach:

- In-depth studies of fatal accidents
- Management by objectives (systematic collaboration between stakeholders; concrete goals — safety indicators; stakeholders' commitment to safety indicators; annual result reports)
- A demand for road safety in the society (consumer information, for example the European New Car Assessment Programme (Euro NCAP); and Quality Assurance of Transport)

Most important measures:

- Safer vehicles: seat belt reminders, injury-mitigating properties, and systems reducing accident risk, eg. electronic stability control (ESC)
- Safer public infrastructure: median barriers, and forgiving road-side areas
- Safer infrastructure: safe crossings for pedestrians and cyclists, more roundabouts
- Speed limits and speed management.

Future challenges:

- Role and responsibilities of authorities
- Further regulation of stakeholders' responsibility
- A broader application of [ISO 39001](#): Road traffic safety (RTS) management systems
- Decrease the number of seriously injured, especially unprotected road users
- Integrate the Vision Zero approach with the development of sustainable and liveable cities
- Autonomous vehicles.

Source Larsson 2014; OECD/ITF 2014a

Box 2 International experience: what measures have worked

International trends in road fatality and injury rates in 21 countries were reviewed by BITRE (2014a). Data back to 1965 were assembled on road deaths and injuries; vehicle kilometres travelled by vehicle type, seat belt wearing rates, and alcohol and speed control.

Consistent and yet varied patterns over time in fatality and injury rates were observed in these countries. After rapid falls from the 1960s, improvements in fatality and injury rates have tended to level out, as seat belt wearing rates pass 90 per cent, and enforcement efforts bear down on the most risky behaviours.

In countries around the world, seat belt wearing has been the largest and most consistent factor influencing reductions in road fatality rates. In the United States of America in 2010 the average seat belt wearing rate was 85 percent and 53 percent of passenger vehicle occupants killed in crashes in 2009 were not wearing restraints. If belt use were increased by 5 percentage points, about 1,200 lives would be saved annually (Transportation Research Board 2010).

Blood alcohol legislation and enforcement—random breath testing—have lowered the fatality rate further. A change in the blood alcohol limit in Austria from 0.8 to 0.5 grams per litre of blood had the effect of reducing the road fatality rate by close to 10 per cent. But legal limits must be enforced to have a continued effect. In the Netherlands, drink driving levels reduced markedly in 1974 under the threat of application of new legislation, resulting in a dramatic reduction in road fatalities. However, the road toll rebounded in the next two years as the legislation was not enforced.

Speed limit legislation and enforcement have lowered the road fatality rate still further in many countries. In France the introduction of a 50 km/hour urban speed limit resulted in the road fatality rate dropping by 12 per cent.

Vehicle safety technology and standards are set to take over from the three main measures that have reduced road trauma so far (seat belts, blood alcohol testing; and speed enforcement) to deliver further reductions in the road fatality rate.

The two most important current vehicle technologies are stability control and side airbags. They will have significant downward influences on the road fatality rate as they spread through the vehicle fleet. BITRE estimates that side airbags and electronic stability control have already resulted in 9 per cent fewer fatalities than if they had not been introduced (see the base case, page 30).

Drug limit legislation and enforcement—random drug testing—are also set to have a major influence as testing becomes more common. In Norway, the introduction of drug legislation in 2011 was associated with the road fatality rate dropping by 22 per cent.

In 2010 New Zealand introduced measures affecting young drivers, along with measures affecting drug users. The combined effect was to reduce the road fatality rate by 30 per cent.

Source BITRE 2014a

Internationally, nations face challenges in trying to continue the downward trends in death and injury, particularly for vulnerable road users. As the main measures responsible for past downward movements in rates reach maximum effect, and traffic continues to grow, previous measures will need to be ramped up and/or new road safety measures brought into play to avoid flat or rising levels of death and injury.

Australian approaches

In Australia, the NRSS is firmly based on Safe System principles and is framed by the guiding vision that no person should be killed or seriously injured on Australia's roads. The NRSS sets out a range of high-level directions and priority actions to drive national road safety performance to 2020.

The NRSS represents the commitment of federal, state and territory governments to an agreed set of national road safety goals, objectives and actions.

Individual state and territory governments have direct responsibility for most areas of road safety regulation and management. There are advantages in this arrangement, not least being the opportunity for jurisdictions to learn from each other about the effectiveness of different initiatives. However, there is scope for greater national collaboration to determine and implement 'best practice' approaches in key road safety areas (NRSS 2011-2020, p.19).

In implementing a Safe System, Western Australia and Victoria have taken different approaches.

Western Australia's approach to a Safe System (Towards Zero - **Box 3**) is a significant departure from the traditional approach to road safety. While the traditional approach brought about a steady downward trend in road trauma between 2000 and 2007, Cameron (2014) states that it still resulted in "unacceptable" levels of death and injury, with the key lessons embodied in Towards Zero being:

- Focus on managing by results using safety key performance indicators
- The need for forward-looking data and analysis to gain new insights
- There is a growing vulnerable road user problem
- Significant change management (to maintain behaviour and build forgiveness in the system)
- That leadership across agencies is vital
- Capacity and capability for change in engineering is a significant challenge and an opportunity (Cameron 2014).

According to Cameron (2014), the priority areas for Western Australia are:

- Intersections (42 per cent/killed or seriously injured (KSI), 83 per cent metropolitan);
- Run-off road crashes (35 per cent/KSI, 59 per cent regional);
- Motorcyclists: 17 per cent/KSI (+18 per cent relative to baseline);
- Pedestrians: 8 per cent/KSI (no change relative to baseline); and
- Cyclists: 5 per cent of KSI (+37 per cent relative to baseline).

The Victorian Safe System Road Infrastructure Programme (SSRIP) is another example of a broader implementation of a Safe System approach in Australia. Announced in March 2013 (**Box 4**), the SSRIP represents a shift to Safe System thinking with an emphasis on designing, ultimately, for no deaths or serious injuries, and maximising the road safety impacts of the safety budget. It includes \$1 billion funding over ten years (2013 to 2022) and will be subject to a major review after four years (Cockfield 2014).

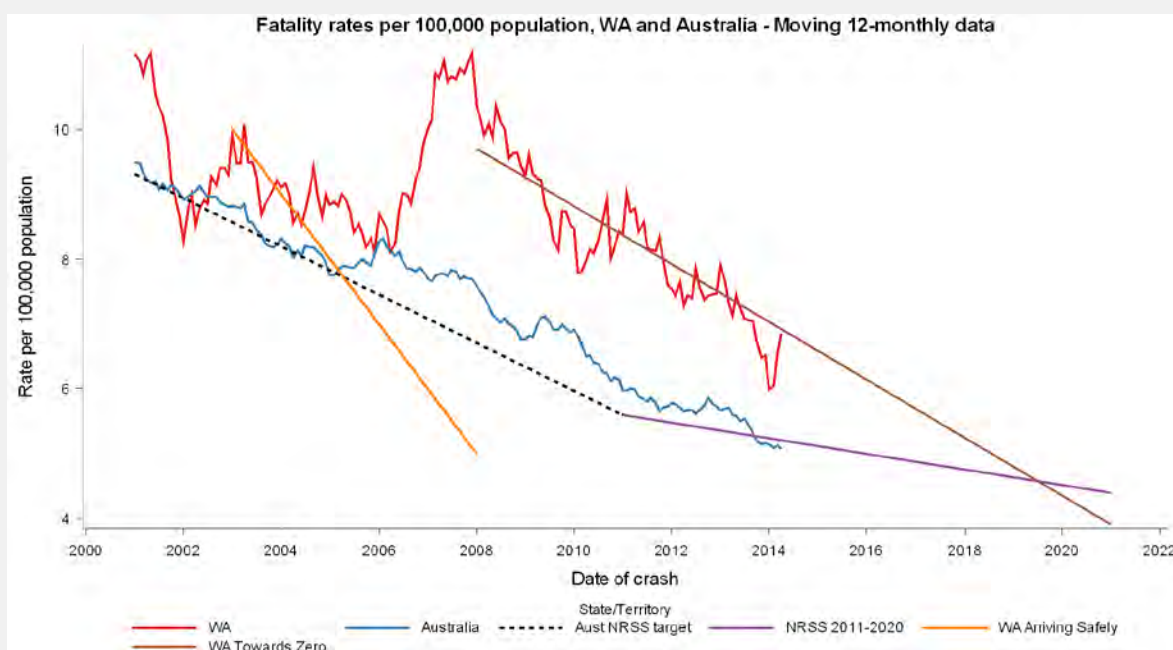
There is evidence that speed can be directly correlated with the overall level of road trauma. NSW provides an example from Australian experience with speed enforcement. In NSW, use of mobile speed cameras was discontinued between December 2008 and July 2010. A review found that the mobile speed cameras program contributed to a 19 per cent statistically significant reduction in fatalities throughout NSW in the first year of operation after re-introduction. This represents a saving of 89 lives and an estimated community saving of around \$575 million (NSW Centre for Road Safety 2014). BITRE (2014a) modelling confirmed that road fatalities increased during the period when speed cameras were discontinued.

Box 3 Towards Zero in Western Australia

Each year there are approximately 2500 serious casualties including 180 road deaths (year ending October 2014) in Western Australia. The annual cost of this trauma is approximately \$2.7 billion.

Western Australia's road fatality rate was 6.43 deaths per 100 000 population in 2013, down from 11.16 deaths per 100 000 population in 2007 (BITRE *Australian Road Deaths database*, November 2014). Western Australia's current road fatality rate is the second highest rate in Australia. It is improving but at a slower rate than other jurisdictions. There are geographic differences with the highest rates in the wheat belt east of Perth.

The Western Australian 'Towards Zero' vision is of a road transport system where crashes resulting in death and serious injury are virtually eliminated. This is a long-term strategy that is based on scientific research. According to Cameron (2014), Towards Zero will save 11 000 people from being killed or seriously injured (KSI) by 2020. The financial cost of the casualties avoided between 2008 and 2020 would have been \$6.6 billion (\$600 000/KSI), compared to the estimated cost of preventing them of \$2.5 billion (\$230 000/KSI).



Note 2020 estimate of Western Australia's Towards Zero road fatality rates calculated as a 40 per cent reduction of the annual average fatality count for 2005 to 2007, divided by the projected population for Western Australia in 2020. Fatality data from the BITRE Australian Road Deaths Database (extracted 25 September 2014).

Source Cameron 2014.

WA Road Safety Key Performance Indicator	Baseline		Change		Compared to WA
Fatal	200	161	-20%	120	+41
KSI	3074	2500	-19%	1844	+656
Alcohol Fatal	61	38	-38%	37	Below
Alcohol KSI	335	184	-45%	201	Below
Speeding Fatal	66	34	-48%	40	Below
Speeding KSI	490	238	-51%	294	Below
Seatbelt Fatal	47	24	-49%	28	Below
Seatbelt KSI	204	90	-56%	122	Below
Age 17-20 KSI	282	157	-44%	170	Below
>60 KSI	185	200	8%	111	+89
Pedestrian KSI	160	157	-2%	96	+61
Motorcyclist KSI	255	285	12%	153	+132
Cyclist KSI	76	107	41%	46	+60

Source Cameron 2014

Box 4 Victorian Safe System Road Infrastructure Programme

The Safe System Road Infrastructure Programme (SSRIP) is funded by the Transport Accident Commission and managed by VicRoads. It has two sub-programs: Safe System Transformations; and the Safer Road Infrastructure Program. There are 3 parts to the transformations sub-programme:

1. Intersection serious casualties
 - Mass action construction of roundabouts (high crash locations, outer metropolitan areas, and major rural intersections).
 - Elevated stop-lines at traffic signals.
2. Lane departure serious casualties by road class³
 - For M and divided A roads, continuous flexible barriers.
 - For undivided A and major B roads or other high volume roads, 2+1 or 2+2 treatments.
 - For minor B roads and C roads, lower speed limits together with localised safety treatments and township gateway treatments.
3. Pedestrian and cyclist serious casualties
 - Popular cycling routes.
 - Commercial areas and routes.

Under the SRIP sub-programme the current cost-effective approaches include:

- Black Spot intersection treatments.
- Run-off-road treatments for black lengths and long routes.
- Run-off-road mass action treatments (treatment of high risk curves, wide centre line treatments, and poles on high-speed urban arterials).
- Pedestrians and cyclists (black areas, painted medians along busy arterials). Complemented by the Local Government Grants Programme under which local authorities can apply for Transport Accident Commission funding for small-scale infrastructure treatments to address pedestrian and cyclist safety.

The strategic priorities for the SSRIP are:

- Maximise savings in serious casualties by a strategic focus on high yield network segments.
- Accelerating the transition to Safe System.
- Recognising trends towards gradually declining BCRs.
- Filling gaps in barriers on high volume 100+ kilometre an hour routes.
- Funding for local roads.
- Reducing unit costs and improving efficiency of delivery.
- Supporting innovation for Safe System outcomes.

Source Cockfield 2014

³ VicRoads' [Statewide Route Numbering Scheme](#): 'M' roads provide a consistent high standard of driving conditions, with divided carriageways, four traffic lanes, sealed shoulders and line marking that is easily visible in all weather conditions. 'A' roads provide a similar high standard of driving conditions on a single carriageway, but carry less traffic. 'B' roads are sealed roads, wide enough for two traffic lines, with good centre line and edge line marking, shoulders, and a high standard of guidepost delineation. 'C' roads are generally two lane sealed roads with shoulders.

International road safety trends

The OECD/ITF (2014a) report that the annual death toll in the IRTAD countries fell by nearly 40 per cent between 2000 and 2012, a reduction of more than 45 000 road deaths a year when compared to the level in 2000.

However, reductions in deaths of pedestrians, cyclists and motorcyclists have levelled-off and some increases have been recorded since 2009–10. Findings include:

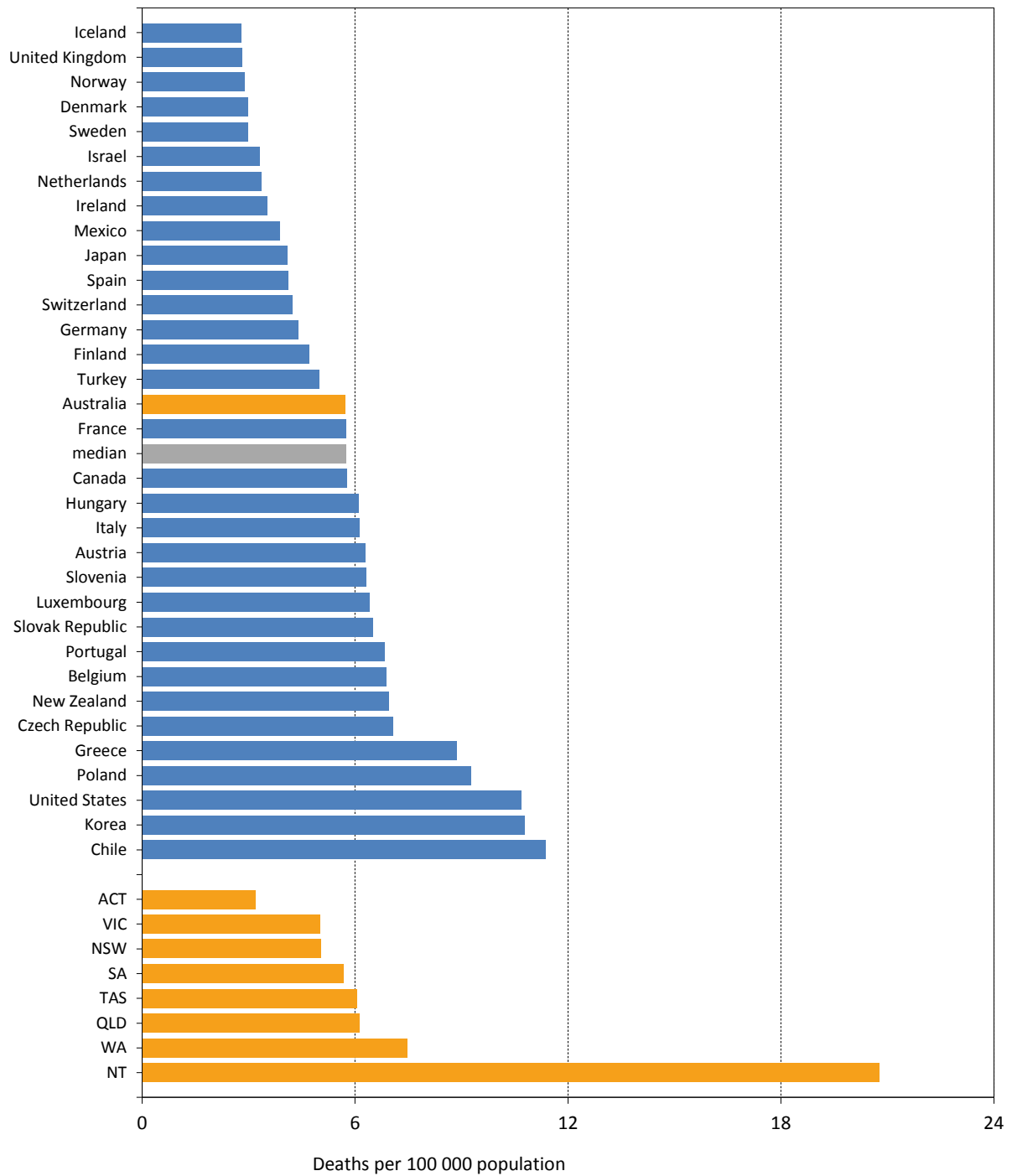
- Pedestrians are the largest group of vulnerable road users in most countries and alone account for around 19 per cent of all fatalities in IRTAD countries, following a slightly increasing trend. Close to 40 per cent of all pedestrians killed belong to the 65+ age group.
- The share of fatalities among elderly road users is slowly increasing in many IRTAD countries, reflecting the changing age structure of populations. In 2012, for European IRTAD members, the share of fatalities in the 65+ age group was for the first time in excess of 30 per cent. In Japan, this share is traditionally even higher, at around 55 per cent.
- Cycling is an increasingly popular alternative transport mode for short trips. The increased number of cyclists has been accompanied by a slowing of the rate of improvement, or even an increase in cycling fatalities over the past decade.
- Males account for the largest share of fatalities across all modes including pedestrians, with the lowest shares in Japan (around 65 per cent of all fatalities) and the highest in Europe (more than 75 per cent in 2012).
- Inappropriate road user behaviour, such as excessive and inappropriate speed, driving under the influence of alcohol and/or drugs and the non-use of safety equipment such as seat belts and crash helmets, remain important contributory factors in fatal crashes and for injuries.
- The costs to society of road crashes are substantial and constitute a major burden for economies. Although no common international approach to assess crash costs has been agreed, estimations range from 1 to 3 per cent of GDP depending on the methodology used, but could grow significantly as research on the consequences of the most severe injuries improves. (OECD/ITF 2014a)

Figure 1 compares OECD countries and Australian states and territories in terms of annual deaths per 100 000 population in 2012. Australia's rate of 5.72 was the 16th lowest rate out of the 33 nations with available data. The nations with the two lowest rates were Iceland (2.81) and United Kingdom (2.83).

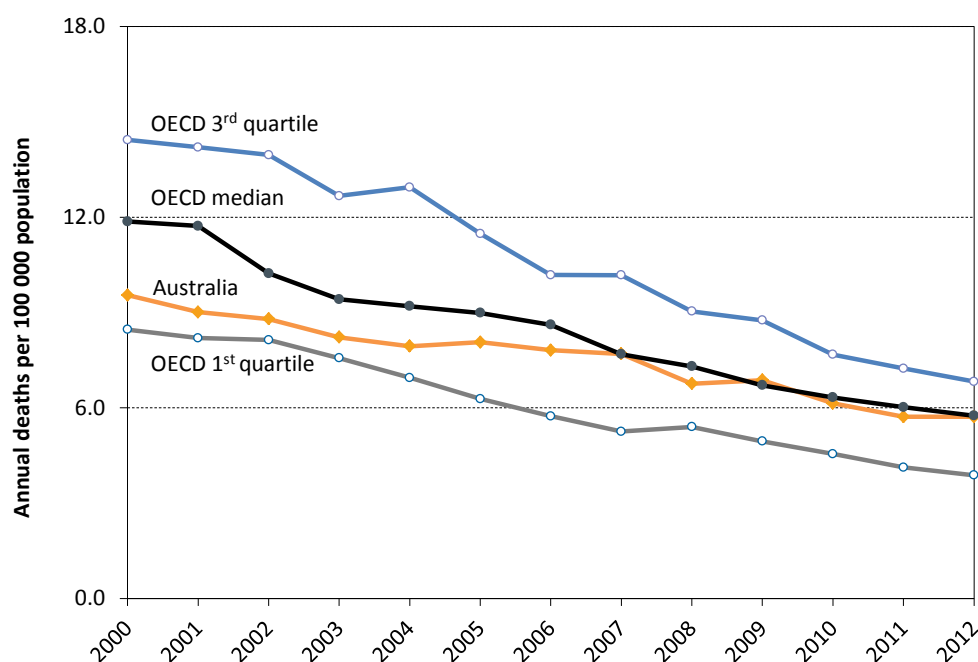
Australia's decline in the rate of deaths per 100 000 population between 2000 and 2012 has been similar to the OECD's median rate for several years (Figure 2).

