

# Contributed articles

## Review of the impacts of road trauma: summary of report 140

By Tim Risbey

Research Manager,  
Bureau of Infrastructure, Transport and Regional Economics  
Department of Infrastructure and Regional Development  
Tim.Risbey@infrastructure.gov.au

This article summarises Bureau of Infrastructure, Transport and Regional Economics (BITRE) Report 140 which presents the results of a BITRE review of the impacts of road trauma.

This review was a Coalition election commitment that tasked the Bureau 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's review evaluated different road safety approaches, both internationally and domestically, and provided a timely stock take of measures that road safety experts believe can reduce deaths and serious injuries on our roads. The report is available for download from [www.bitre.gov.au](http://www.bitre.gov.au).

### Trends in road trauma

The trends in Australian road deaths, population and registered vehicles since 1950 are shown in Figure 1. While population has increased by 66 per cent (+1.3 per cent per year) and 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).

The main influences on this long term reduction are seat belts, random breath testing and speed cameras. BITRE [11] 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. (The safety weighted vkt combines

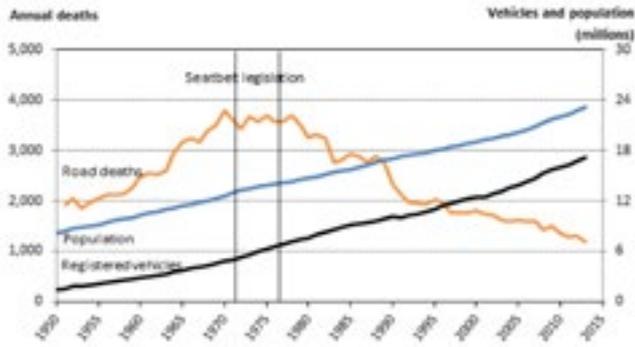
the two influences of distance driven and vehicle type. The more distance travelled, the higher the risk of a road crash occasioning fatalities. Vkt driven is modified by the type of vehicles doing the travelling. A motorcycle rider/passenger runs 26 times the fatality risk per kilometre of a car driver/passenger.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

- 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.

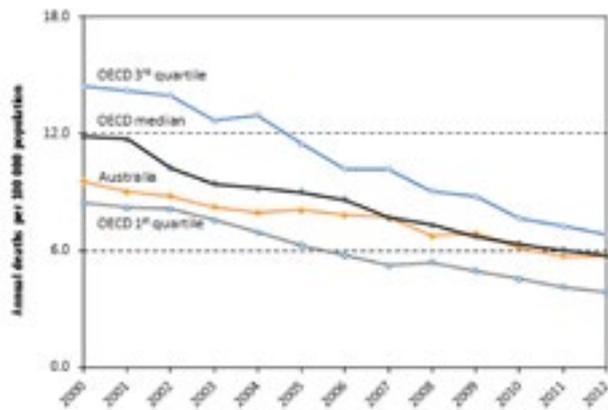
Internationally, the annual number of road deaths in International Traffic Safety Data and Analysis Group countries fell nearly 40 per cent between 2000 and 2012. Australia's decline in the rate of deaths per 100 000 population between 2000 and 2012 has been similar to the OECD's median rate for several years (see Figure 2).

In 2012 Australia's rate of 5.72 deaths per 100,000 population was the sixteenth lowest rate out of the 33 OECD nations with available data (see Figure 3). The nations with the two lowest rates were Iceland (2.81) and United Kingdom (2.83).

However, there has been limited success in saving lives among vulnerable road users and the share of fatalities among elderly road users is slowly increasing in many countries. The OECD/ITF [17] found for International Traffic Safety Data and Analysis Group countries:



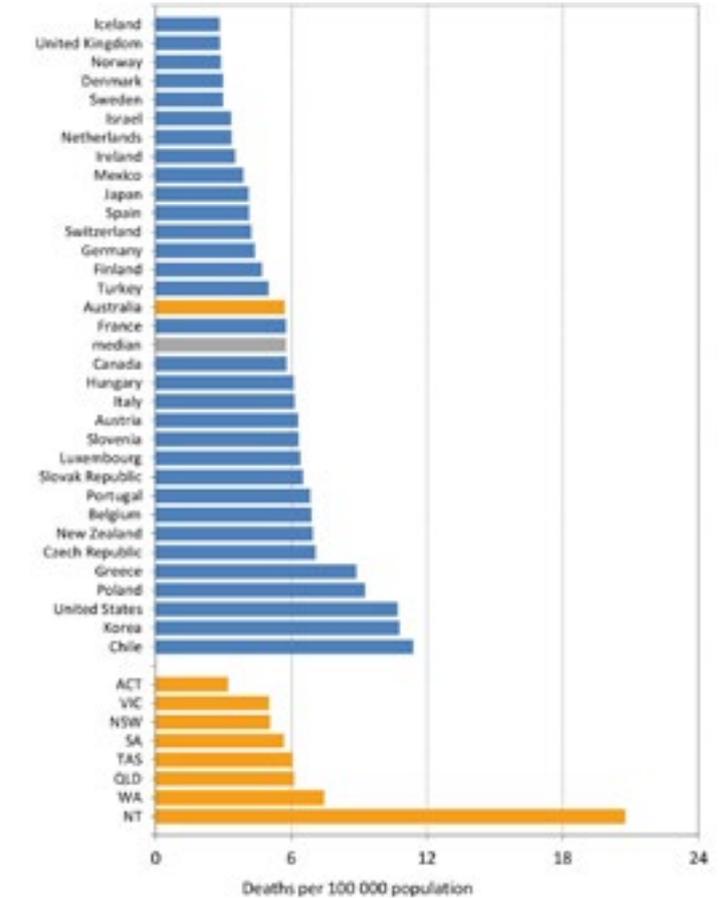
**Figure 1. Australian road deaths, vehicles and population**  
 Source: [11, BITRE Road Deaths in Australia 1925–2008, Information Sheet 38, Canberra; Australian Road Deaths Database; Australian Bureau of Statistics Cat No. 3101.0 and 9309.0].



**Figure 2. Road deaths per 100 000 population: OECD and Australia, 2000 to 2012 [12]**

- Pedestrians are the largest group of vulnerable road users in most countries and account for around 19 per cent of all fatalities in member 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 member countries, reflecting the changing age structure of populations. In 2012, for European 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 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, in member countries over the past decade.

In Australia over the ten years to June 2014, the key trends for road deaths were:



**Figure 3. Road deaths per 100 000 population: OECD countries and Australian states and territories, 2012 [12]**

- 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 in the first half of the decade, motorcyclist deaths subsequently fell. Deaths in the 55 and over age group increased; now accounting for almost a quarter of all motorcycle deaths.
- 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.

- Pedestrian deaths have decreased by 20 per cent over the decade. Deaths have fallen in New South Wales and Queensland, with 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 of traffic-related hospitalised injuries to pedal cyclists are the result of non-collision crashes.[4]
- High threat-to-life injuries to pedestrians remained stable between 2001 and 2009.

### Best practice approaches to reducing road trauma

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”. The Safe System vision is based on ambitious targets and the aspiration to progressively eliminate 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 and vehicle manufacturers) to take appropriate actions to ensure that road crashes do not lead to serious or fatal injuries.

Australia was amongst the first to adopt a Safe System approach, with the National Road Safety Strategy 2011–

2020 (NRSS) firmly based on Safe System principles and 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 commits federal, state and territory governments to a national collaboration on road safety improvement, with a 10-year plan to reduce the annual numbers of deaths and serious injuries on Australian roads by at least 30 per cent.

Individual state and territory governments have direct responsibility for most areas of road safety regulation and management. Western Australia (Box 3 in Report 140) and Victoria (Box 4 in Report 140) have taken different approaches to implementing a Safe System approach.

At the national level there has been significant progress made towards the National Road Safety Strategy 2011-2020 target of a 30 per cent reduction in casualties. While vehicle occupant deaths have trended down, the analysis confirms the relatively high risk for motorcyclists, pedal cyclists, older drivers and remote communities as shown in Figure 4.

### Measures with the most potential to reduce road trauma

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).