Between 2003 and 2012, the annual population-standardised risk of a road crash fatality in Australia declined by a total of 30.5 per cent. Over the same period the OECD median rate fell 38.9 per cent.

Figure 1 Road deaths per 100 000 population: OECD countries and Australian states and territories, 2012



Source BITRE 2014c

Figure 2 Road deaths per 100 000 population: OECD and Australia, 2000 to 2012

Source BITRE 2014c

Trends for vulnerable road users in ten selected⁴ OECD countries since 2000 shows:

- For motor cyclists there was a declining ten year trend. Australia and NZ have flat or increasing trends, and the United States of America has a strong upwards trend. Motorcyclists account for 15–25 per cent of all fatalities in selected countries, with this proportion increasing.
- For pedestrians there were declining trends in all ten selected countries. Pedestrians now account for 15–25 per cent of all fatalities, with this proportion increasing or flat.
- For pedal cyclists there were mixed trends over the last ten years. Declining trends were evident in the Netherlands, Sweden, the United Kingdom, France and Japan. Pedal cyclists account for 4 per cent of deaths in Australia, and up to 16 per cent in Japan and 26 per cent in the Netherlands.

⁴ Ten countries were chosen to include countries with the lowest road fatality rates per 100 000 population, as well as countries similar to Australia in terms of economic development. Countries include Sweden, the United Kingdom, Netherlands and Japan with lower fatality rates than the OECD median, and the United States of America and South Korea with higher rates than the OECD median.

Australian road safety trends

This summary of Australian trends in road trauma uses these definitions:⁵

- A road crash is an unpremeditated event reported to police, or other relevant authority, that results in death, injury or property damage, and is attributable to the movement of a road vehicle on a public road.⁶
- A road death or fatality is a person who dies within 30 days of a crash as a result of injuries received in that crash. This excludes deaths resulting from deliberate acts and deaths due to natural causes.
- A serious injury (hospitalised injury) is a person who is confirmed as being admitted to hospital as a result of a crash, irrespective of the length of stay. The trends in hospitalised injury are based on Australian Institute of Health and Welfare estimates of the cases of hospital admissions and high threat-to-life⁷ sub-set of cases from traffic-related crashes.^{8,9}

Figure 3 shows trends in Australian road deaths, population and registered vehicles since 1950. Key trends in Australia between 1975 and 2013 include:

- Population has increased by 66 per cent (+1.3 per cent per year).
- Vehicle registrations have increased by 174 per cent (+2.5 per cent per year).
- Road crash deaths have decreased by 68 per cent (–2.9 per cent per year).
- Road deaths per 100 000 population have decreased from 26.6 to 5.1 (–4.2 per cent per year).

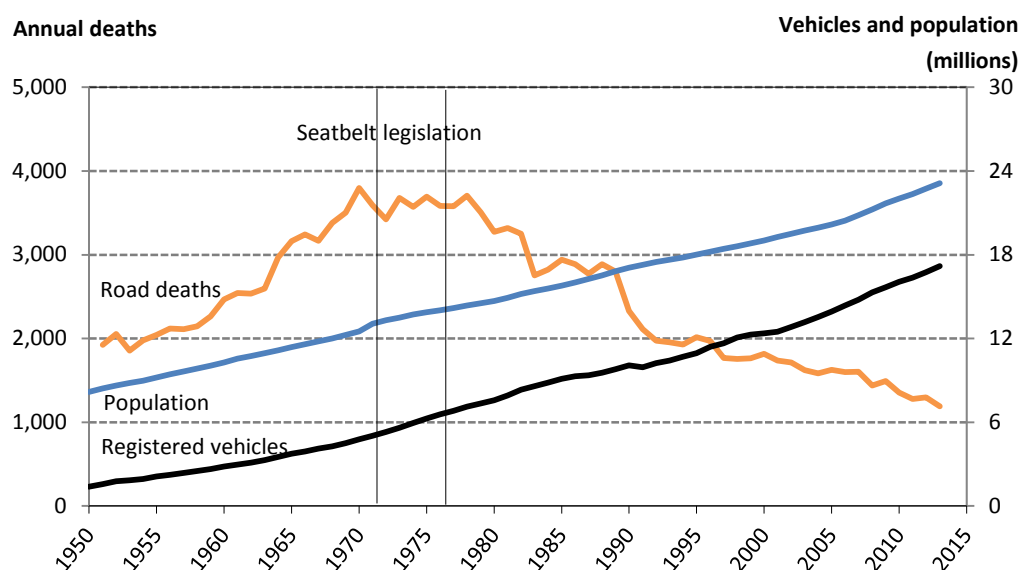
⁵ The terms ‘accident’ and ‘crash’ are often used interchangeably to describe vehicle incidents that result in injury or property damage on public roads. BITRE uses the term crash to illustrate that collisions are generally avoidable and not the result of chance events.

⁶ This definition means that trauma resulting from crashes in drive ways, car parks, roads that are closed to the public, and off road areas such as farms are not captured in crash data. Trauma from off road crashes is an important public safety issue. On average, seven pedestrians aged 0 to 14 years were killed each year (2001 to 2010) and 60 seriously injured each year (2002-03 to 2008-09) due to being hit by a four-wheeled motor vehicle moving around a home (BITRE 2012a).

⁷ High threat-to-life hospitalisations are the subset of hospitalised persons which comprises those with a survivability risk of less than 94 per cent (Henley and Harrison 2012). That is, the probability of dying is 6 per cent or more.

⁸ BITRE does not use crash data to report national injury trends for serious injury. This is because jurisdictions apply different injury definitions when recording crash data, and in most cases do not confirm that people who are taken to hospital after a crash are admitted.

⁹ Australian Institute of Health and Welfare hospital data includes a significant number of cases—particularly motorcyclists and pedal cyclists—where a crash has not been reported to police, and does not provide a direct link to crash data.

Figure 3 Australian road deaths, vehicles and population

Source BITRE 2014a; BITRE 2010c; Australian Road Deaths Database; Australian Bureau of Statistics Cat No. 3101.0 and 9309.0

The main influences this long term reduction are seat belts, random breath testing and speed cameras. BITRE (2014a) found that:

- Seat belts alone were responsible for reducing the safety-weighted road fatality rate from 38 per billion safety-weighted vehicle kilometres travelled (vkt) in 1965 to 12.5 in 2013—a 67 per cent reduction in the fatality rate.¹⁰
- Blood alcohol legislation and enforcement (random breath testing) has lowered the road fatality rate further, from 12.5 with seatbelts alone to 7.5 fatalities per billion safety-weighted vkt with alcohol limit enforcement (RBT) added—a 40 per cent reduction.
- Speed limit legislation and enforcement (speed camera checks) has lowered the road fatality rate still further, from 7.5 to 5 fatalities per billion safety-weighted vkt—a 33 per cent reduction.

¹⁰

The safety weighted vkt combines the two influences of distance driven and vehicle type. The more distance travelled, the higher the risk of a road crash occasioning fatalities. Vkt driven is modified by the type of vehicles doing the travelling. A motorcycle rider/passenger runs 26 times the fatality risk per kilometre of a car driver/passenger. A change in the percentage of motorcycle kilometres versus total kilometres will thus increase the risk of fatalities.

Over the ten years to June 2014, the key trends for road deaths were:

- The number of road deaths has reduced by 26.6 per cent.
- Road deaths per 100 000 population declined for all age groups over the decade, with the strongest falls for young adults (17 to 25) and children (16 years and under).
- There have been increased injuries and deaths for older road users. Deaths in the 55 and over age groups increased marginally over the decade, and the last few years have seen no reduction in age-specific rates per 100 000 population.
- Motorcyclist deaths increased by a net 8 per cent. After increasing by 24 per cent in the first half of the decade, motorcyclist deaths subsequently fell 13 per cent. Deaths in the 55 and over age group increased, now accounting for almost a quarter of all motorcycle deaths. The number of registered motorcycles doubled over the decade.
- Pedal cyclist deaths have increased since 2008, with significant increases in the last two years. Deaths in the 25 and under age group have fallen marginally and all older ages have seen annual deaths increase. The most consistent increasing trend is in the 55 and over age group.
- Pedestrian deaths have decreased by 20 per cent over the decade. While deaths have fallen in New South Wales and Queensland, there were no consistent falls in other jurisdictions.

Key trends for traffic-related hospitalised injuries since 2001 include:

- An increase in traffic hospitalised injuries of 22 per cent from 2002 to 2011.
- High threat-to-life injuries reduced by 21 per cent for children (to 2008-09).
- High threat-to-life injuries increased by 29 per cent for people aged 65 and over (to 2008-09).
- High threat-to-life injuries increased by 27 per cent for all age groups to 2008-09.
- Hospitalised motorcyclist injuries increased 52 per cent in the five years to 2008-09. Around half of all hospitalised motorcyclist injuries are from non-collision crashes.
- High threat-to-life injuries to pedal cyclists increased over 80 per cent between 2001 and 2009. More than half (55 per cent) of traffic-related hospitalised injuries to pedal cyclists are the result of non-collision crashes.¹¹
- High threat-to-life injuries to pedestrians remained largely stable between 2001 and 2009. Counts of all traffic related hospitalised injuries also remained stable in the five years to 2009.

Figure 4 gives a breakdown of Australian road deaths for common crash types.

The most common fatal crashes are run-off road crashes (35 per cent) and intersection and head on crashes (both approximately 20 per cent). While fatal run-off road crashes have decreased, the numbers of intersection crashes and head-on fatal crashes have barely declined over the five years.

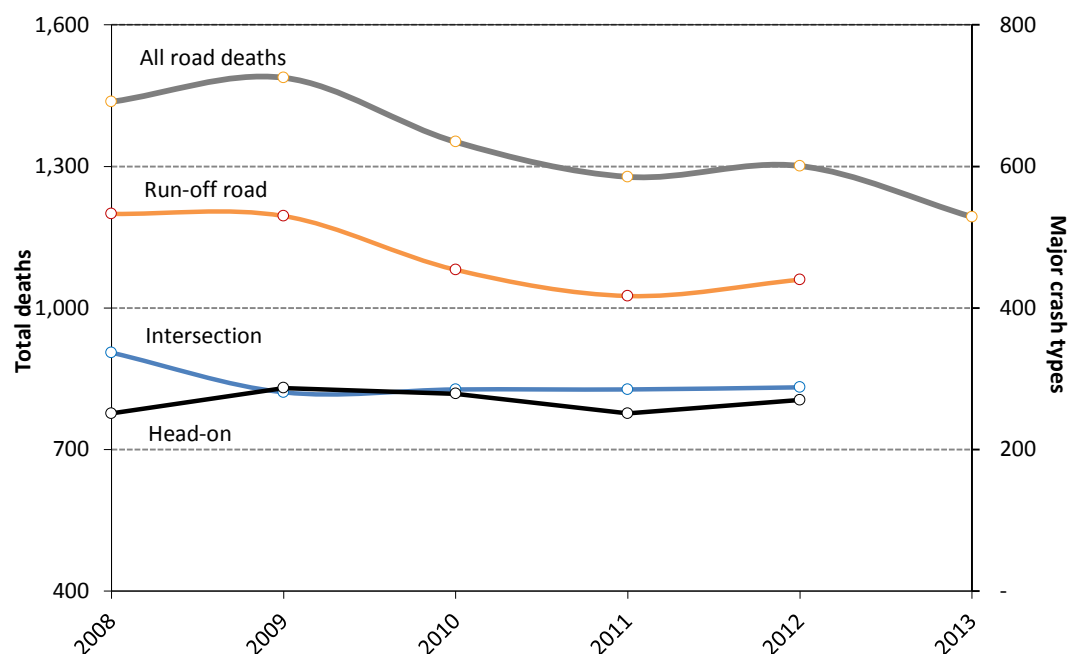
Vulnerable road users—motorcyclists, pedal cyclists and pedestrians—account for 44 per cent of deaths in intersection crashes. This compares with 29 per cent of deaths at non-intersection crashes.

Ninety per cent of fatal heavy truck intersection crashes involved a collision with another vehicle.

¹¹

Australian Institute of Health and Welfare unpublished data.

Figure 4 Australian road deaths by common crash types 2008 to 2012

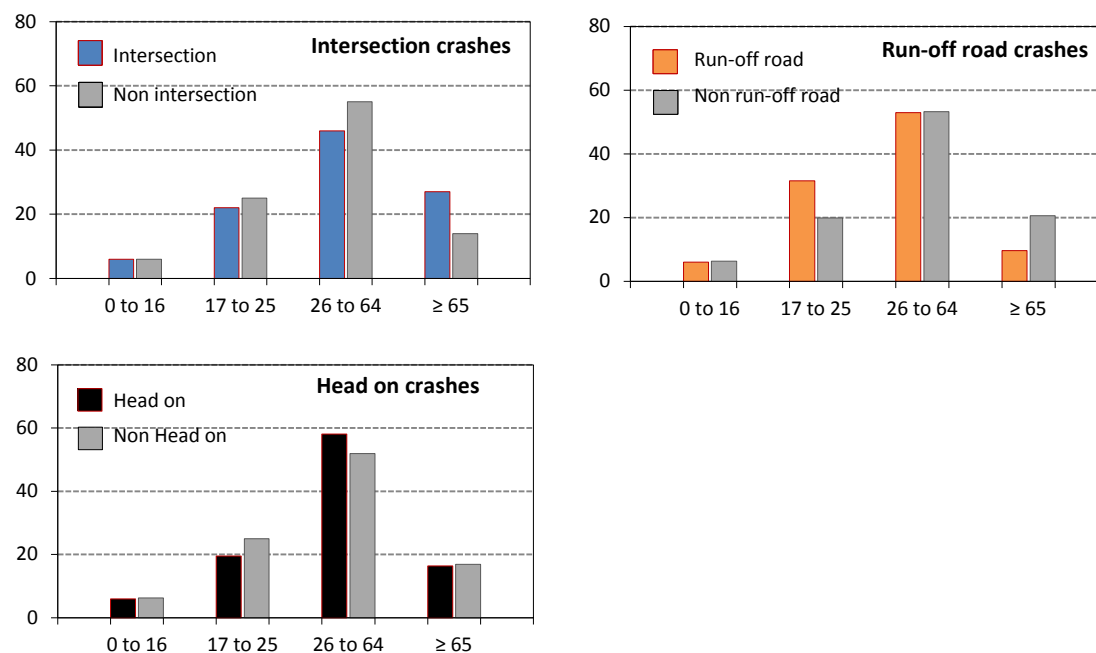


Source BITRE unpublished data (not available for 2013); Australian Road Deaths Database

Figure 5 breaks down these common types of crash by the age of people killed.

It shows that older drivers are more likely to be involved in intersection crashes than other major crash types, and that the 17 to 25 age group are more likely to be involved in run-off road crashes than other major crash types.

Figure 5 Age groups of people killed in major crash types 2008 to 2012 (proportions)



Source BITRE unpublished data; Australian Road Deaths Database

Figure 6 gives a breakdown of road deaths for crashes by Remoteness Area.¹² There are significant differences in trauma outcomes for major cities, regional and remote areas:

- Regional and remote areas account for 65 per cent of deaths and 40 per cent of hospitalised injuries.
- Major cities account for 35 per cent of deaths and 60 per cent of hospitalised injuries.
- Compared to the rates in major cities, annual hospitalised injuries per 100 000 population are around 50 per cent higher in regional areas, and double in remote areas.
- In major cities more than half (54 per cent) of deaths occur in 50 to 60 kilometre an hour zones.
- In regional areas more than half (52 per cent) of deaths occur in 100 kilometre an hour zones.
- In remote areas more than half (51 per cent) of deaths occur in 110 kilometre an hour zones.

Table 2 summarises road fatality rates per 100 000 population by remoteness area for 2008, 2010 and 2012. Rates have fallen in all areas, with the largest improvement in very remote areas.

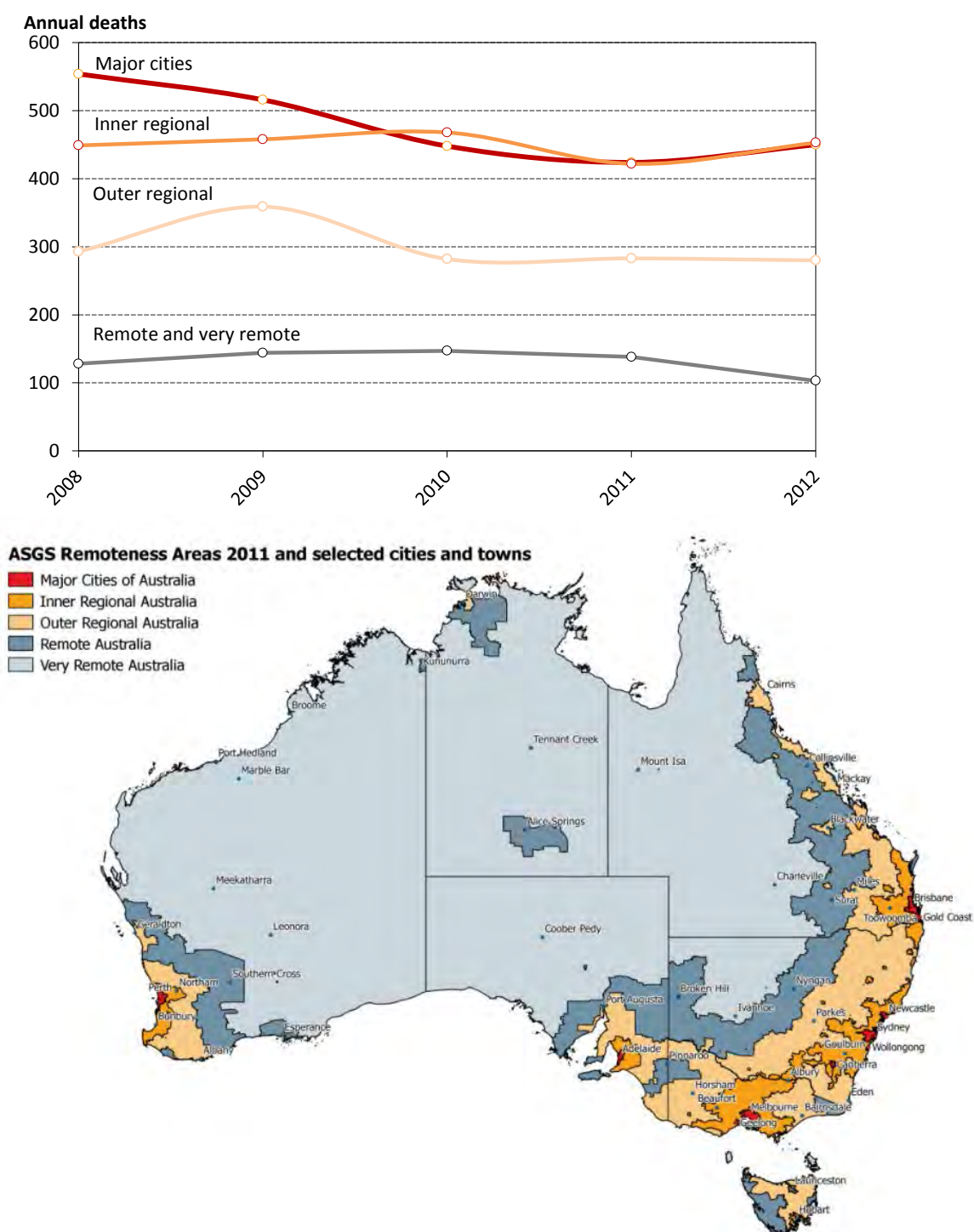
Major cities have the lowest rates at approximately 3 deaths per 100 000 population.

Regional areas are over-represented on the basis of road deaths per 100 000 population which is twice the national average (Table 2), with rates in remote areas four to five times the national average.

While this is likely due in part to the greater distances travelled by people in regional and remote areas compared to major cities, and more non-residents travelling through these areas, it also reflects riskier behaviours (see Figure 12: behaviour contributory factors by Remoteness Area).

¹² Remoteness Areas are defined in the Australian Statistical Geography Standard (ASGS). For more information see Australian Bureau of Statistics (2013).

Figure 6 Road deaths by Remoteness Area



Source BITRE unpublished data; Australian Bureau of Statistics 2013

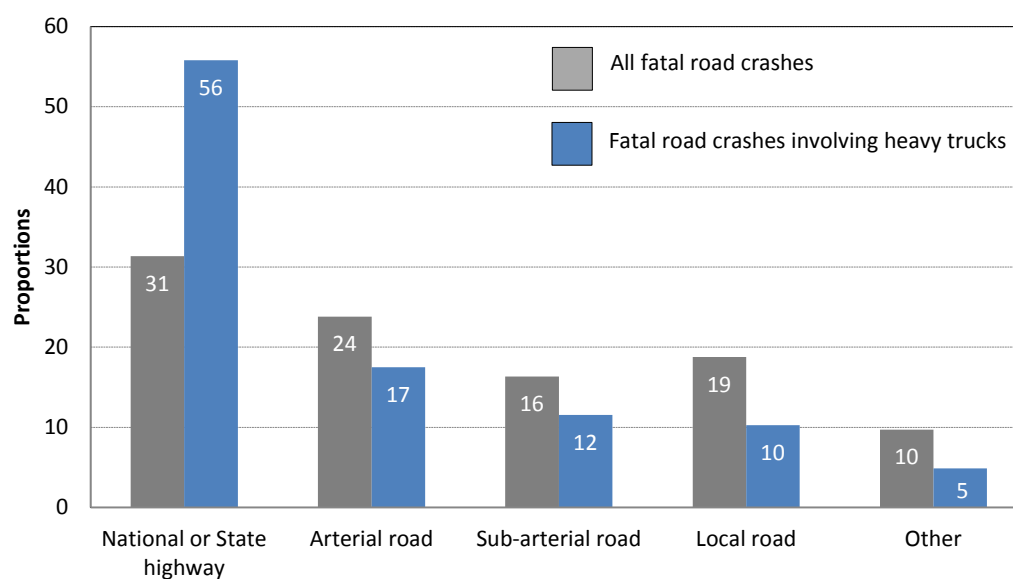
Table 2 Road deaths by remoteness class, deaths per 100 000 population

Remoteness Class	2008	2010	2012	2008–2012 change
Major Cities	3.7	2.9	2.8	-0.9
Inner Regional	11.5	11.5	10.9	-0.7
Outer Regional	14.9	14.0	13.7	-1.2
Remote	18.9	22.1	15.7	-3.2
Very Remote	38.2	39.5	27.1	-11.1
Australia	6.8	6.1	5.7	-1.0

Source BITRE unpublished data; Australian Road Deaths Database, June 2014

Figure 7 gives a breakdown of all crashes and heavy truck-involved crashes by road type:

- About one third of all fatal crashes are on national or state highways (compared to 56 per cent of crashes involving heavy trucks)
- Nineteen per cent of all fatal crashes were on local roads, with 10 per cent on other road types.
- Articulated truck crashes (not separately shown in Figure 7) were more likely to occur on national or state highways than crashes involving rigid trucks or buses.

Figure 7 Fatal crashes by road type, all crashes and heavy truck-involved crashes (proportions)

Note Other public roads include tracks, paths, connector roads, access roads and unknown road type.

Source BITRE unpublished data

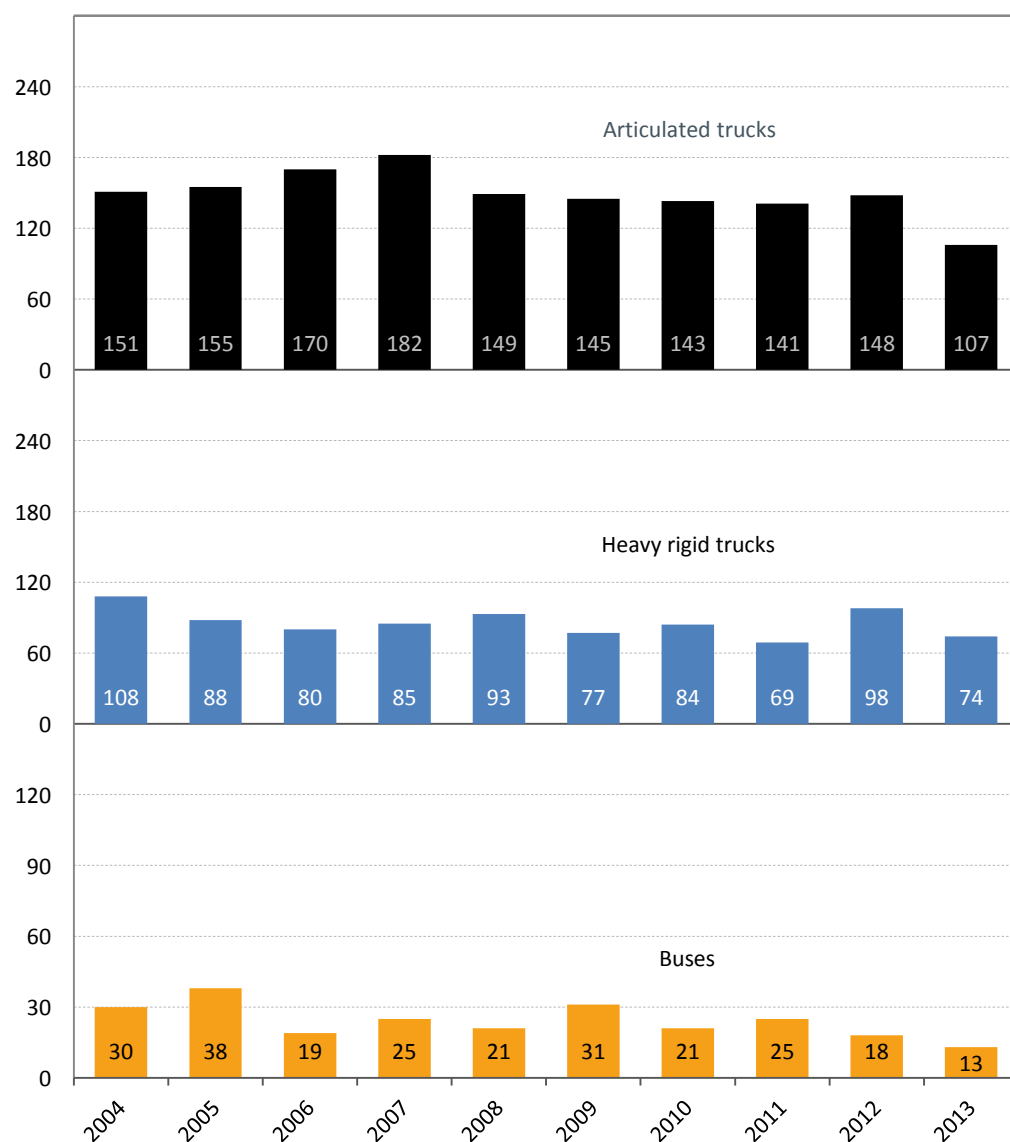
For crashes involving heavy vehicles between 2004 and 2013:

- Fatal crashes involving an articulated truck decreased 36.2 per cent, rigid truck fatal crashes decreased by 26.1 per cent, and the number involving a bus decreased by 63 per cent.
- Fatal crashes involving buses now account for approximately 1 per cent of all fatal crashes, down from 2 per cent ten years ago, and 7 per cent of all crashes involving a heavy vehicle.
- The number of registered articulated trucks grew by 37 per cent and the number of registered heavy rigid trucks increased by 19 per cent.

Figure 8 shows trends in the numbers of deaths from crashes involving articulated trucks, rigid trucks and buses. Deaths from crashes involving a heavy vehicle decreased 33.5 per cent from 281 to 187 between 2004 and 2013 (a trend reduction of 3.2 per cent per year).

Hospital admissions and high-threat-to-life cases from traffic crashes involving a heavy truck increased between 2002 and 2009 (not shown in Figure 8).

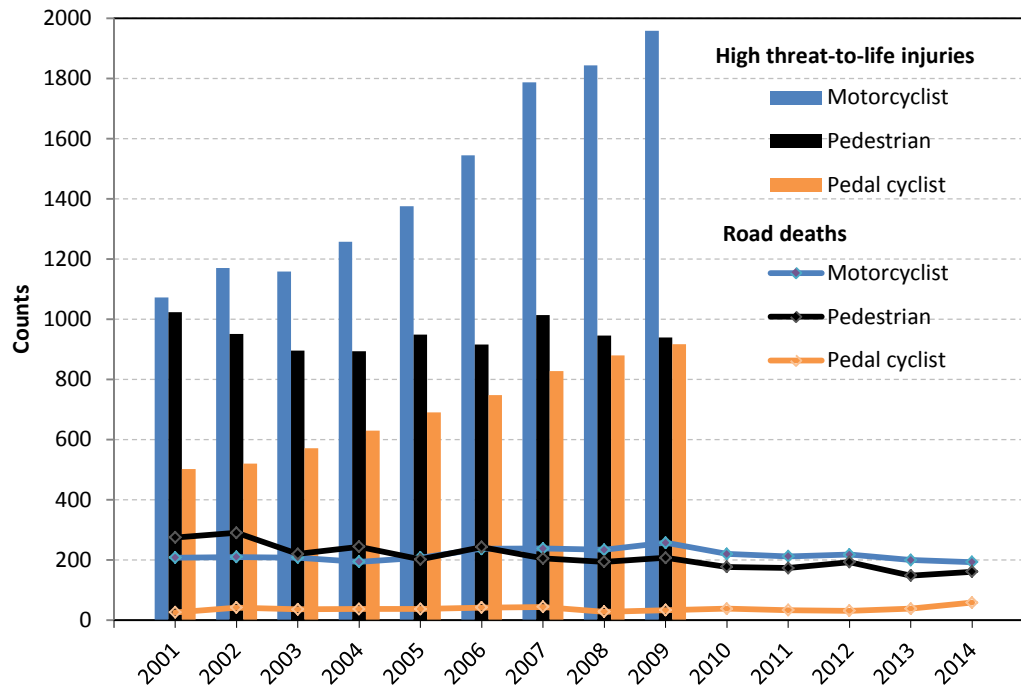
Figure 8 Deaths from crashes involving articulated trucks, rigid trucks and buses, 2004 to 2013



Source BITRE 2014b

Figure 9 shows trends in road deaths and high threat-to-life injuries to key vulnerable road user groups: motorcyclists, pedestrians and pedal cyclists.

Figure 9 Vulnerable road user groups: road deaths and high threat-to-life injuries



Source BITRE Australian Road Deaths Database; Australian Institute of Health and Welfare

For motorcyclists:

- Forty five per cent of motorcycle deaths occur in a major city compared with 27 per cent of vehicle occupant deaths. The proportion of motorcycle deaths occurring in regional areas is increasing.
- Sixty per cent of motorcycle deaths occur on local, sub arterial or smaller roads, and 40 per cent occur on highways or arterials. These proportions are reversed for vehicle occupant deaths.
- Forty two per cent of motorcyclist deaths occur in single-vehicle crashes. For vehicle occupant deaths the proportion is 55 per cent
- Twenty two per cent of all motorcyclist deaths occur on a weekend afternoon (noon to 6pm). This compares with 11 per cent of vehicle occupant deaths occurring on a weekend afternoon.

For pedal cyclists:

- Over 50 per cent of pedal cyclist deaths occur in a major city. For vehicle occupant deaths, this proportion is 27 per cent.
- Over half of all pedal cyclist deaths occur on local, sub-arterial or smaller roads. For vehicle occupant deaths the proportion is 40 per cent.
- Approximately 35 per cent of pedal cyclist deaths occur at an intersection. For vehicle occupant deaths, the proportion is around 20 per cent.

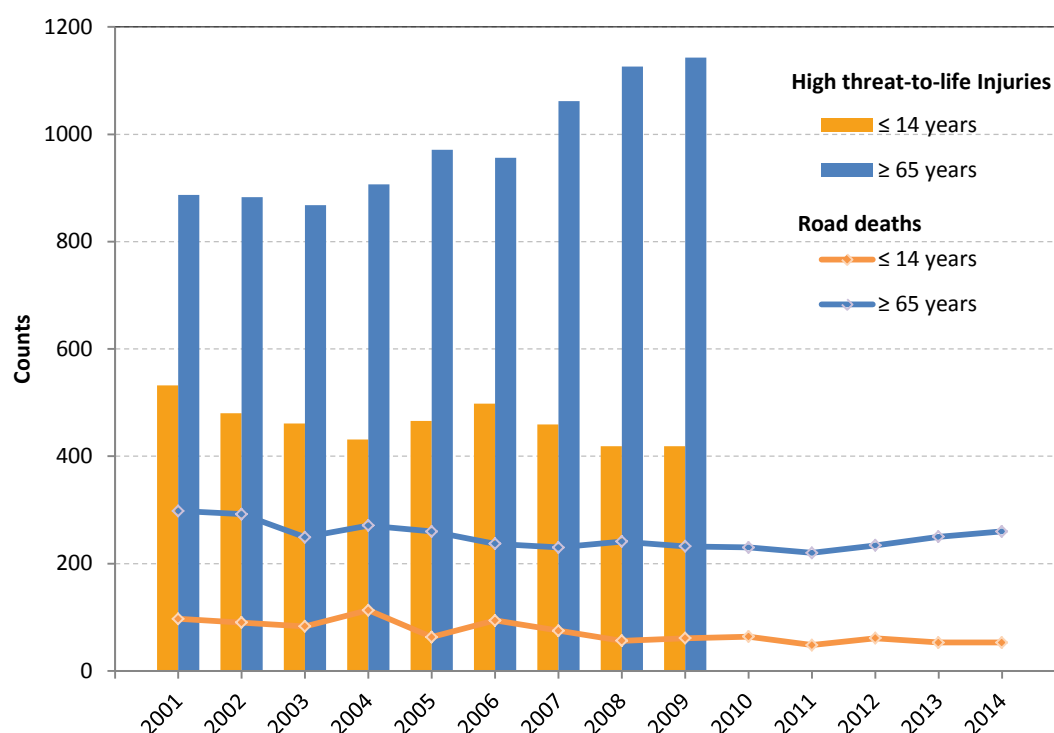
For pedestrians:

- Over 60 per cent of pedestrian deaths occurred in a major city. For vehicle occupant deaths, this proportion is 27 per cent.

- Half of all pedestrian deaths occur on local, sub-arterial or smaller roads. For vehicle occupant deaths the proportion is 40 per cent.
- Around 30 per cent of all pedestrian deaths occur at an intersection. For vehicle occupant deaths, the proportion is around 20 per cent.

Figure 10 shows road deaths and high threat-to-life injuries for vulnerable younger and older age groups. There is a decreasing trend for children under 15. Since 2011 there has been an increase in deaths for the 65 and older age group.

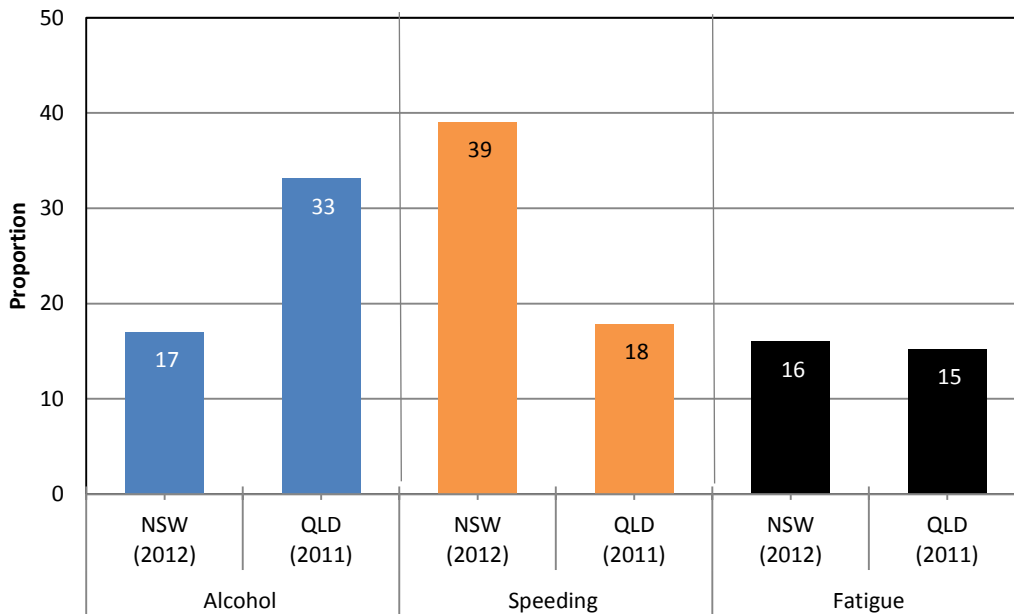
Figure 10 Vulnerable age groups: road deaths and high threat-to-life injuries



Source BITRE Australian Road Deaths Database; Australian Institute of Health and Welfare

Figure 11 shows State-reported contributory factors data for road deaths in NSW and Queensland for alcohol, speeding and fatigue.

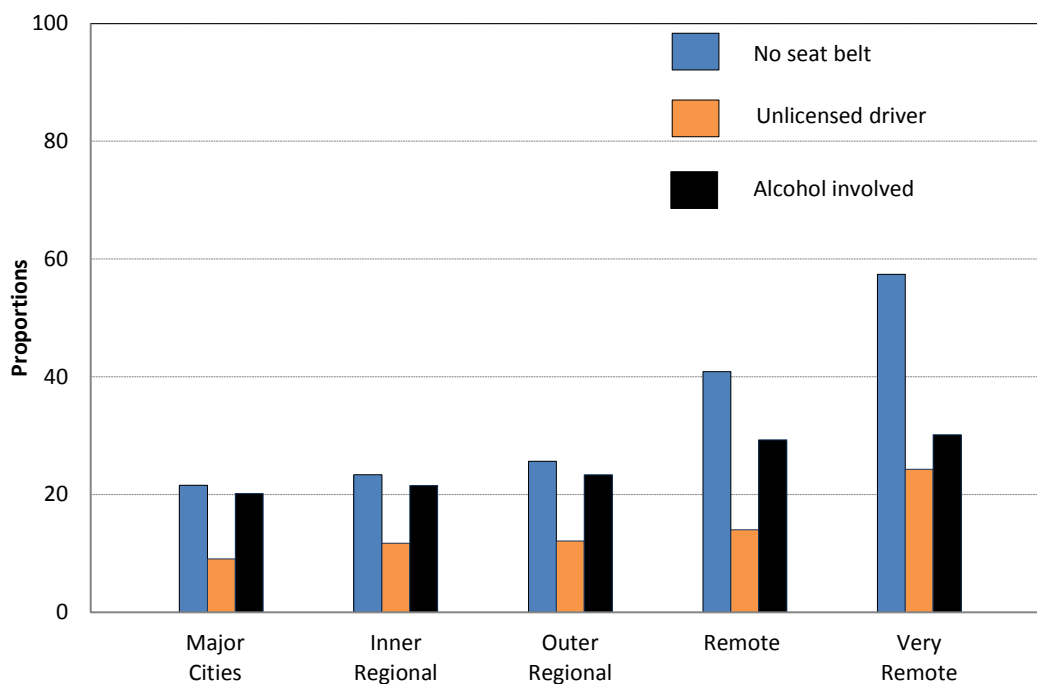
Figure 11 Contributory factors: alcohol, speeding and fatigue, NSW and Queensland, road deaths (proportions)



Note NSW and Queensland apply different definitions of speeding and fatigue.
Source Transport and Main Roads 2012; Transport for NSW 2013b

Figure 12 breaks down contributory factors for vehicle occupants killed by remoteness area. It shows a clear pattern of riskier behaviour in remote areas, with increased cases of no seat belt, unlicensed drivers, and alcohol involvement.

Figure 12 Behaviour contributory factors: vehicle occupant deaths 2008 to 2012 (proportions)



Note Excludes cases where the killed occupant's seatbelt use, drivers' licence status and blood alcohol content status were unknown.
Source BITRE unpublished data

Current measures to reduce road trauma

National programmes

Two Australian Government programmes specifically target road safety issues: the Black Spots Programme and the Heavy Vehicle Safety and Productivity Programme. Ex-post analysis of previous Black Spot Programme projects has found that the programme reduced fatal and casualty crashes at treated locations by 30 per cent (see Box 5 and BITRE 2012b).

The Australian Government has committed \$500 million to the Black Spot Programme from 2014-15 to 2018-19 (Department of Infrastructure and Regional Development 2014b).

In addition, there are safety benefits from the Australian Government's multi-billion-dollar annual roads investment in the national land transport network.¹³ These investments contribute to road safety outcomes, with safety benefits captured in project benefit-cost ratios.

However, trauma reductions are usually not separately identified, in large part because it is difficult to attribute reductions in trauma to specific projects or measures.¹⁴

Despite this, there is substantial evidence that these investments reduce road trauma, including:

- The estimated 70 per cent casualty reduction from roundabouts (including Black Spot program treatments, see Box 5).
- Divided roads: Austroads (2012) suggest that fatal crash rates per vehicle kilometre on freeways are between 60 and 80 per cent lower than rural undivided roads, and between 40 and 70 per cent lower on non-freeway divided carriageways. Box 6 provides examples of divided road projects which have reduced road trauma.
- Grade separation, where pedestrians, trains and road vehicles are physically separated (see Box 7: the Springvale Road level crossing grade separation).