Stable or increasing trends for vulnerable road user groups, combined with population increases, makes the search for ways to further reduce road trauma even more challenging. As the measures such as seat belts, random breath testing, speed cameras and air bags that have driven past reductions in road trauma reach maximum effect, and traffic grows, previous road safety measures will need to be ramped up and new measures found to further reduce road deaths and injury.

In order to identify measures with the most potential, BITRE commissioned consulting firm Jacobs to interview road safety experts to identify initiatives they considered had the most potential to reduce road injury and deaths.

Collectively, over 400 initiatives were suggested [16]. A workshop of road safety experts held on 16 May 2014 narrowed this to the top initiatives with the most potential to save lives and reduce injuries.

The top ten ranked initiatives as voted by workshop participants are summarised in Table 1, with a number of initiatives receiving the same number of votes.

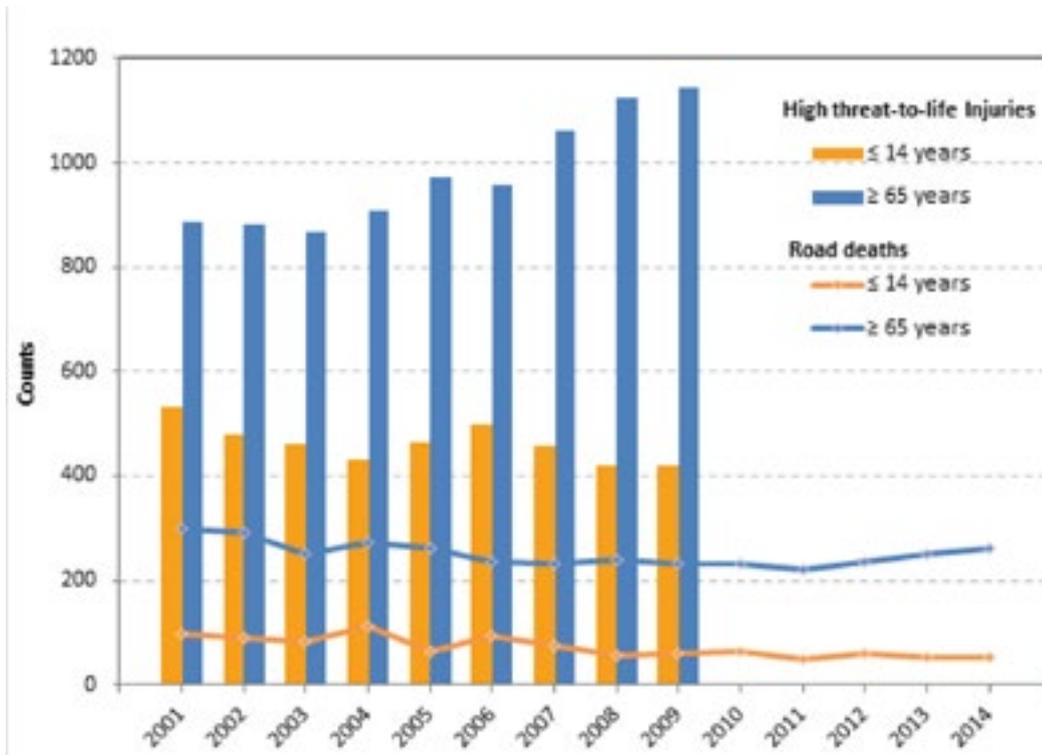


Figure 4. Vulnerable road user groups: road deaths and high threat-to-life injuries  
 Source BITRE Australian Road Deaths Database; Australian Institute of Health and Welfare

Table 1. Summary of workshop voting on initiatives to reduce road trauma

Initiative	Number of votes
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
Note For a full list of initiatives proposed and voting results see Table 5.1 in Jacobs [16]	

Three of the top measures suggested - research, management and leadership - are strategic and not amenable to economic analysis. These important strategic issues were addressed in the broader Review of the National

Road Safety Strategy [5]. Another, the general enforcement of road rules, was not amenable to BITRE’s analysis.

BITRE’s analysis therefore focused on four priorities identified by road safety experts: infrastructure, safer intersections, distraction from mobile phones and autonomous emergency braking. BITRE’s initial assessment of the top ranking measures takes account of:

- Expected timing of some measures currently being implemented and;
- 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. Only real losses are considered and not financial transfers. (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). Counting both income losses and compensation payments would result in double counting.