¹³ In 2012-13, Australian Government investments in roads (including research and urban public transport) totalled \$3.2 billion (BITRE 2014d).

¹⁴ Ex-post project evaluations can help establish links between projects and trauma outcomes. An example is BITRE's evaluation of the Black Spot Programme (see **Box 5**).

Box 5 Australian Government Black Spot Programme

The Black Spot Programme is a road safety investment programme, targeted to those road locations where accidents are occurring. The programme funds measures such as traffic signals and roundabouts. The current eligibility criteria for the programme is for a location to have experienced 2 casualty crashes over 5 years or 0.13 casualty crashes per kilometre per year over 5 years.

Ex-post analysis of previous projects in the Australian Government's Black Spot Programme has found that the programme reduced fatal and casualty crashes at treated locations by 30 per cent.

In total, 2,578 projects approved between 1996-97 and 2002-03 were estimated to have saved approximately 30 lives per year. The analysis also found a high economic return for the programme, achieving a benefit cost ratio of 6.7 (using a discount rate of 4 per cent).

In terms of total trauma reduction, the most effective treatments were roundabouts, reducing casualty crashes by over 70 per cent. The next most effective treatments were new signals during the day, and altering traffic flow direction, both reducing crashes by more than 50 per cent.

In terms of benefit cost ratios, the best-performing treatment types were priority signs, and altering traffic flow direction.

Source BITRE 2012b

Box 6 Divided roads

Duplication of the Hume Highway between Sydney and Melbourne was completed in 2013. Fatalities have reduced from 71 in 1976 to 10 in 2013. As well as improved road conditions, safer vehicles, compulsory seat belts and better policing tools such as radar guns and breath testing have been introduced.

Reduction of road-related injuries and fatalities on the Hume Highway since 1976

<i>Year</i>	<i>Total crashes</i>	<i>Injuries</i>	<i>Fatalities</i>
1976	2499	1453	71
1983	2088	1142	49
1993	1409	716	30
2003	1332	715	14
2013	1062	648	10

Source [Roads and Maritime Services, Transport for NSW](#)

In 2011 the NSW Government estimated that duplicating the remaining Pacific Highway would avoid around 1000 fatalities and 7400 injuries between 2007 and 2050 (compared to a base case with no capital works from 1994). Estimates of the impact of two major Pacific Highway upgrades (Port Macquarie to Raleigh and Woolgoolga to Ballina) show 565 fatalities would be avoided between 2010 and 2048 (PwC 2011).

Analysis undertaken by ARRB Group for the National Roads and Motorists' Association (McTiernan 2014), suggests that the duplication of the Princes Highway between Oak Flats and Kiama in New South Wales resulted in 48 less casualty crashes between 2008 and 2012, compared to the five years prior.

Box 7 Springvale Road level crossing grade separation

Prior to the rail grade separation, the Springvale Road level crossing was one of the busiest in Melbourne with more than 50 000 vehicles, 200 trains and around 5000 pedestrians sharing the same road space every day at this location.

This level crossing had the worst safety record in Victoria, with a total of 42 incidents between 2001 and 2005. The next highest ranked crossing had 19 incidents.

A study was completed by Whitehorse City Council in 2008 which identified the issues affecting safety and traffic congestion on Springvale Road and at the Springvale Road/Whitehorse Road intersection. The study found that a rail grade separation (lowering the rail line below Springvale Road) was needed to eliminate the potential for conflict between trains, vehicles and pedestrians.

This project involved the rail grade separation of the Belgrave-Lilydale rail line below Springvale Road in Nunawading, removing the level crossing and constructing a new Nunawading Station.

Planning commenced in late 2008 and major construction commenced in July 2009. The grade separation was completed in January 2010, several months ahead of schedule. The final project cost was \$125.2 million with an Australian Government contribution of \$71.2 million and State Government contribution of \$54 million.

Source Department of Infrastructure and Regional Development

National Road Safety Strategy Road Safety Action Plan 2015-2017

Released on 7 November 2014 the NRSS Road Safety Action Plan 2015-2017 (Action Plan) supports the NRSS implementation, addressing key road safety challenges identified in the Austroads Review, and details priority national actions to be taken by governments over the three years.

Table 3 lists the action items and responsibilities from the Action Plan. While most actions are joint responsibilities, specific Commonwealth measures include:

- Pole Side Impacts standards: Implementation of the Global Technical Regulation on Pole Side Impact, as an ADR subject to RIS outcomes
- ABS for motorcycles: Development of a RIS in conjunction with VicRoads
- ESC for heavy vehicles: development of a RIS in close cooperation with the heavy vehicle industry (Hogan 2014).

Where relevant, BITRE's analysis is relevant to these Actions:

- Actions 1, 2 and 3 – Infrastructure measures
- Action 5 – BITRE has used willingness-to-pay based values for saving a life and preventing a hospitalised injury in its analysis of safety benefits
- Action 6 – the Base case includes the estimated impacts of side airbags
- Action 7 (ABS for motorcycles) and Action 8 (ESC for new heavy vehicles): While relevant, the Base Case does not take into account these actions. Implementation of these measures is subject to Regulatory Impact Statement outcomes.

Table 3 National Road Safety Strategy Action Plan 2015-2017

<i>Prioritising investments in infrastructure:</i>	<i>Responsibility</i>
1. Prioritise and treat high-risk rural and urban roads, focusing on the main crash types and vulnerable road users.	States and territories
2. Assess road safety risk on state and territory controlled roads carrying the highest traffic volumes.	States and territories
3. Review road infrastructure safety programmes to establish best practice processes for identifying, prioritising and developing projects based on fatal and serious casualty reduction criteria.	Commonwealth, States and territories
4. Establish an assessment framework and training package to help translate current Safe System infrastructure knowledge and research into practice.	States and territories
5. Apply national willingness-to-pay values for infrastructure investment and other road safety project appraisals.	Commonwealth, States and territories
<i>Actions to improve the safety of the vehicle fleet:</i>	
6. Mandate pole side impact occupant protection standards for new vehicles (subject to Regulatory Impact Statement outcomes).	Commonwealth
7. Mandate anti-lock brake systems for new motorcycles (subject to Regulatory Impact Statement outcomes).	Commonwealth
8. Mandate ESC for new heavy vehicles (subject to Regulatory Impact Statement outcomes).	Commonwealth
9. Promote the market uptake of new vehicle technologies with high safety potential.	Commonwealth, States and territories
<i>Encouraging safer road use</i>	
10. Strengthen speed compliance provisions in the Heavy Vehicle National Law (HVNL).	National Transport Commission
11. Implement measures to improve heavy vehicle roadworthiness.	National Transport Commission and National Heavy Vehicle Regulator
12. Expand the application of lower speed limits in areas with high pedestrian and cyclist usage.	Austroads, States and territories
13. Implement programmes to build community understanding and support for effective speed management measures.	States and territories in consultation with local governments
14. Continue to review and adjust alcohol interlock programmes to improve their effectiveness in addressing convicted drink driving offenders.	States and territories
15. Strengthen national police enforcement operations to improve road safety compliance.	States and territories, ANZPAA
<i>Advancing the Safe System</i>	
16. Establish an operational framework to enable the introduction and operation of Cooperative Intelligent Transport System safety applications in Australia.	Austroads
17. Implement and promote a range of Safe System demonstration projects in urban settings, with a focus on the safety of vulnerable road users.	States and territories in consultation with local governments
18. Encourage private sector organisations to implement best practice fleet and workplace safety policies.	Commonwealth, States and territories
19. Examine and progress options to improve measurement and reporting of non-fatal and disabling injury crashes, particularly through the development of matched crash and hospital database systems.	Commonwealth, States and territories, Austroads

Source Transport and Infrastructure Council 2014

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Chapter 2 Measures with the most potential to reduce road trauma

BITRE commissioned consulting firm Jacobs to interview road safety experts to identify initiatives to reduce road deaths and injury. Collectively, over 400 initiatives were suggested (Jacobs 2014). The survey responses were grouped by the Safe System cornerstones of safe people, safe vehicles, safe speeds, and safe roads and roadsides, as well as measures to advance the Safe System approach.

A workshop was held on 16 May 2014 to narrow this list to the initiatives with the most potential to save lives and reduce injuries. Participants were divided into groups to review key survey themes by cornerstone. The process used to help filter themes involved the groups doing the following:

- Reviewing the key themes identified as part of the survey;
- Identifying any themes that might be missing;
- Estimating the potential outcomes of responding to the key theme; and
- Identifying likely level of resources to implement.

The working groups were then asked to identify the highest ranking themes within the cornerstone. This required the groups to make an estimate of the outcomes expected, and the investment and resources needed to implement each of the measures (figures 5.2.1 to 5.2.5 in Jacobs 2014).

Each of the groups was then asked to identify more detail around the most important initiatives, including additional initiatives it considered more relevant, and to develop specific initiatives and provide additional information regarding benefits, resources required, evidence to support benefits, and risks associated with implementation.

At the completion of the session, workshop participants voted to give an indication of the level of group support for specific initiatives. The voting gives an indication of the perceived relative value of the initiatives based on the views of the workshop participants.

The top ten initiatives ranked by number of votes are summarised in Table 4, with a number of initiatives receiving the same number of votes. For a full list of initiatives proposed and voting results see Table 5.1 in Jacobs (2014).

Table 4 Summary of Workshop voting on initiatives to reduce road trauma

<i>Initiative</i>	<i>Number of votes</i>
1. Improved road infrastructure safety standards (26) Safety in capital investment (1)	27
2. Research Platform	19
=3. Management capacity	13
=3. Safer Intersections–new/existing	13
5. Distraction (BAD) mobile phone usage: enforcement	12
=6. Police enforcement to maximise general deterrence	11
=6. Autonomous braking vehicle based crash avoidance	11
=8. Leadership	10
=8. Drug driving initiatives	10
=8. Insurance Incentives	10

Source Jacobs 2014

Initiatives such as the development of a research platform (second), management capacity (equal third) and leadership (equal eight), while ranked highly by the group, are not amenable to economic analysis and have not been assessed in this report. To the extent that initiatives in these areas are critical to the success of the NRSS, they have been considered by Austroads in the review of NRSS implementation.

The top five measures from the workshop—excluding research platform, management capacity and leadership initiatives—were:

1. Infrastructure (28* votes 1st).
2. Intersections (13 votes = 3rd).
3. Mobile phones / distraction (5th).
4. Police enforcement (11 votes = 6th).
5. Autonomous braking (11 votes = 6th).

Although enforcement is very important to ensuring key measures—seatbelts, random breath testing, detecting speeding, unlicensed driving and mobile phone use—are effective, it is not amenable to analysis.

The remaining measures are assessed in this report.

Costing the full impacts of road trauma

BITRE (2010a) estimated the social cost of road crashes at \$27 billion annually, the equivalent of 18.3 per cent of health expenditure and 1.8 per cent of Gross Domestic Product in 2012-13 (Australian Institute of Health and Welfare 2014).

The impacts of road trauma include private costs to individuals and their families, as well as impacts on hospitals and the wider health system, workplaces, governments and other road users. These social impacts of the cost of trauma are borne by insurers, employers, all levels of government, emergency services, correctional and road authorities, and others.

In order to capture the full impacts—both private and social—in this review, BITRE has used a revised method of valuing avoided trauma that combines values derived for an individual's willingness-to-pay (Hensher et al 2009) with the social costs of road trauma as estimated by BITRE (2010a). The approach to costing avoided road trauma is detailed in Appendix A.

BITRE has used a willingness-to-pay approach to valuing the avoided human costs from road trauma¹⁵ consistent with the NRSS 2011-2020 statement that:

“Investment decisions are informed by the estimated value of expected safety benefits. However, such estimates are influenced by the particular methods used to place an economic value on human life. Best practice in this area favours the use of a valuation method known

¹⁵ BITRE (2010a) estimated that the annualised cost of crashes using a modified human capital approach was \$17.85 billion in 2006; and that using a willingness to pay based value of approximately \$6 million (Hensher et al 2009) increased this to \$27.1 billion (BITRE 2010a, Table 7.10).

as the willingness-to-pay approach, which tends to produce higher estimates than other, more traditional, methods. ... There is a need for Australia to develop and adopt suitable willingness-to-pay estimates at a national level.” (p. 49)

The stated willingness-to-pay is expected to capture the additional costs that would be borne by the average road user in the event of a road crash leading to death or hospital admission. These private costs are assumed to include individual’s losses in income, and non-economic or non-pecuniary costs such as pain and suffering, but exclude the wider social impacts not incurred by the individual and their families.

Consequently, there is likely to be a significant difference between an individual’s willingness-to-pay to avoid a serious casualty and society’s (higher) willingness-to-pay to avoid a serious casualty. The latter is the appropriate cost to consider when assessing counter measures to prevent road trauma.

Assessing benefits and costs of suggested measures

BITRE’s initial assessment of the top ranking measures takes account of:

- Expected timing of some measures currently being implemented.
- Expected future changes in trauma outcomes that are expected with the current approach.

The primary basis of assessment is the expected reduction in road trauma outcomes—that is, the avoided loss of life and injuries—compared to what would have happened otherwise (the base case). The base case projects future levels of road trauma taking account of population and economic growth as well as technologies in passenger vehicles such as ESC, side airbags and Autonomous Emergency Braking (AEB).

Taking account of both costs and benefits is important as it is likely that different measures could achieve similar reductions in trauma but with very different costs.

BITRE has assessed measures based on expected safety outcome (benefit) which is the avoided number of road deaths and hospitalised injuries as a proxy measure of serious injury outcomes, combined with the expected implementation costs where these can be identified.

It should be noted that only real losses are considered and not financial transfers. Counting both income losses and compensation payments would result in double counting.¹⁶

Key assumptions used in the costing are:

- A real, risk-free discount rate of 4 per cent to reflect social time preference. This is broadly consistent with the Department’s guidelines which recommend rates of 4 per cent and 7 per cent when calculating benefit cost ratios (Department of Infrastructure and Regional Development 2014a).

¹⁶

Financial transfers include payments from insurers for loss of personal income or vehicle repairs, and government payments to people who suffer an on-going disability as a result of an injury from a road crash. In an economic costing framework, the losses are attributed to the individual rather than the financial loss to company shareholders or taxpayers.

- The social willingness-to-pay to avoid road trauma is \$7.7 million for preventing a fatality and \$259 000 for preventing a hospitalised injury (2014 dollars) (see Appendix A).

The base case

To assess the impact of any one proposed measure it is necessary to compare the expected road trauma outcomes with the new measure (a scenario) against what is expected happened without the proposed measure (the base case).

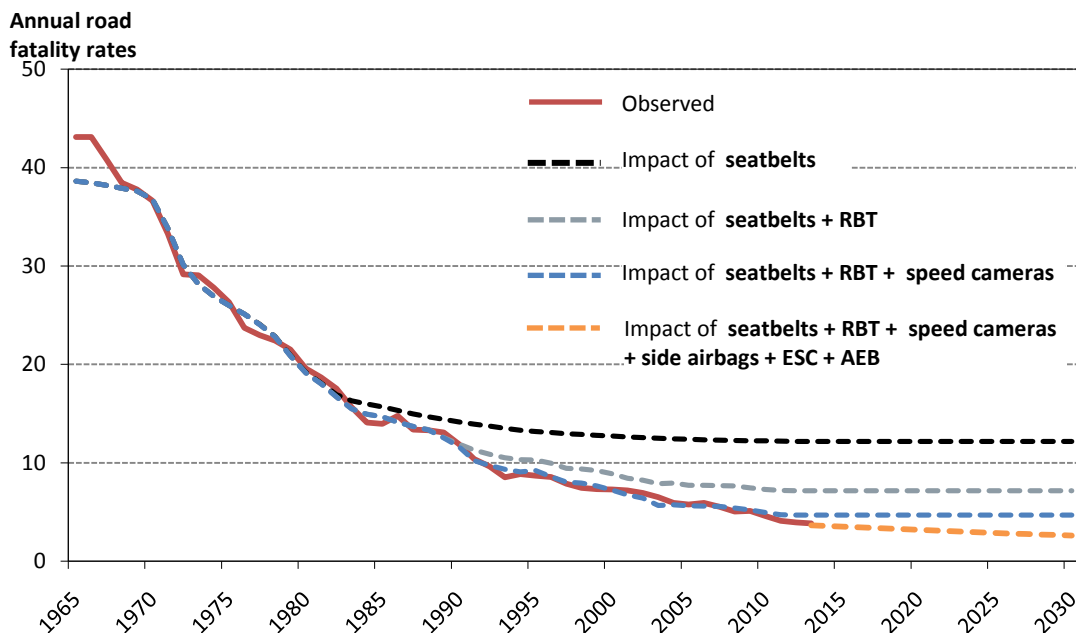
Defining a base case is critical as there is on-going road investment, better vehicles, improved enforcement, education and licencing measures, as well as demographic and economic changes that influence the number and severity of crashes, and hence the expected level of future road trauma.

This includes expected trends in the numbers of crashes, deaths and injuries over coming decades.

Figure 13 shows the decline in the annual road fatality rate to 5 deaths per 100 000 population in 2014 and BITRE projections to 2030. The projection in Figure 13 takes the projections in BITRE 2014a as a baseline, and adds in the likely impacts for light passenger vehicles of side airbags, ESC and AEB.

As can be seen in Figure 13, seat-belt use reached saturation levels in the 1990s. Improvements in road trauma since then have related to blood alcohol testing and speed enforcement.

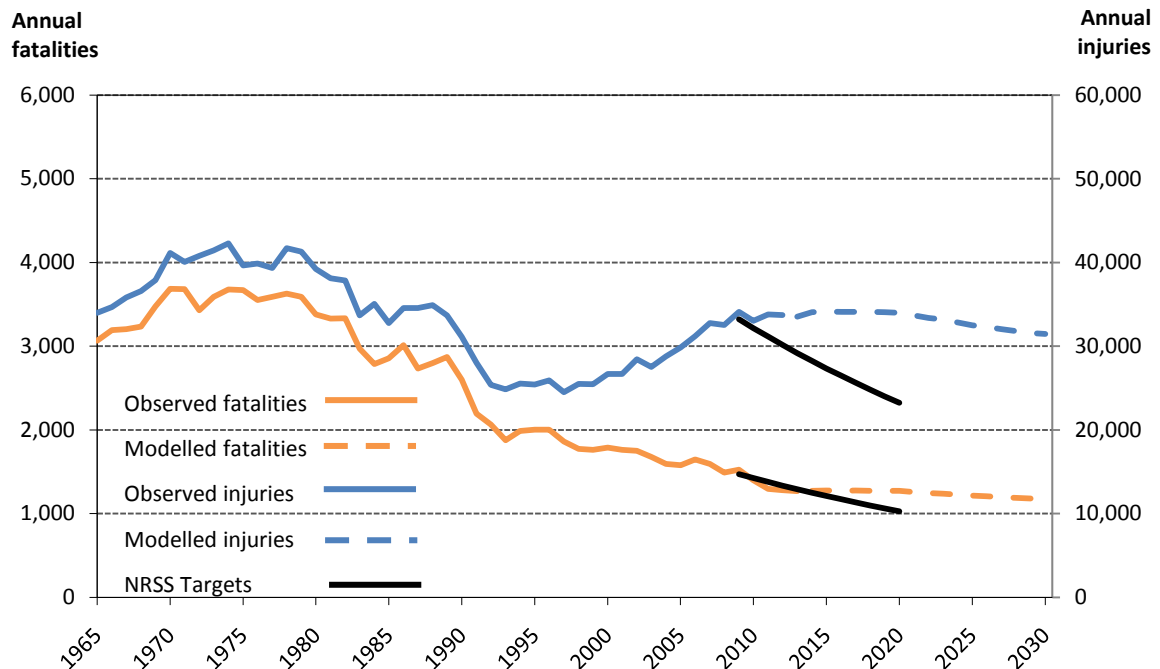
Figure 13 Actual and projected annual Australian road fatality rates: the impact of seatbelts, RBT and speed cameras, 1965 to 2030



Source BITRE 2014a Figure 4.1 and Figure 4.2, BITRE estimates

Figure 14 gives projections of increases in road deaths and road injuries¹⁷ based on expected future growth in vehicle registrations, population and vehicle-kilometres travelled (BITRE 2014a).

Figure 14 Actual and modelled Australian road deaths and injuries^a, 1965 to 2030



a Road injury series from BITRE 2014a.
Source BITRE 2014a Figure 4.3 and Figure 4.6, BITRE estimates

Future crash numbers will depend on a number of factors, including:

- Growth rates in travel of each road user type (which are largely driven by factors outside the influence of road safety policy).
- Vehicle technologies, many of which would be taken up to some extent even without active policy encouragement.

BITRE projects that growth in vehicle travel will average 1.5 per cent per annum over the next 20 years (BITRE 2014a). This is consistent with unchanged vehicle use per person. For vulnerable road user groups, motorcycle is assumed to average 1.8 per cent per annum over the next 20 years. No adjustment has been made for expected changes in exposure for other vulnerable road user groups (such as an increase in road users 65 years and over).

This base case is built on BITRE (2014a) which looked at the expected uptake of various safety-enhancing vehicle technologies and projected fatality and injury rate, assuming no major change in roads, vehicles and driver behaviour. BITRE (2014a) projected that the impact of the measures considered would have been fully incorporated by 2014, with crash rates per vehicle kilometre

¹⁷ See BITRE (2014a) for a discussion of the historical road injury series.

projected to be steady from 2014 on, but did not attempt to measure the impact of technologies such as ESC, side airbags and AEB.

BITRE has updated these projections for this report, with the base case now taking into account the likely impact in light passenger vehicles of these technologies:

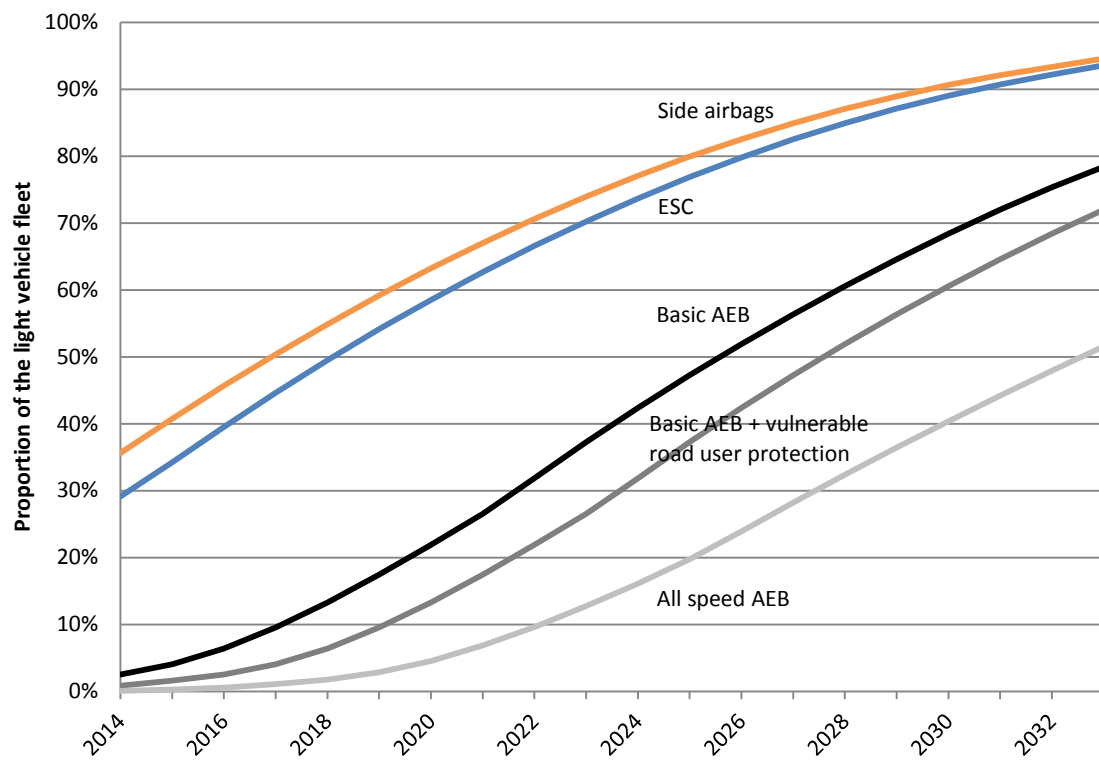
- ESC, primarily reducing run-off-road crashes. The base case assumes that from 2014, 100 per cent of new passenger vehicles are equipped with ESC. ESC is a requirement for new models of cars, passenger vans and sports utility vehicles from 1 November 2013. ESC and Brake Assist Systems will be compulsory from 1 November 2015 for new models of light commercial vehicles, with Brake Assist Systems also compulsory for new models of light passenger vehicles from the same date (Minister for Infrastructure and Regional Development 2013).
- Side airbags, primarily reducing the severity of side impact crashes. Side impact crashes are assumed to account for 20 per cent of road deaths in Australia (United Nations 2013). Fitzharris et al (2013) show that the proportion of road deaths that are due to side impacts internationally ranges from 6 per cent to 25 per cent. They estimate that throughout the first 30 years, the improved side impact safety requirements demanded by the Pole Side Impact Global Technical Regulation¹⁸ will translate to 761 fewer passenger car and light commercial vehicle fatalities.
- AEB primarily reduces collision crashes. The base case assumes gradual introduction of a range of AEB systems, with the projection taking into account the type of AEB system and relevant crash sub-type.

The base case projections used in this report do not take into account ESC for heavy vehicles and ABS for motorcycles.

For this analysis, BITRE has assumed that new light vehicles travel the same distance on average as the fleet as a whole. As new cars are used disproportionately intensively, this leads to a conservative estimate of the impact of new technologies on overall casualty rates.

Figure 15 shows the projected proportions of the light vehicle fleet with these technologies. It takes many years for the proportion of equipped vehicles to increase as old vehicles are scrapped and are replaced with new vehicles.

¹⁸ The Global Technical Regulation (GTR) on Pole Side Impact will set performance criteria for passenger cars and light commercial vehicles in a pole side impact test. The GTR will require improved side curtain airbags/thorax protection (Fitzharris et al 2013).

Figure 15 Proportion of the Australian light vehicle fleet with key vehicle safety technologies

Source BITRE estimates

These long lags mean that—despite ESC being mandatory from 1 November 2013 for new models of light passenger vehicles and 1 November 2015 for light commercial vehicles—it takes until 2018 before 50 per cent of the light vehicle fleet is equipped with ESC.

In the case of AEB, in the base case it takes until 2025 before 50 per cent of the light vehicle fleet is equipped with a basic AEB system.

The assumptions about the resulting reductions in fatality risk are detailed in Table 5.

Table 5 Assumptions for impact of new technologies on fatality risk

<i>Safety feature</i>	<i>Relevant crash types</i>	<i>Proportion of deaths accounted for by relevant crash types¹</i>	<i>Reduction in fatality risk (per cent)</i>	<i>Overall reduction in fatality risk (per cent)</i>
ESC	Run-off road	38	53 ²	20
Side airbags	Side impact	20	51 ³	10
Basic AEB Systems	Low speed collisions	10	20	2
AEB protection for vulnerable road users (at low speeds)	Low speed collisions involving cyclists and pedestrians	10	20	2
High speed AEB	Higher speed collisions (including cyclists and pedestrians)	34	20	7

1 BITRE unpublished data and United Nations 2013

2 Scully and Newstead 2007, citing a US study

3 D'Elia, Scully and Newstead 2012

Source Scully and Newstead 2007; D'Elia, Scully and Newstead 2012; BITRE unpublished data

Figure 16 shows the resulting impacts on overall road fatality rates, relative to a base case with no additional measures. The modelled impact of each technology in light passenger vehicles is the incremental effect, over and above the impact of previous technologies. For example, the effect of AEB is modelled taking into account the expected reduction in road deaths from side airbags. The interaction of ESC with AEB was not taken into account, as ESC is assumed to primarily affect run-off-road crashes.

Over the next 20 years, BITRE projections suggest that the road fatality rates per vehicle kilometre travelled will decline at an average of 1.9 per cent per annum.¹⁹

This is slower than the 4 per cent per annum average for cars from 1992 to 2012 (BITRE 2014a).

As several measures that might reduce trauma rates are not included in this base case, it should not be taken as a forecast of the most likely rate of fatality risk per kilometre in future years. Rather, it is a conservative projection of the expected reduction in fatal risk taking into account the impacts of vehicle measures already implemented and expected future economic activity.

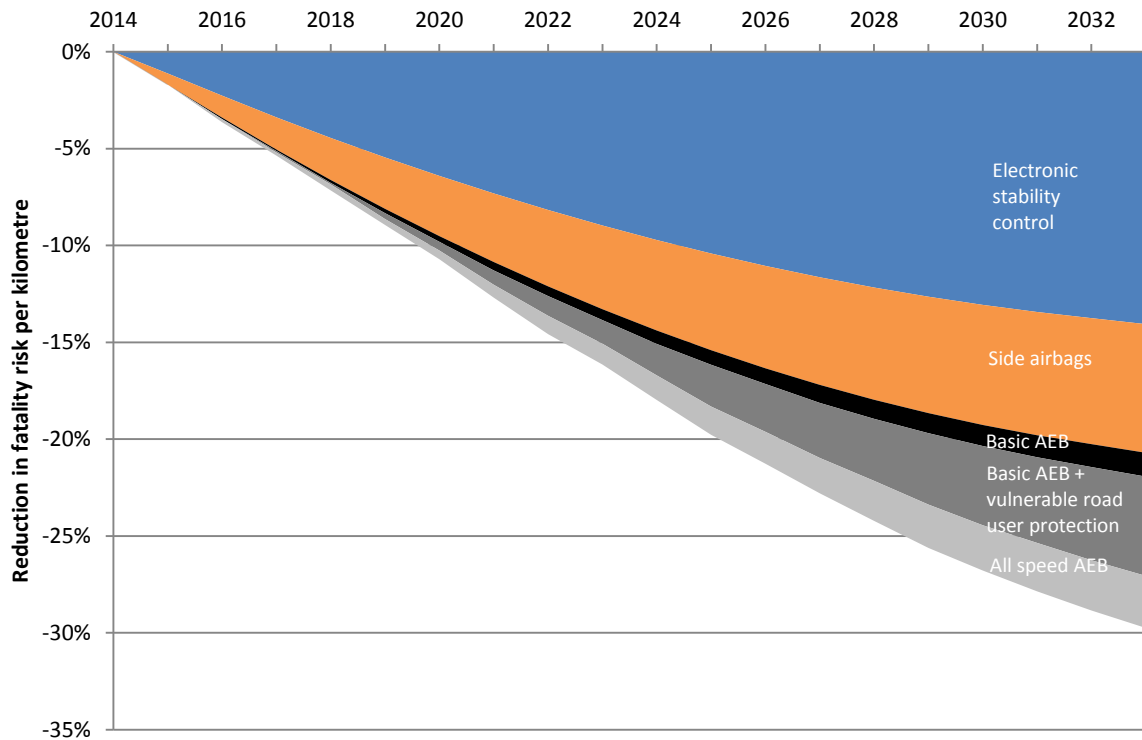
Some of the major trends that are likely to continue but have not been explicitly included in this base case include:

- Improved enforcement.
- Additional infrastructure improvements.
- Any further increase in distracted driving (including from mobile devices).

¹⁹ This road fatality rate per vehicle kilometre travelled is for all vehicles, not light vehicles.

Improved enforcement was not included in the base case, but is likely responsible for at least some of the reduction in crashes in recent years. BITRE (2010b) found that an expected reduction in road casualty rates from infrastructure improvements was not detectable in the data, and suggested it may have been offset by increased distraction.

Figure 16 Projected reduction in fatality risk per kilometre from new technologies in base case



Source BITRE estimates

Interaction between measures

To some extent, success in one potential measure may reduce the case for other measures.

For example, AEB will reduce the incidence of collision crashes, and thus reduce the road trauma benefits of intersection treatments as these also target a subset of collision crashes.

To the extent that AEB is likely to be adopted without government intervention, an attempt has been made to capture this effect. The extent to which intersection treatments could reduce overall deaths, and thereby affect the case for mandating AEB for all new vehicles, depends on the potential number of treatments:

- Only around 3 per cent of road deaths are of a type consistent with right filter turns. Some of these will be at fully controlled intersections where filter turn treatments are unlikely to have a significant impact.
- The number of fatality crashes at intersections that could be addressed by roundabouts is unknown.

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Chapter 3 Infrastructure measures

The proposed measures as summarised by Jacobs (2014) were:

- 5 star safety rated roads over 15 years.
- All new roads 4+ stars.
- All maintenance raises at least 1 star.
- No road user group less than 3 star.²⁰

BITRE has analysed two paths to partially achieving these:

- Upgrade the National Land Transport Network (NLTN) to the point where 85 per cent of the network was rated 3 stars or above. While not a specific measure suggested in Jacobs (2014), this would be a significant step towards 5 star safety rated roads over 15 years.
- Reducing speed limits to improve road safety star ratings.

The NLTN is defined under the *Auslink (National Land Transport) Act*, and is the network of roads and rail funded by the state, territory and federal governments. Roads that are part of the National Land Transport Network carry an estimated 20 per cent of Australian vehicle kilometres (BITRE 2014e).

Risk assessment for roads

There are two main risk assessment systems for roads available in Australia: the Australian Road Assessment Programme (AusRAP) based on the International Road Assessment Programme (iRap), and the Australian National Risk Assessment Model (ANRAM) which is a related model developed by ARRB Group (Bekavac et al 2012, ARRB Group 2014a).

ANRAM takes AusRap scores as an input to the model, and uses benefit-cost analysis and benefit-cost ratios to refine the mix of treatment options. ANRAM also uses a different treatment of traffic volumes and past crash history. According to ARRB Group (2014a), AusRAP uses the total number of fatalities and serious injuries and crash types across the road network to calibrate the fatality estimation model, but does not rely on the spatial location of crashes. In ANRAM the spatial location of crashes is used to achieve a more accurate estimate of expected fatal and serious injury crashes for a given road network or route. At this stage, ANRAM has not been comprehensively used for any set of Australian roads. Further use of ANRAM would facilitate prioritising infrastructure investments from a safety perspective.

The AusRAP model is used to produce star ratings for roads as a method to assess safety of road infrastructure, at 100 metre intervals, with 1 star being the least safe, and 5 stars being the most safe.

²⁰

Separate star ratings can be calculated for different road user groups, including car occupants, motorcyclists, cyclists and pedestrians.

Star ratings are calculated based on the infrastructure, including road dimensions, pavement quality, and roadside characteristics, along with speed limit—for given infrastructure quality, a higher speed limit translates into a lower star rating. Star rating methodology is designed in such a way that an additional star is associated with a reduction in fatality risk.

Improving 85 per cent of NLTN roads to 3 stars or above

The Australian Automobile Association (AAA) has advocated that the national highway network be rated at a minimum of 3 stars by 2020, and that new road sections should be a minimum of 4 stars (AAA 2014). The AAA presented an analysis of investment in the national road network which would upgrade it to a point where 85 per cent of the NLTN roads are rated at 3 stars or above. The AAA estimate this measure would reduce serious injuries and fatalities by over 36 000 over a 20 year period, with an overall benefit-cost ratio of 3.49 (AAA 2013).²¹

Key areas which contribute to AAA's estimate of net benefits (Figure 17) are:²²

- Roadside barriers: 53 per cent of the benefits and 49 per cent of the costs
- Central median barriers: 16 per cent of the benefits and 11 per cent of the costs
- Shoulder rumble strips: 11 per cent of the benefits and 16 per cent of the costs.

Modelling parameters

- Traffic growth: AAA's assumed average annual daily traffic (AADT) growth of 3 per cent is significantly higher than BITRE's projections of 1.5 per cent.²³ However, this assumption only affects the outcome in combination with the assumed change in crash rates per kilometre.
- Trauma projections: AAA assume fatalities and injuries are unchanged over a 20 year period in the absence of 'stars for roads' related infrastructure upgrades. The implicit assumption is that on-going improvements in non-infrastructure factors are counteracted by the forecast increase in general traffic levels. This is broadly consistent with BITRE's base case used for this analysis (see above), in which traffic is projected to grow 1.55 per cent and (base case) crash risk per kilometre is projected to fall at 1.9 per cent per annum.
- Discount rate of 4 per cent: This is consistent with the Department's guidelines, which ask for benefit cost ratios to be calculated at 4 per cent and 7 per cent (Department of Infrastructure and Regional Development, forthcoming)

In estimating the benefits of preventing road trauma, the AAA has assumed:

²¹ It is not clear what definition of serious injury is assumed by AAA. For the remainder of this section, an estimate of the impact on hospitalised injuries is used instead, meaning some figures differ from those published by AAA.

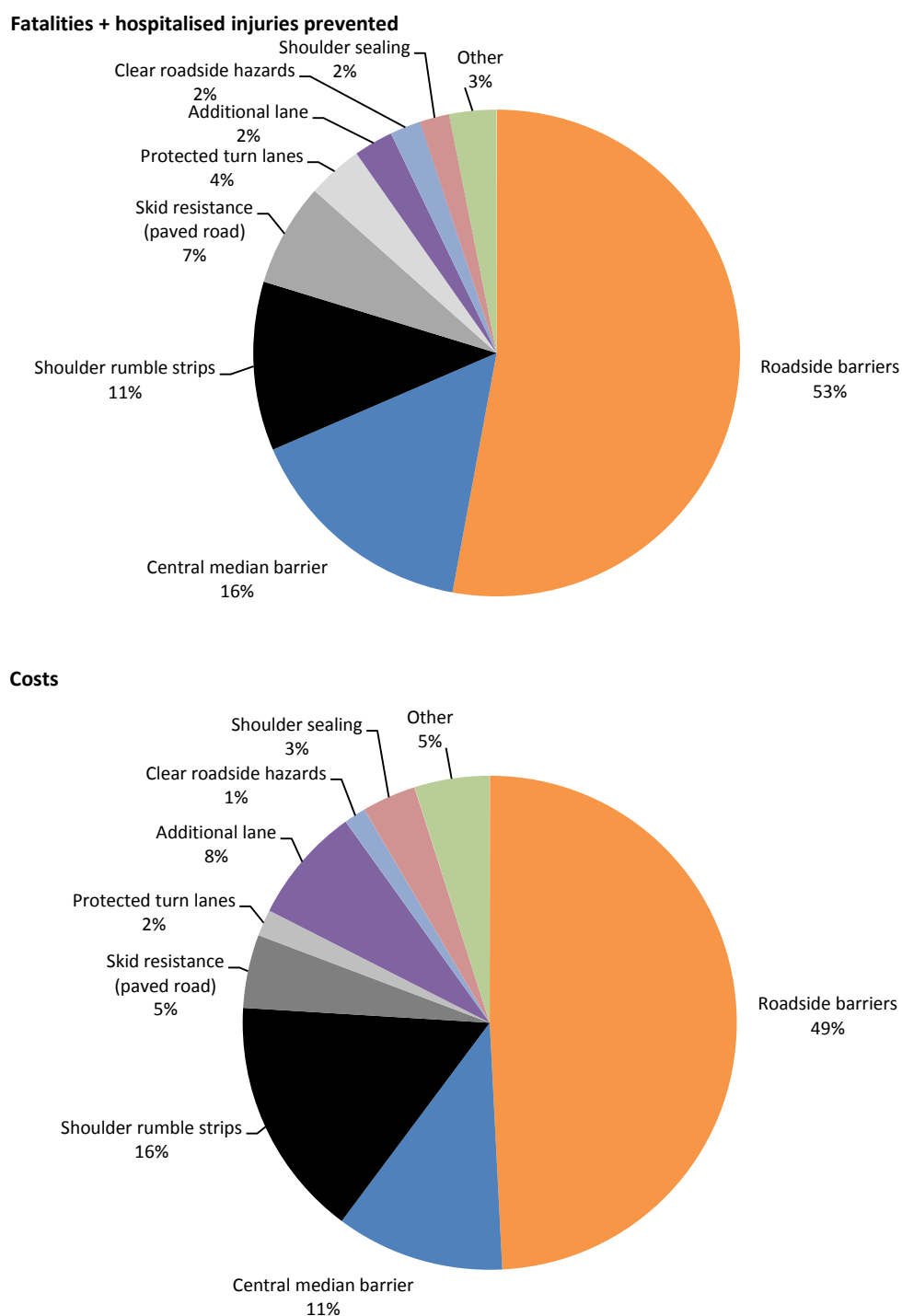
²² From AAA 2013, Table 5. Shares are of the total of measures included in Table 5.

²³ BITRE (2009) projected that traffic on the non-urban National Land Transport Network would grow by 1.55 per cent per annum, and BITRE (2014a) projected that overall Australian traffic would grow at 1.5 per cent per annum.

- A cost of avoiding the loss of a life (\$7.2 million) consistent with recent Australian estimates of the willingness-to-pay to avoiding a fatality by Hensher et al (2009). BITRE has used a social willingness-to-pay based estimate of \$7.72 million for preventing a fatality (see Appendix A).
- A cost of avoiding a serious injury of \$340 000. While this value is consistent with the willingness-to-pay estimate for a serious disabling injury in Hensher et al (2009), it is substantially higher than the corresponding value for preventing a hospitalisation (\$75 000 in 2007 dollars). BITRE has used a social willingness-to-pay based estimate of \$259 000 for preventing a hospitalised injury (see Appendix A).
- A ratio of 20 serious injuries avoided for every fatality avoided. BITRE has used an Australia-wide ratio of 26 hospitalised injuries for each fatality avoided, based on current levels of road deaths and the most recent data on traffic-related hospitalisations.

While BITRE has used a lower value for preventing a hospitalised injury this is offset by a higher ratio of hospitalised injuries to road deaths, balancing out the net effect on total injury costs.

Figure 17 Proportion of AAA estimated costs and benefits accounted by each measure



Source BITRE estimates based on measures presented in AAA 2013, Table 5

Cost assumptions

- Costs for roadside barriers of \$270 000 per kilometre are broadly consistent with other estimates (UMA/AECOM 2007). In Australia, the estimated cost is approximately \$120 000 per kilometre, plus associated roadside civil works (including, for example, tree removal and sloping batters) (VicRoads, pers. comm., 2014).
- Costs for central median barriers of \$390 000 per kilometre are broadly consistent with other estimates (UMA/AECOM 2007). In Australia, the estimated cost is similar, per kilometre, to that

of roadside barriers. However, in some case costs will be significantly higher, as road widening and provision of U-turn facilities may be required. For example, a project on the South Gippsland Highway cost over \$1 million per kilometre (VicRoads, pers. comm., 2014).

- Costs for shoulder rumble strips of \$160 000 per kilometre are higher than some estimates (New Zealand Transport Agency 2009). In Australia, the estimated cost per kilometre for audio-tactile line marking is approximately \$4000 per kilometre (VicRoads, pers. comm., 2014). However, rumble strips across the width of the shoulder are likely to cost significantly more.

Estimating the impact of infrastructure measures

The assumed fatality and injury reductions from roadside barriers are broadly consistent with empirical evidence, however the decline would vary significantly depending on which stretches of road were treated.

- As AAA does not provide underlying assumptions about crash rate reductions, it is not possible to directly verify AAA's estimate. For the segments for which AAA recommends roadside barriers, the average reduction based on AAA's assumptions is a 0.11 reduction in fatalities per kilometre from roadside barriers. For median barriers, AAA assumptions result in an average 0.2 reduction in fatalities per kilometre.
- Candappa et al (2009) estimated the impacts of installation of barriers in Victoria. Combined with BITRE assumptions on the frequency of crash types, this implies reductions of 0.23 fatalities per kilometre on a heavily trafficked section of the Eastern Freeway and 0.03 fatalities per kilometre on a more lightly trafficked section of the Hume Highway.
- Overall, AAA fatality and injury reductions from barriers are broadly consistent with Candappa et al (2009), however the reduction would vary significantly depending on which stretches of road are treated.

Key issues

The magnitude of benefits depends on what is assumed to happen in the future. If safety risks change in a way significantly different to the base case (see the Base case section), the benefits of improved infrastructure will be different.

AAA (2013) methodology appears to assume a proportional reduction in crashes—and consequently deaths and injuries—for each countermeasure. This proportion is derived from international experience and may not apply to particular roads. It is difficult to confirm the magnitude of benefits estimated for Australia without knowing which roads the measures are proposed for.

It is possible that some proposed infrastructure measures might have negative impacts on vulnerable road user groups. For example, there is some concern that roadside barriers may be associated with increased motorcycle deaths (NSW Injury Risk Management Research Centre 2010).

As fatal motorcycle crashes are growing as a proportion of fatal crashes, this could have a significant impact on the estimated benefits. The trend, partly due to increasing motorcycle kilometres as a proportion of the total, would be expected to continue if vehicle technologies such as ESC are adopted faster in cars than in motorcycles. The risk to motorcycles can be mitigated through choice of barrier type.

Findings

BITRE analysed two paths to partially achieve the goal of 5 star safety-rated roads over 15 years:

- Improving 85 per cent of the NLTN to 3 stars or above (the AAA proposal).
- Reducing speed limits.

The key areas contributing to AAA's estimate of the net benefits of infrastructure upgrades are roadside barriers, central median barriers and shoulder rumble strips. These measures reduce road trauma. However, these are specific to the site and traffic conditions.

While these particular infrastructure measures are important, a number of issues were identified with AAA's modelling assumptions:

- Traffic growth of 3 per cent is significantly higher than BITRE's projections.
- Total deaths and injuries are unchanged over a 20 year period (that is, the trend in improving road safety from other developments is not considered, although this is mostly offset by the AAA's assumed increase in traffic volumes).
- AAA's methodology appears to assume a proportional reduction in crashes (and consequently deaths and injuries) for each countermeasure. This proportion is derived from international experience and may not apply to particular Australian roads.

Road side barriers can have negative impacts on some road users, notably roadside barriers may be associated with increased motorcycle deaths.

Despite these qualifications, BITRE's analysis confirms that infrastructure measures can reduce road trauma.

BITRE considers that the use of ANRAM with Australian parameters and traffic volumes, with programme BCR analysis (see Bekavac et al 2012), would help in prioritising infrastructure investments to achieve the best safety and benefit-cost outcomes.

Lowering speed limits

Safety outcomes can be improved by lowering speed limits as well as investing in road infrastructure.

Lowering speed limits would have an impact on both the number and severity of crashes, as lower speeds in general lower casualty rates, reduce the severity of injuries, and facilitate evasive action thereby avoiding some crashes.

BITRE (2003) looked at the economics of lowering speed limits and concluded that, in the context of all roads in Australia, 'there are likely to be many more roads that would warrant a lower average speed than the number that would warrant a higher speed regime'. However, it did not make recommendations for particular roads or classes of roads such as the National Highway Network.

Benefits of lowering speed limits

- There is evidence that lowering speed limits reduces actual speed travelled, particularly where there is little congestion, and that lower speed travelled leads to lower numbers of deaths and injuries (Austroads 2010).
- At high speeds, there are also reductions in exhaust emissions, noise and vehicle operating costs from marginally lower speeds (Austroads 2010 and Archer et al. 2008).

Costs of lowering speed limits

A cost of lowering speed limits is longer travel times.

However, the reduction in average travel speeds is lower than reduction in posted speed. Austroads (2010) suggests that at high speeds a 10 kilometres an hour reduction in speed limits is associated with approximately a 5 kilometres an hour speed reduction.

Estimating the economic impact of lower speed limits

Austroads (2010) modelled the impacts of reducing speed limits on a set of urban roads, finding that the economic costs of reduced average speeds (in the form of increased travel time, and increased emissions) significantly outweighed the crash reduction benefits.

However, the results may be different for high speed rural roads. BITRE undertook a high level analysis of lowering speed limits from 100 kilometres an hour to 90 kilometres an hour on an indicative high speed rural road.

BITRE has assumed:

- Initial road fatality rate of 0.7 per hundred million vehicle kilometres. This was the average road fatality rate for the Bruce Highway in 2003-07, based on the Royal Automobile Club of Queensland and Australian Automobile Association (2010, p.12).
- There were 26 hospitalised injuries for each fatality.
- The relationship between speed and crashes follows Nilsson's Power Model ($\text{Number of crashes} = C^{\text{after}}/C^{\text{before}} = (V^{\text{after}}/V^{\text{before}})^n$) with exponent 4.71 (based on an estimate by Austroads 2010).
- An initial mean speed of 107.5 kilometres an hour (consistent with modelling assumptions in Austroads 2010).

- Average speeds would reduce by 4.25 kilometres an hour (assuming the mid-point of the 4.0-4.5 kilometres an hour reduction in Table 1 of Austroads 2010).
- Time savings are proportional to the change in mean speeds.
- A value of time of \$25.32 an hour (weighted average of values of time by vehicle class from Austroads (2012) in 2014 dollars).
- Social willingness-to-pay based values of \$7.72 million for avoiding a fatality and \$259 000 for avoiding a hospitalised injury (see Appendix A).

With these assumptions, the safety benefits are found to be 1.9 cents per kilometre, with costs in terms of extra travel time of 1.0 cents per kilometre. In addition, at this speed there would be slightly reduced fuel consumption, meaning lower vehicle operating costs and emissions.

For a hypothetical rural highway with high crash risk per vehicle kilometre, the safety benefits of a reduction in speed limit from 100 to 90 kilometres an hour that resulted in an effective average speed reduction of 4.25 kilometres an hour may outweigh the costs of the extra travel time (BCR 1.9, excluding benefits from lower vehicle operating costs and emissions).

Key issues

While posted speed limits reductions can—with appropriate enforcement—reduce average speeds, the actual reduction in average vehicle speeds is likely lower than reduction in posted speed.

As vehicles safety improves, the benefits are reduced. In the base case projected crash rates reduce at approximately 1.9 per cent per year reducing the future safety benefits of speed limit reductions.

If the projected reduction in crash rates in the base case were realised, the safety benefits of reducing speed limits in the hypothetical example would no longer outweigh the costs of increased travel times in twenty years.

Findings

Reducing speed limits can increase road safety and will reduce road trauma, but this will also increase travel times on uncongested roads.

BITRE's analysis suggests that reductions in speed limits may be warranted on some rural roads. However, whether it would be warranted on any particular stretch would depend on specific crash rates and characteristics of that road.

The option of reducing speed limits may therefore be of benefit pending infrastructure investment.²⁴

²⁴ Intelligent Transport Systems technology can be used to reduce speed limits depending on the road environment. An example is variable speed limits for rural intersections. This has not been modelled.

Chapter 4 Intersection measures

The proposed intersection measures as summarised by Jacobs (2014) were:

- More roundabouts and more control over right turning movements (that is, either signalised or an outright ban on filter turns).
- Focus on worst rated intersections (Jacobs 2014, Table 3.4).

Other measures suggested by road safety experts to reduce trauma crashes at intersections were variable speed limits for rural intersections²⁵ and channelising right turns.²⁶

Over the five year period from 2008 to 2012, 22 per cent of fatal crashes in Australia were at intersections. In major urban areas, this increases to 40 per cent of fatal crashes.

Roundabouts

Costs of roundabouts

The main costs of introducing roundabouts include construction costs and the impact on traffic flow.

- Of the roundabout projects for which full costs (including traffic costs) were analysed by BITRE (2012b), construction costs ranged from \$100 000 to \$600 000 (average \$200 000).
- While many intersection treatments have a negative impact on traffic flow, roundabouts can improve traffic flow at some traffic volume levels. In the roundabout projects analysed by BITRE (2012b), costs to road users (primarily time costs) were up to 5 cents per vehicle.
- Compared with traffic lights, roundabouts may also have negative safety impacts for cyclists. Daniels et al (2008) found that for roundabouts replacing traffic signals, fatality and serious injury crashes increased by 42-44 per cent.

Benefits of roundabouts

BITRE (2012b) found that roundabouts were generally the most effective Black Spot programme treatment, reducing casualty crashes by over 70 per cent and property damage only crashes by about 50 per cent. For Black Spot programme roundabout treatments, the average benefit cost ratio

²⁵ Variable speed limits at rural intersections are an application of Intelligent Transport Systems technology (BITRE 2003). New Zealand trials of variable speed limits at rural intersections in which the speed limit is lowered in real-time if a vehicle is detected on an adjacent road have found significant reductions in speed. Bradshaw et al (2013) found this technology reduced speeds significantly at most intersections where it was trialled. Using Elvik's power model they estimated that vehicle activated signs could reduce fatal crashes by an average of 18 per cent and serious injury crashes by an average of 12 per cent at similar sites. According to Jacobs (2014), 'the cost of implementing this is generally \$NZ200-250,000'. In addition, there would be ongoing maintenance costs (Mackie et al 2014).

²⁶ BITRE (2012b) did not separately assess channelisation projects for definitional reasons. Oxley et al (2004), drawing on evidence from Victorian rural black-spot sites, found associated benefits of channelisation and delineation include crash reductions between 30 and 60 per cent and BCRs of 2.3

for single treatment sites was 11.3 at a 4 per cent discount rate. This used standard Austroads recommended unit values to estimate safety benefits derived using the human capital approach, counting only the benefits of savings from casualty crashes.

When traffic impacts are taken into account (for a subset of analysed projects), the estimated benefit cost ratios from the subset of roundabout treatments are lower, ranging from -5.4 to 9.3, with an average across four projects of 3.0 (BITRE 2012b, p. 182).

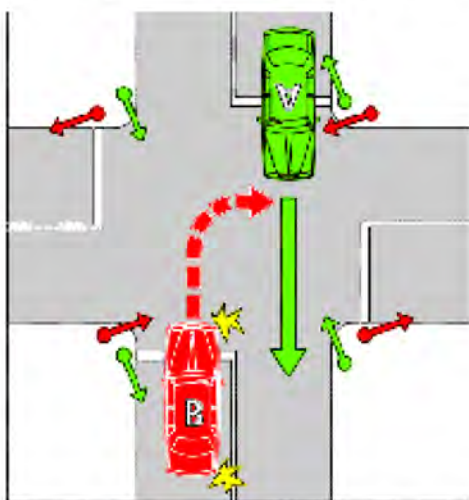
There is significant evidence that roundabouts bring large benefits compared with unsignalised intersections, and more limited evidence that roundabouts are safer than signalisation for low traffic volumes.

Filter turns

A potentially addressable class of intersection crash is a 'filter turn', in which right turning traffic has to 'filter' through oncoming traffic, without a dedicated green light. Figure 18 shows a representation of a right filter turn in the Australian Road Rules.

Figure 18 Right filter turn

Driver turning right giving way to an oncoming vehicle going straight ahead



Source National Road Transport Commission 2012

While it is not possible to identify the number of crashes of this type, the proportion of fatalities resulting from right-turning intersection is between 2.3 per cent and 3.5 per cent across three jurisdictions. Right-turning intersection crashes also result in between 8 to 9 per cent of reported injuries (including non-hospitalised).²⁷

²⁷ BITRE unpublished data.

It is also not possible, with the data available to BITRE, to identify the number of intersections where filter turns are currently allowed.

Possible ways of addressing dangerous filter turning are converting the intersection to fully controlled right turns, or disallowing right turns altogether. Costs will depend on the treatment chosen, the location and the affected traffic volumes.

Bui et al (1991) and Taylor (1991) have estimated the safety benefits of removing filter turns, and the impacts on intersection performance.

While fully signalling right turns, and banning right turns, were both treatments included in the Australian Government's Black Spots programme, neither treatment type was separately assessed by BITRE (2012b).

Benefits of eliminating filter turns

Chen and Meuleners (2013) evaluated the effectiveness of replacing right filter turns with controlled turns in Western Australia. It was found that fully controlling the right turn reduced serious injury crashes at these intersections by 58 per cent. A significant reduction in rear end crashes was also found.

Bui et al (1991) found that the change from partially controlled to fully controlled right turn phase showed an overall reduction in 65 per cent in all types of casualty accidents. Right-Through and Cross-Traffic casualty accidents were reduced by 93 per cent and 51 per cent respectively. For the intersections in the study, this amounted to up to 1.87 casualty crashes saved per year through the measure.

Costs of eliminating filter turns

BITRE has not found estimates of the direct costs of treatments to eliminate filter turns. Where no new infrastructure is required, the main cost will be additional delays to road users, as either traffic in other directions faces a red signal for longer. Taylor (1991) found that the average increase in delay from changing from a partially controlled to fully controlled right turn phase was between 2 seconds and 17 seconds, depending on the type of intersection.

Alternatively, in the case that right turns are banned altogether, some road users will face increased travel time.

Estimating the economic impact of eliminating filter turns

The following assumptions were made in estimating the economic impact of eliminating filter turns

- Based on the finding in Bui et al (1991), and adjusting for the reduction in underlying casualty crash rates since 1991, it may be expected that the equivalent effect in 2014 is 0.73 casualty crashes per year.
- For casualty crashes at intersections, a road fatality rate of 0.06 and a hospitalised injury rate of 1.44 were assumed, based on average road fatality rates at intersections from 2008 to 2012 (BITRE unpublished data), and assuming 26 hospitalised injuries per fatality.
- Social willingness-to-pay values of \$7.72 million for preventing a fatality and \$259 000 for preventing a hospitalised injury (see Appendix A).

- The value of time is based on Austroads (2012).
- The average extra delay, and peak hour traffic, across all types of intersection considered was 5000 vehicles an hour being delayed 9 seconds each.
- It is assumed there are four hours of peak traffic a day, for 280 days each year.

Based on these estimates and assumptions, the safety benefit of eliminating filter turns is \$799 000 per year, and the cost in terms of extra travel time is \$309 000 per year, giving a BCR of 2.6.

Findings

Intersection treatments can be very effective, particularly roundabouts.

BITRE (2012b) found that roundabouts are generally the most effective Black Spot programme treatment, reducing casualty crashes by over 70 per cent. There is significant evidence that roundabouts bring large benefits compared with unsignalised intersections, and more limited evidence that roundabouts are safer than signalisation for low traffic volumes.

However, the BCRs for roundabouts reduce when traffic impacts are taken into account and they can have negative impacts on motorcyclists, pedal cyclists and pedestrians.

For filter turns, the available evidence suggests that eliminating filter turns can be economically warranted, with BITRE analysis suggesting BCRs of approximately 2.6. However, whether it should be applied at any particular intersection depends on specific characteristics of that intersection.

Chapter 5 Mobile phone distraction

The road safety experts workshop (Jacobs 2014) ranked mobile phone distraction equal fifth place in the final rankings of the identified road safety related measures.

It is illegal in all Australian states and territories to use a hand-held mobile phone while driving. This includes:

- Talking
- Texting
- Playing games
- Taking photos and video
- Using any other function (for example, watching video) on a phone.

Using a hand-held mobile phone is also illegal when a vehicle is stationary but not parked, for example, when stopped at traffic lights.

Some jurisdictions (including Victoria) have extended these laws to make it illegal:

- For probationary or provisional licence holders to use fixed (hands-free) mobile phones
- To interact with other units that have visual displays while driving (for example, DVD players or tablet computers) that are not driver's aids.

Distraction as a crash factor

While the focus is often on mobile phone use (hands-free talking, texting, playing games and other phone functionality), using devices such as MP3 players, video players, radios/CD players and GPS units while driving is also likely to be a significant source of driver distraction.

Driver distraction is “the diversion of attention away from activities critical for safe driving toward a competing activity” (Regan et al 2009, p.34). There are four types of driver distraction: physical distraction, visual distraction; auditory distraction; and cognitive distraction. A distracting activity involves one, or more, of these.” (WA Office of Road Safety 2013).

The Curtin Monash Accident Research Centre (C-MARC 2011) reports that one third of all serious casualties in Western Australia over the period 2005-2007 have been associated with driver distraction. Sources of driver distraction can be in car or external. Internal distractions include passengers and operating a mobile phone.

Operating a hand-held mobile phone may involve all four types of distraction: physical distraction (dialling); visual distraction (looking at the display); auditory distraction (holding a conversation with the other person); and cognitive distraction (focusing on the topic of conversation).

Symmons and Langford (2008, cited by C-MARC 2011) find that both simulator studies and naturalistic driving studies have concluded hands-free mobile telephone use while driving leads to significant driving impairment. Some studies confirmed this finding for both hand-held and hands-free mobile telephones. Other studies showed that while hands-free mobile telephones had advantages over hand-held devices, the former were still associated with significant driving impairment. However, C-MARC note that impairment does not necessarily translate to an increase in serious crashes.

In 2013 the NHTSA published a US naturalistic driving study of hand-held, fixed and integrated phone systems confirming that the highest risk of a safety critical event was during visual-manual operation of the phone, and that fixed and integrated hands-free systems reduced—but did not eliminate—the need to manually operate a mobile phone. While talking on a phone, for all interfaces, was not associated with an increased risk of a safety critical event there was concern that many integrated or fixed systems still allow, and sometimes require, visual-manual phone tasks (Fitch et al 2013).²⁸

Prevalence of mobile phone use by drivers

In 2013 a survey of 1500 people found that nine in ten active Australian drivers (91 per cent) reported having a mobile phone and 61 per cent reported they used a mobile phone while driving, up from 59 per cent in 2011 (Petroutias 2014).

With the exception of reading text messages while driving, other usage measures among active drivers increased:

- 56 per cent answered calls (54 per cent in 2011).
- 35 per cent made calls (27 per cent in 2011).
- 32 per cent read text messages (31 per cent in 2011).
- 18 per cent sent text messages (14 per cent in 2011).

Of all active drivers who answered or made calls while driving, 41 per cent used a hands-free phone either sometimes or all of the time, compared with 30 per cent in 2009 and 28 per cent in 2011 (Petroutias 2014, p. 64).

Reported mobile phone use while driving was significantly higher amongst:

- Males (67 per cent), than females (55 per cent).
- 15 to 24, and 25 to 39 year olds (69 per cent and 81 per cent respectively).
- Provisional licence holders (78 per cent), than full car licence holders (61 per cent).
- Commuters (77 per cent).
- Frequent distance drivers (71 per cent) (Petroutias 2014).

Mobile phone use while driving was significantly lower amongst drivers 60 years and over (29 per cent). The Centre for Accident Research and Road Safety Queensland (CARRS-Q 2012) finds that the most common types of crashes associated with mobile phone usage are run-off the road and rear end crashes, and that:

- Younger drivers are particularly at risk as there is a greater prevalence of driving while using a mobile phone, particularly sending and reading texts. In addition, evidence demonstrates that

²⁸ Fitch et al (2013) defined a safety-critical event as including: a crash (where measurable contact is made between the subject vehicle and an object), a near-crash (where a crash would have transpired had a rapid evasive manoeuvre not been made), and a crash-relevant conflict (which is a conflict that is less severe than a near-crash, but more severe than normal driving).

undertaking secondary tasks while driving, such as using a mobile phone, causes greater problems for inexperienced drivers who already have a higher crash risk.

- Older drivers (55 years and older) also find it difficult to conduct two tasks simultaneously and their response times are impaired.

Evidence of crash outcomes

While research shows clear links between mobile phone use and crash events, there is limited crash data which records driver mobile phone use as a contributory factor.

Only a few Australian jurisdictions record mobile phone use during crashes: in these jurisdictions, in-car sources of distraction was cited as a factor in 10 to 15 per cent of reported casualty crashes, with mobile phone use cited as a factor in 1 per cent or less of casualty crashes. No data were available on pedestrian crashes where mobile device related distraction was a factor. Between 2008 and 2012:

- In one jurisdiction, distraction was a factor in less than 10 per cent of casualty crashes and hand-held mobile phone use was a factor in less than 1 per cent of casualty crashes.
- In one major jurisdiction, distraction was a primary factor in 15 per cent of casualty crashes. The source of distraction for more than half of these crashes was external to the vehicle, with using a mobile phone cited as a primary factor in only 0.2 per cent of all casualty crashes.

However, significant under-reporting would be expected given the legal implications for drivers and difficulty for investigators in proving mobile use at the time of or just prior to a crash.

In terms of run-off road and in-line crashes—the types often associated with mobile phone use (CARRS-Q 2012)—Australian data for fatal crashes between 2008 and 2012 show that:

- Run-off road crashes (a broad grouping of different crash types) account for approximately 40 per cent of road deaths.
- In-line crashes—including rear end crashes, changing lanes and pulling out from the kerb—account for 5 per cent of road deaths in Australia.

However, distraction including mobile phone use may also be a factor in other crash types where failing to give way or inattentiveness is a factor.

Estimating phone use as a factor in crashes

In the absence of reliable crash data, an estimate the number of casualty crashes can be made based on the prevalence of mobile phone use and increase in the relative risk of having a crash.

In Australia, the Community Attitudes Survey (Petroulias 2014) provides a national indicator of the prevalence of mobile phone use by drivers and how this has changed over time:

- Most drivers now have a mobile phone, with increasing proportions of drivers taking and making calls while driving.
- Younger drivers are more likely to receive and send texts.
- More drivers are using hands-free and integrated systems.

The Survey does not indicate the proportion of drivers who are using a phone at any point in time.

There is extensive research showing that mobile phone use increases the risk of a crash, with texting while driving especially dangerous. A person using a hand-held or hands-free mobile phone is four times more likely to have a serious crash resulting in hospital attendance (McEvoy 2005).

While relative risk estimates can be used to estimate the number of crashes resulting from mobile phone use, this requires accurate data on in-car usage by drivers. Estimates for the United States of America have suggested that “at least” 26 per cent of all crashes are a result of mobile phone use.

However, in-vehicle studies suggest that this estimation approach is likely to over-state the role of distraction from mobile use in crash outcomes. CARRS-Q (2012) cite naturalistic driving studies (Klauer et al 2006; Olsen et al 2009) that suggest up to 22 per cent of car crashes and near crashes, and 71 per cent of truck crashes—and 46 per cent of near crashes—involve, as a contributing factor, inattention from non-driving related activities. The use of hand-held devices was found to contribute to 7 per cent of those car crashes and near crashes.

Estimated impacts and cost of mobile related crashes

While it is difficult to determine how important mobile phone distraction is in real world crashes, hand held devices more broadly may be a factor in 7 per cent of crashes.

In 2013, 7 per cent of fatal crashes resulted in approximately 83 deaths. In addition, there were an estimated 2300 hospitalised injuries. The cost of this road trauma was \$1.26 billion (2014 dollars).

However, using a hand-held device may not have been the only contributory factor in these crashes. Consequently, stopping drivers using a hand-held device may not have avoided all crashes.

Measures to reduce crashes due to mobile phone use

Survey respondents and workshop participants (Jacobs 2014) suggested increased enforcement, specifically:

- Greater use of unmarked vehicles to increase the public perception of being caught. Respondents cited a recent Western Australian trial with unmarked motorcycles as evidence that this will effectively detect distracted drivers (particularly those using mobile phones).
- Immediate licence and registration suspension for high-risk activities such as distracted driving including mobile phone use, combined with public education focussing on the effects of distracting technologies such as mobile phones, headphones and portable devices.

Other suggestions included impounding of vehicles of offending drivers, investigating technology to detect in-vehicle use, and technology to prevent in-vehicle use while driving (Jacobs 2014).

The use of in-vehicle technology to prevent phone use while driving is currently voluntary, although some businesses may limit in-vehicle mobile use as part of workplace health and safety policy.

Many smartphone users have Apps pre-installed or are able to download Apps that block or auto-reply to calls, texts, or both, while a vehicle is moving. However, downloaded Apps can be difficult to find in official stores, require users to allow Apps from unofficial sites, or do not work with all mobile phones. cursory investigations suggest many identified Apps are not widely used, with official user downloads often being low.

The World Health Organisation suggests a comprehensive strategy (that combines legislation, strong and sustained enforcement, and continuing campaigns to support enforcement and increase public awareness of risks and of the penalties associated with breaking the law) is likely to be effective in tackling mobile phone use (World Health Organisation 2011).

Australian jurisdictions have already responded to evidence on the risk of mobile phone use by banning hand-held phone use, with some extending this to bans on fixed phone use by high risk groups such as novice drivers, and extended enforcement campaigns to target mobile phone use (in addition to other risk factors such as speeding, drink driving and failing to wear seat belts).

Findings

It is difficult to determine the involvement of mobile phone distraction in real world crashes.

The best estimates indicate that 7 per cent of casualty crashes may have distraction from mobile devices (including GPS and other in car device use) as a contributory factor.

In 2013 seven per cent of casualty crashes equates to 83 deaths and an estimated 2300 hospitalised injuries. However, stopping drivers using a mobile device would not necessarily have avoided all crashes as this may not have been the only contributory factor.

BITRE finds that best practice in reducing the road trauma from mobile device distraction is a comprehensive strategy. BITRE was unable to model specific measures identified by Road Safety experts (Jacobs 2014).

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Chapter 6 Autonomous Emergency Braking

The Jacobs (2014) road safety experts workshop results, ranked AEB—a component of emerging vehicle based collision avoidance systems—equal sixth place in the workshop rankings of the identified road safety related measures.

What is AEB?

Euro NCAP (2014) describe the system as:

- Autonomous: the system acts independently of the driver to avoid or mitigate the accident
- Emergency: the system will intervene only in a critical situation
- Braking: the system tries to avoid the accident by applying the brakes.

AEB systems improve safety in two ways: firstly, they help to avoid accidents by identifying critical situations early and warning the driver; and secondly they reduce the severity of crashes by lowering the speed of collision and, in some cases, by preparing the vehicle and restraint systems for impact.

There are three broad variations within AEB systems:

- Basic system for lower speed urban traffic to mitigate or avoid low speed urban crashes
- Basic system also providing mitigation of crashes with vulnerable road users like pedestrians and pedal cyclists
- High end systems accounting for both the urban traffic crashes and vulnerable road users while also operating at higher (or all) speeds.

AEB comes under many different names, depending on the vehicle make.²⁹

Volvo first launched AEB in the XC60 in 2009 (Dowling 2014) and AEB first started appearing in sales figures as a standard feature in new light passenger vehicles around 2010. By 2013 AEB was appearing as a standard feature in a number of the premium light passenger models.

A large proportion of AEB systems appearing as a standard features in new light passenger vehicles are the basic AEB systems intended to mitigate urban crashes at lower speeds, notably rear end crashes at intersections or in stop-start traffic.

Benefits of AEB

Thatcham Research (2014a) find that AEB:

- Reduces the occurrence of low speed accidents by around 20 per cent
- Are most effective at lower speeds (less than 40 km/h) where more than 75 per cent of accidents occur

²⁹

The Victorian Transport Accident Commissions' publication '[How Safe is Your Car](#)' lists alternative names and availability for AEB systems in Australia (as at May 2014).

- Are also effective in mitigating the effects of higher speed crashes.

Thatcham Research (2014b) note that initial data suggests that vehicles fitted with AEB systems have 18 per cent fewer third party injury claims.

Similarly Moore and Zuby (2013) showed that vehicles fitted with forward collision avoidance systems with AEB had a 10-14 per cent lower claim frequency.

The CEO of the Australasian New Car Assessment Program (ANCAP) is reported as stating that: "Real-world data suggests AEB can reduce crashes by up to 27 per cent and ANCAP would like to see this life-saving technology become a mandatory requirement for all new vehicles sold in our region." (Collette 2013)

Rosen et al. (2010) found that with a field of view of 40 degrees from forward facing AEB sensors, fatal and seriously injured pedestrian crashes were reduced by 40 per cent and 27 per cent respectively.

Andersen, Doecke, Mackenzie and Ponte (2013) looked at the potential benefits from AEB from crash reconstructions and simulation and found overall reductions in risk produced by the various AEB systems were predicted to reduce fatal crashes by 20-25 per cent and injury crashes by 25-35 per cent, but noted: "these results do indicate that differences in the way that systems operate will make a material difference to their effectiveness, in terms of either speed reductions or injury risk."

Rosen (2013) showed that the effectiveness of AEB systems for both pedestrians and pedal cyclists (vulnerable road users) had "...considerable potential to save lives and mitigate severe injuries for vulnerable road users in frontal collisions with passenger cars." However, the author did note that this potential effectiveness was highly sensitive to parameters controlling the brake capacity of the AEB system and restrictions in darkness and at high speeds. In terms of their reference scenario for vulnerable road users in frontal collisions (a 50 per cent decrease in deaths and 40 per cent for severe injuries), combining all these restrictions (darkness, high speed, timing and deceleration) would virtually eliminate the real-life effectiveness.

Costs of AEB

According to the Head of Research at NRMA Insurance, the cost to manufacturers could be less than \$200 to include AEB as a feature in a vehicle (NewsCorp, 2014). Thatcham Research (2014b) suggest £1000 (approximately A\$1800) as the additional cost for a vehicle fitted with an AEB system.

The unit cost of fitting AEB systems is expected to reduce significantly over time, particularly for high end systems and if it is fitted to all new light vehicles.

For this analysis BITRE has assumed the incremental costs of adding:

- A base level AEB system: \$200 per new vehicle.
- AEB plus vulnerable road user detection: an additional \$400 (total cost \$600 per vehicle).
- All speed AEB systems: an additional \$600 (total cost of \$1200 per vehicle).

Assessing the impact of mandating AEB

This analysis of AEB focuses on the 'light passenger vehicle' market, although AEB systems are also available in heavy vehicles (Transport for NSW 2013a) and motorcycles (Savino et al., 2013).

BITRE has modelled the following hypothetical scenario for the light vehicle market to estimate the potential for AEB to reduce road trauma:

1. A requirement that all new light vehicles include an AEB system that identifies vulnerable road users by 2018; and
2. A requirement that all new light vehicles will include an all speed AEB system (including vulnerable road users) by 2020.

Modelling the effectiveness of AEB systems

AEB is already available in some new passenger vehicles and—in the absence of a mandatory requirement for AEB in new vehicles—the proportion of AEB equipped light vehicles is projected to increase over time (see the Base Case). This base case is a projection of the expected future level of road trauma given future traffic flows and known changes in vehicle standards.

In modelling the scenario, the cost of complying with the hypothetical AEB requirements for new passenger vehicles from 2018 and from 2020 is the relevant unit AEB cost applied to the number of new vehicles in the base case that would *not* have had an AEB system installed.

The expected trauma outcomes (reductions in deaths and hospitalised injury cases) in the scenario are compared to the outcomes in the base case.

BITRE notes that different types of AEB systems are likely to have different effectiveness for different types of crashes, as well as crashes at different speeds.

In terms of the types of crashes where AEB will be most effective, Andersen et al (2013) conclude that “AEB has the potential to reduce the impact speed, and hence the severity, in pedestrian crashes, right turn crashes, head on crashes, rear end crashes and hit fixed object crashes. It appears that they may have little or no effect on right angle crashes, Potential benefits appear to be greatest in pedestrian crashes, rear-end crashes and head on crashes.”

In modelling outcomes, BITRE has assumed that the main crash types where AEB is likely to be effective are:

- Multi-vehicle crashes (more than one vehicle but excluding pedestrians or pedal cyclists)
- Pedestrian involved crashes (excluding pedal cyclists).
- Pedal cyclist involved crashes.

In order to model the impact of AEB, BITRE has made the following assumptions about different subsets of crashes in two different speed contexts (using speed zone as a proxy):

- Basic AEB systems with vulnerable road user protection: assumed to be effective in reducing collision crashes and crashes involving pedestrians and pedal cyclists in speed zones of 60 kilometres an hour or less.
- High speed AEB systems: are assumed to be effective in all speed zones (including where the speed zone is unknown) for collision crashes, including pedestrian and pedal cyclist crashes.

BITRE assume that all levels of AEB reduce *relevant* subsets of fatal crashes by 20 per cent and injury crashes by 25 per cent (the lower bound of the effectiveness found by Andersen et al (2013)).

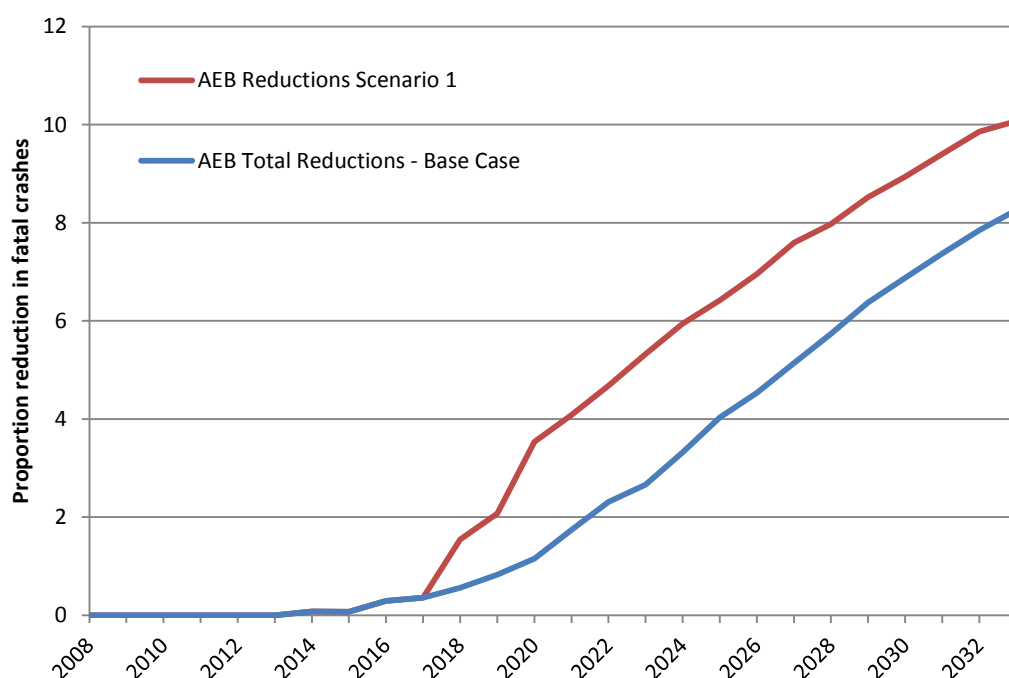
BITRE notes that this is likely to be conservative, as it has not modelled the reduction in trauma from reduced crash severity (for example, a crash still occurs but a person who would have been killed is instead taken to hospital).

Estimating the scenario benefits of mandating AEB

The modelling results for the base case show a gradual reduction in fatal crashes, with AEB estimated to reduce fatal crashes in the base case by 8.3 per cent in 2033.

In the two-step scenario (Scenario 1 in Figure 19), the effect of mandating AEB for all new light vehicles accelerates this reduction from 8.3 per cent to 10.1 per cent of fatal crashes by 2033. The long life of light vehicles and low natural attrition rates mean that, with the mandate, approximately 90 per cent of the light vehicle fleet have a basic AEB system fitted by 2033.

Figure 19 Comparing AEB in the scenario and base case



Source BITRE modelling

Findings

Most current light vehicle AEB systems are low speed. In the base case the number of light vehicles equipped with basic AEB is assumed to gradually increase, reaching approximately 80 per cent of the light passenger vehicle fleet in 2033.

In assessing the impact of AEB, BITRE has assumed that it has the most potential in reduce collision crashes and—where applicable—crashes involving pedestrians and pedal cyclists. BITRE has modelled low and high speed AEB systems with different subsets of crashes for both low speed and high speed contexts.

BITRE finds that, even without mandating AEB, the technology is expected to save 1200 lives and prevent 54 000 hospitalised injuries by 2033. There is however a significant lag before AEB-equipped light vehicles comprise a significant proportion of the fleet.

BITRE has modelled a hypothetical scenario to bring forward AEB to all new light vehicles from 2018:

1. From 2018 an AEB system with vulnerable road user protection is made a requirement for all new light vehicles; and
2. From 2020 a high speed system with vulnerable road user protection is a requirement for all new light vehicles.

The scenario results in an additional saving of 597 deaths and 24,100 hospitalised injuries by 2033. Based on the assumed unit costs, AEB in the scenario has a BCR of 1.3. While AEB is expected to generate significant benefits over the decade to 2030, self-driving vehicles may be available by 2033 with even larger expected safety benefits (see **Box 8**).

Box 8 Driverless cars

Fully autonomous vehicles—often referred to as self-driving or driverless cars—could reduce current road deaths by up to 80 (Carey, 2014) or 90 per cent (Pettendy, 2014).

ARRB Group (2014b) state “forecasts suggest ...a movement from semi-autonomous to fully driverless technology ...within the next two decades. It is quite possible that 75 per cent of all cars on the network could be fully autonomous within 20 years. And while the existing vehicle fleet will take many years to phase out ..., new enabling infrastructure will need to be implemented much sooner.”

To achieve the potential reduction in road trauma, self-driving vehicles will need to be an integrated part of a network of intelligent transport systems.

Hammer (2014) identifies four stages towards a fully self-driving Intelligent Transport System:

- Stage 1: Current. Vehicles sense and can act on their surroundings, for example, AEB.
- Stage 2: Within 2 – 10 years. Vehicle-to-vehicle communication.
- Stage 3: Within 10 – 20 years. Vehicles communicate with the road infrastructure.
- Stage 4: 20+ years. Fully autonomous vehicles and infrastructure.

A number of vehicle manufacturers have announced self-driving initiatives, with some testing self-driving vehicles. These include Audi which has stated it can have a fully driverless car on the market by 2015 (Hagon, 2013), Nissan which will offer self-driving cars by 2020 (Shankland, 2013), and Toyota which has said they will produce near-autonomous cars in 2015 (Cunningham, 2013).

In Australia, development of a national Intelligent Transport System Architecture is a priority action in the Policy Framework for Intelligent Transport Systems (Transport and Infrastructure Council 2012). This includes national positions on key Intelligent Transport System issues including legal implications, regulation and privacy. Austroads (2014) has recommended a reference architecture (the European Intelligent Transport System Framework Architecture) that will enable Australian industries and agencies to deploy Intelligent Transport System ‘in a consistent, interoperable way’.

Several trials and tests of enabling technologies have been conducted or are planned:

- The New South Wales CITI Project is a 42 km stretch of Intelligent Transport System enabled road with up to 60 heavy vehicles fitted with Cooperative Intelligent Transport System devices that will enable receiving of the broadcast safety and weather information and real time information on the three sets of intersections (NSW Transport 2014).
- La Trobe University conducted a successful trial in 2012 using 70 vehicles fitted with Intelligent Transport System sensors to determine whether the sensors would eliminate or reduce level crossing crashes (Hutchinson, 2013).
- COHDA (a wireless company founded in 2004 by University of South Australia researchers) took part in a major Intelligent Transport System trial on 100 km of roads within Ann Arbor, Michigan, where 3000 cars, trucks and buses were fitted with Intelligent Transport System devices allowing communication between roads and vehicles. Results saw 12 different car manufacturers commit to commercially deploying the technology in some of their vehicles by 2015 (Hutchinson, 2013).

Appendix A Economic values for preventing fatalities and hospitalised injuries

The economic benefits of avoiding human losses can be valued using a human capital or willingness-to-pay approaches. Each approach has advantages and disadvantages.^{30,31}

In assessing measures to improve road trauma outcomes, the choice of approach has different implications for costing avoided deaths and injuries: for fatal crashes willingness-to-pay values are substantially higher than human capital values, the difference is far less for serious injury crashes.

Under either approach, most of the benefits of preventing road deaths are the avoided current and future losses to individuals and their families. This is not the case for hospitalised injuries.

In this report BITRE has used willingness-to-pay values for a statistical life that are based on Australian estimates rather than international values.³²

BITRE has revised the method of valuing avoiding fatalities and hospitalised injuries to combine values derived using a willingness-to-pay approach (Hensher et al 2009) with the social costs of road trauma estimated by BITRE (2010a).

A stated willingness-to-pay estimate is expected to capture the costs that would be borne by the average road traveller in the event of a road crash leading to a serious casualty. These costs are assumed to include losses in income, and non-economic or non-pecuniary costs such as pain and suffering, but exclude the wider social impacts not incurred by the individual and their families.

Put another way, there is likely to be a significant difference between an individual's willingness-to-pay to avoid a serious casualty, and society's willingness-to-pay to avoid a serious casualty. The latter is the appropriate cost to consider when assessing counter measures to prevent road trauma.

These wider social impacts of the cost of crashes are borne by insurers, government, emergency services and police, correctional and road authorities, and others. These costs are particularly significant for injury, accounting for almost half the social cost of a hospitalised injury (Table 6).

³⁰ An advantage of the human capital approach is that it identifies and costs the wider social impacts of road crashes—including the costs of emergency services, hospital care, rehabilitation, costs to workplaces, the legal system, insurers, all levels of government and other road users. A major disadvantage of the human capital approach is that it values human losses based on lost production. This is widely acknowledged to significantly under-estimate the social losses.

³¹ A major advantage of willingness to pay values is that they capture individual preferences, rather than lost production, making them theoretically superior to human capital values. A major disadvantage of willingness-to-pay is that individuals' safety valuations do not capture costs such as police attendance, in-hospital care, damage to road furniture and congestion. Other disadvantages are that willingness-to-pay based values will vary by context and it is difficult to produce reliable and consistent estimates.

³² It is not a matter of simply applying international willingness-to-pay values to Australia, as international studies have produced wide variation in value of a statistical life estimates that are exaggerated by significant changes in exchange rates over time. The cost of producing reliable Australian willingness-to-pay estimates has been estimated at more than \$1 million.

Table 6 Human capital based estimates of the social costs of road trauma (2014 dollars)

<i>Cost component</i>	<i>Estimated cost per fatality (thousands)</i>	<i>Estimated cost per hospitalised injury (thousands)</i>	<i>Included in stated willingness-to-pay?</i>
Output losses	2314.2	101.7	Yes
Non-economic or non-pecuniary costs	560.5	41.1	Yes
Disability cost	0.0	73.6	No
Insurance administration	10.2	10.1	No
Medical and other related cost	2.6	20.2	No
Legal costs	28.1	9.1	No
Emergency and police services cost ^a	5.9	2.5	No
Work place disruption	7.9	3.1	No
Ambulance ^b	2.8	2.4	No
Recruitment and re-training	11.8	0.1	No
Premature funeral costs	5.1	0.0	No
Coronial costs	5.5	0.0	No
Total personal costs	2956.9	263.9	-

a. Emergency and Police service costs includes fire and police, but excludes ambulance costs as there were estimated separately.

b. Ambulance costs include the cost of patient transfers.

Source BITRE 2010; Australian Bureau of Statistics 2014

In Table 6, BITRE's (2010a) estimates of the output losses and non-economic or non-pecuniary cost components (expected to be captured in a stated willingness-to-pay estimates) total \$2.87 million (2014 dollars).

Adding the costs of the residual, the wider social cost components, to a stated willingness-to-pay value of \$7.6 million (based on Hensher et al (2009) for NSW) gives an estimate of society's willingness-to-pay to avoid a fatality of \$7.7 million (2014 dollars).

In Table 6, the cost components of a hospitalised injury that are expected to be captured in a stated willingness-to-pay value estimates (output losses and non-economic or non-pecuniary costs) total \$143 000 (2014 dollars).

A major cost to society from road trauma is the cost of disability. However, not all injuries result in disability. In order to adjust for the social costs of disability, BITRE has weighted an individual's willingness-to-pay value (based on Hensher et al 2009 values for NSW) by the expected injury outcomes to derive a value of \$138 000 (2014 dollars). This weighted willingness-to-pay value takes into account the relative likelihood of a disabling and non-disabling hospitalised injury.

Table 7 gives the values and frequencies used for weightings.

Adding the wider social costs of road trauma to the weighted individual willingness-to-pay values gives a value for preventing a hospitalised injury of \$259 000 (2014 dollars).

Table 7 Willingness-to-pay parameters used to estimate the value of preventing a fatality

		<i>Number</i>	<i>Value (2014 dollars, thousands)</i>
Permanent injuries	Urban	551	\$375
	Non-urban	761	\$234
Other hospitalised injuries	Urban	1652	\$91
	Non-urban	1799	\$69
Average hospitalised injury			\$138
Fatality	Urban	133	\$7692
	Non-urban	220	\$7605
Average fatality			\$7638

Source Hensher et al 2009; Australian Bureau of Statistics 2014

Table 8 presents the values used in this report for preventing a serious casualty.

Table 8 Willingness-to-pay based estimates of the value of preventing serious casualties (2014 dollars, thousands)

	<i>Fatality</i>	<i>Hospitalised injury</i>
Personal willingness-to-pay	7638	138
Additional social costs	82	121
Total social willingness-to-pay	7720	259

Source BITRE estimates; BITRE 2010a; Hensher et al 2009; Australian Bureau of Statistics 2014

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References

- Anderson, R., Doecke, S., Mackenzie, J., and Ponte, G. 2013, *Potential benefits of autonomous emergency braking based on in-depth crash reconstruction and simulation*, Centre for Automotive Safety Research, The University of Adelaide, Paper Number 13-0152.
- Archer, J., Fotheringham, N., Symmons, M. and Corben, B. 2008, *The impact of lowered speed limits in urban and metropolitan areas*, Monash University Accident Centre, Melbourne.
- ARRB Group 2014a, [ANRAM FAQs](#).
- ARRB Group 2014b, [Driverless cars](#), 24 June.
- Australian Automobile Association (AAA) 2013, [Star rating Australia's National Land Transport Network](#), AAA, Canberra.
- Australian Automobile Association (AAA) 2014, [Action for road safety](#).
- Australian Bureau of Statistics 2013, *Australian Statistical Geography Standard (ASGS) Volume 5—Remoteness Areas*, Cat. No. 1270.0.55.005, released 31 January.
- Australian Bureau of Statistics 2014, *Consumer Price Index, Australia, Sep 2014*, Cat. No. 6401.0.
- Australian Institute of Health and Welfare 2014, *Health expenditure Australia 2012–13*, Health and Welfare Expenditure Series No. 52, Cat. No. HWE 61, Canberra.
- Austroads 2010, *Impact of Lower Speed Limits for Road Safety on Network Operations*, Austroads, Sydney.
- Austroads 2012, *Guide to Project Evaluation Part 4: Project Evaluation Data*, Sydney.
- Austroads 2014, [Vision for National Intelligent Transport System Architecture](#), 11 November.
- Austroads *forthcoming*, Assistance with 2014 Review of the National Road Safety Strategy.
- Bekavac, M., Excell, R., Jurewicz, C. and Winker, E. 2012, [ANRAM: a case study of integrating asset management into road safety](#), ARRB Group.
- Bradshaw, C.L., Bui, B., and Jurewicz, C. 2013, [Vehicle Activated Signs: An emerging treatment at high risk rural intersections](#), Proceedings of the 2013 Australasian Road Safety Research, Policing & Education Conference 28th to 30th August, Brisbane.
- Bui, B., Cameron, M. and Foong C. 1991, *Effect of right turn phases at signalised intersections, Part 1—Safety performance*, Monash University Accident Research Centre, Report No. 20.
- Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2003, [Road speed limits: economic effects of allowing more flexibility](#), Working Paper 59, Canberra.
- BITRE 2009, [National road network intercity traffic projections to 2030](#), Working Paper 75, Canberra.
- BITRE 2010a, [Cost of road crashes in Australia 2006](#), Report 118, Canberra.
- BITRE 2010b, [Effectiveness of measures to reduce road fatality rates](#), Information Sheet 39, Canberra.
- BITRE 2010c, [Road Deaths in Australia 1925–2008](#), Information Sheet 38, Canberra.

- BITRE 2012a, [*Child pedestrian safety: 'driveway deaths' and 'low-speed vehicle run-overs', Australia, 2001–10*](#), Information Sheet 43, Canberra.
- BITRE 2012b, [*Evaluation of the National Black Spot Program, Volume 1*](#), Report 126, Canberra.
- BITRE 2014a, [*Road Safety: Modelling a Global Phenomenon*](#), Research Report 141, Canberra.
- BITRE 2014b, [*Road trauma involving heavy vehicles: crash statistics*](#), Canberra.
- BITRE 2014c, [*International Road Safety Comparisons Report 2012*](#), Canberra.
- BITRE 2014d, [*Infrastructure, Transport and Productivity*](#), Information Sheet 55, Canberra.
- BITRE 2014e, [*Traffic on the national road network, 2011–12*](#), Information Sheet 63, BITRE, Canberra.
- Cameron, I. 2014, Towards Zero: Using Evidence and Aspiration to Reduce Road Trauma in Western Australia, Presentation to the [*OECD Working Group on Road Safety*](#) 1-2 October 2014, Western Australian Office of Road Safety.
- Candappa N., D'Elia A., Corben B., Newstead S. 2009, *Evaluation of the effectiveness of flexible barriers along Victorian roads*, Monash University Accident Research Centre, Melbourne.
- Carey, A. 2014, [*Driverless cars closer than you think*](#), *The Sydney Morning Herald*, 23 June.
- CARRS-Q 2012, *State of the Road: Mobile phone use and distraction while driving fact sheet*, updated October 2012.
- Chen H.Y. and Meuleners L. 2013, [*The effectiveness of dedicated right turn signals at signalised intersections: Perth Western Australia*](#), Curtin-Monash Accident Research Centre, School of Public Health, Curtin University.
- Cockfield, S. 2014, *Victoria's new Safe System Road Infrastructure Program*, Presentation to the 2014 National Road Safety Forum, 22 September, Transport Accident Commission.
- Collette, T. 2013, [*Australian Road Safety Groups Look To The Future On Pedestrian Safety*](#), 8 May.
- Cunningham, W. 2013, [*Toyota rolling out near autonomous cars in five years*](#).
- Curtin Monash Accident Research Centre (C-MARC) 2011, *Using mobile telephones while driving*.
- D'Elia, A., Scully, J. and Newstead, S. 2012, [*Evaluation of vehicle side airbag effectiveness*](#), Monash University Accident Research Centre, Melbourne.
- Daniels, S., Brijs, T., Nuyts, E., Wets, G. 2008, *Roundabouts and safety for bicyclists: empirical results and influence of different cycle facility designs*.
- Department of Infrastructure and Regional Development 2014a, [*Overview of project appraisal*](#), Canberra.
- Department of Infrastructure and Regional Development 2014b, *Black Spot Programme* web page.
- Dowling, J. 2014, [*NRMA Insurance offers discounts for cars with automatic braking*](#), News Corp Australia Network.
- Euro NCAP 2014, [*Autonomous Emergency Braking*](#).
- Fitch, G.A., Soccolich, S.A., Guo, F., McClafferty, J., Fang, Y., Olson, R.L., Perez, M.A., Hanowski, R.J., Hankey, J.M., and Dingus, T.A 2013, *The impact of hand-held and hands-free cell phone use on*

driving performance and safety-critical event risk, Final Report, National Highway Traffic Safety Administration, US Department of Transportation.

Fitzharris, M. and Stephan, K. 2013, *Assessment of the need for, and the likely benefits of, enhanced side impact protection in the form of a Pole Side Impact Global Technical Regulation*, Monash University Accident Research Centre, Melbourne.

Hagon, T. 2013, [Audi says cars that accelerate, steer and brake in traffic jams could be here sooner than most think](#), *Drive.com.au*.

Hammer, M. 2014, [Emerging Intelligent Transport System Safety Technologies, Benefits & Enablers](#), Presentation to the *National Road Safety Forum*, 22 September, Canberra.

Henley G. and Harrison J.E. 2012, *Trends in serious injury due to land transport accidents, Australia, 2000–01 to 2008–09*. Injury research and statistics series no. 66, INJCAT 142, AIHW, Canberra.

Hensher, D. A., Rose, J. M., de Ortúzar, J. and Rizzi, L. I. 2009, *Estimating the willingness-to-pay and value of risk reduction for car occupants in road environment*, Transport Research Part A.

Hogan, R. 2014, [Vehicle Standards in Australia](#), presentation to the *National Road Safety Forum*, 22 September.

Hutchinson, J. 2013, [Talking cars to hit the road in 2015](#), *Australian Financial Review*.

Jacobs 2014, *National Road Trauma Review: Analysis of Surveys and Workshop Outcomes*.

Klauer, S. G., Dingus, T.A., Neale, V.L., Sudweeks, J.D., and Ramsey, D.J. 2006, *The impact of driver inattention on near crash/crash risk: An analysis using the 100-car Naturalistic Driving Study data*. Report No. DOT HS 810 594. Washington DC, National Highway Traffic Safety Administration.

Larsson, P. 2014, *Vision Zero in Sweden*, Swedish Transport Agency.

Mackie, H., Russell, M., Holst, K., Brodie, C., Lilley, M. 2014, [Variable speed limit trials at rural intersections and rural schools in New Zealand](#), paper presented at the 13th Intelligent Transport Systems Asia Pacific Forum 2014.

McEvoy, S., Stevenson, M., McCartt, A., Woodward, M., Haworth, C., Palamara, P., and Cercarelli, R. 2005, Role of mobile phones in motor vehicle crashes resulting in hospital attendance: A case-crossover study, *British Medical Journal*, 331: 428-430.

McTiernan, D. 2014, *Princes Highway Strategic Road Improvement Plan*, ARRB Group Contract Report for the National Roads and Motorists' Association, NRMA, Sydney.

Minister for Infrastructure and Regional Development 2013, [Mandating Safety Technology for Light Vehicles](#), Media Release JB003/2013, 25 October.

Moore, M., and Zuby, D. 2013, *Collision avoidance features: initial results*, National Highway Traffic Safety Administration, Washington DC.

National Road Transport Commission 2012, *Australian Road Rules*.

New Zealand Transport Agency 2009, *Rumble strips—questions and answers*, March (<http://www.nzta.govt.nz/network/operating/safely/doc/rumble-strips-info-sheet.pdf>).

[News Corp Australia Network 2014](#), *Self-braking cars should be standard: NRMA*.

NSW Centre for Road Safety 2014, [Annual NSW speed camera performance review](#), NSW Government.

NSW Injury Risk Management Research Centre 2010, *Motorcycle crashes into roadside barriers stage 1: crash characteristics and causal factors*, University of New South Wales, Sydney.

NSW Transport 2014, [CITI Project](#).

OECD/ITF 2014a, *Road Safety Annual Report 2014: Summary*.

OECD/ITF 2014b, *Working Group on Safe System Implementation, Annual Summit*.

Olsen, R.L., Hanowski, R.J., Hickman, J.S., and Bocanegra, J. 2009, *Driver distraction in commercial vehicle operations*, Report No. FMCSA-RRR-09-042, US Department of Transportation, Washington DC.

Oxley, J., Corben, B., Koppel, S., Fildes, B., Jacques, N., Symmons, M. and Johnston, I. 2004, *Cost-effective infrastructure measures on rural roads*, Report No. 217, April.

Petroulias, T. 2014, *Community Attitudes to Road Safety—2013 Survey Report*, WAVE 23, INFRA2137, Department of Transport and Regional Development, April.

Pettendy, M. 2014, [‘Self driving cars here in four years’](#), *motoring.com.au*

PwC 2011, *Pacific Highway Upgrade Program: Economic Appraisal, 2011 Update*, Report prepared for the Roads and Traffic Authority of NSW, October.

Regan, M. A., Lee, J. D., and Young, K. L., eds., 2009. *Driver Distraction: Theory, Effects, and Mitigation*. Boca Raton: CRC Press.

Rosén, E. 2013, *Autonomous Emergency Braking for Vulnerable Road Users*, IRCOB Conference 2013.

Rosén, E., Källhammer, J.-E., Eriksson, D., Nentwich, M., Fredriksson, R., and Smith, K. 2010, *Pedestrian Injury Mitigation by Autonomous Braking*, Autoliv Research, Sweden.

Royal Automobile Club of Queensland and Australian Automobile Association (AAA) 2010, [How safe are Queensland’s roads: rating Queensland’s roads for risk](#).

Savino, G., Giovannini, F., Baldanzini, N., Pierini, M. and Rizzi, M. 2013, Assessing the Potential Benefits of the Motorcycle Autonomous Emergency Braking Using Detailed Crash Reconstructions, *Traffic Injury Prevention*, 14:sup1, S40-S49, DOI: 10.1080/15389588.2013.803280.

Scully, J. and Newstead, S. 2007, [Preliminary evaluation of electronic stability control effectiveness in Australasia](#), Monash University Accident Research Centre, Melbourne.

Shankland, S. 2013, [Nissan pledges affordable self-driving car models by 2020](#).

Taylor, M.A.P. 1991, *Effect of right turn phases at signalised intersections, Part 2—Mobility performance*, Monash University Accident Research Centre, Report No. 21, May.

Thatcham Research 2014a, [Autonomous Emergency Braking](#).

Thatcham Research 2014b, [How better brakes will save lives and cut costs](#).

The Coalition 2013, *The Coalition’s Policy to Improve Road Safety*, August.

- Transport and Infrastructure Council 2012, [*Policy Framework for Intelligent Transport Systems in Australia*](#), March, INFRA1250, Department of Infrastructure and Transport, Canberra.
- Transport and Infrastructure Council 2014, [*Communiqué*](#), Launceston, 7 November.
- Transport and Main Roads 2012, *2011 Fatal road traffic crashes in Queensland: A report on the road toll*, October.
- Transport for NSW 2012, [*NSW Speed Camera Strategy*](#), NSW Government.
- Transport for NSW 2013a, [*Safety Technologies for Heavy Vehicles and Combinations*](#), January.
- Transport for NSW 2013b, *Road traffic crashes in New South Wales: statistical statement for the year ended 31 December 2012*, September.
- Transportation Research Board 2010, [*Achieving traffic safety goals in the United States: lessons from other nations*](#), Committee for the Study of Traffic Safety Lessons from Benchmark Nations, Transportation Research Board Special Report, National Academy of Sciences.
- UMA/AECOM 2007, [*Capital Costs for Roadside/Median Barrier Systems*](#), June.
- United Nations 2013, *Addendum 14: Global technical regulation No. 14 – Global technical regulation on pole side impact*, United Nations, Geneva.
- WA Office of Road Safety 2013, *Driver distraction*, Perth, Western Australia: 2.
- World Health Organisation 2011, *Mobile phone use: a growing problem of driver distraction*, Geneva, Switzerland.

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Abbreviations

AAA	Australian Automobile Association
AADT	Average annual daily traffic
ABS	Anti-lock brake systems
AEB	Autonomous Emergency Braking
ANCAP	Australasian New Car Assessment Program
ANRAM	Australian National Risk Assessment Model
ASGS	Australian Statistical Geography Standard
AusRAP	Australian Road Assessment Programme
BCR	Benefit-cost ratio
BITRE	Bureau of Infrastructure, Transport and Regional Economics
CARRS-Q	The Centre for Accident Research and Road Safety Queensland
C-MARC	Curtin-Monash Accident Research Centre
ESC	Electronic Stability Control
Euro NCAP	European New Car Assessment Programme
iRAP	International Road Assessment Program
IRTAD	The International Traffic Safety Data and Analysis Group
ITF	International Transport Forum
KSI	killed or seriously injured
MUARC	Monash University Accident Research Centre
NLTN	National Land Transport Network
NRSS	National Road Safety Strategy 2011-2020
OECD	The Organisation for Economic Co-operation and Development
SSRIP	Safe System Road Infrastructure Program
Vkt	Vehicle kilometres travelled



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ISBN 978-1-925216-10-3