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 [15].
- 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 (Appendix A, Report 140).

In assessing these measures, the primary basis of assessment was the expected reduction in road trauma - the avoided loss of life and injuries - compared to what would have happened otherwise (the base case).

The base case used is built on a BITRE research report [11] 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. This updated base case projected future levels of road trauma taking account of population and economic growth as well as currently planned measures to reduce road trauma, including electronic stability control, side airbags and autonomous emergency braking in passenger vehicles.

Figure 5 shows the projected reduction expected in fatality risk per kilometre from new technologies in base case.

As several measures that might reduce trauma rates are not included in this base case, it should not be taken as a forecast. 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 have not been explicitly included in this base case include:

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

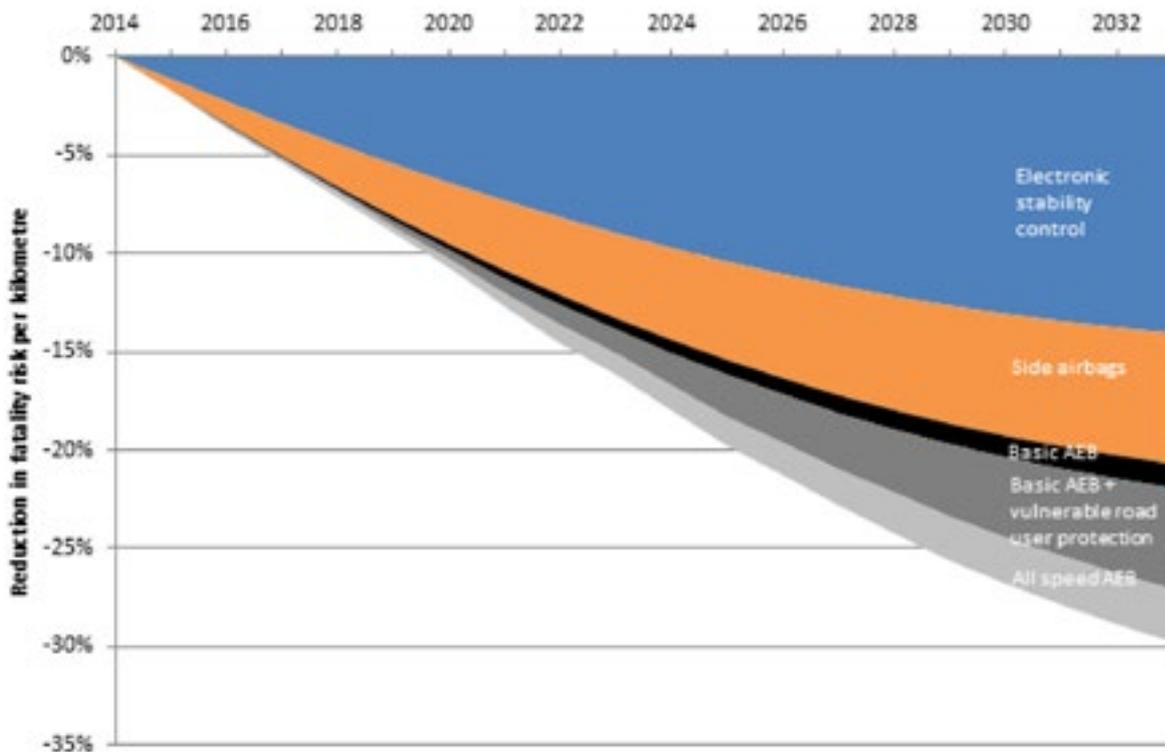


Figure 5. Projected reduction in fatality risk per kilometre from new technologies in base case  
Source: BITRE estimates

## Infrastructure measures

Improved road infrastructure safety standards - a group of 27 related measures excluding intersection safety - was the highest ranking measure in the final workshop rankings of identified road safety related measures.

The proposed infrastructure measures as summarised by Jacobs [16] 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.

(Note that separate star ratings can be calculated for different road user groups, including car occupants, motorcyclists, cyclists and pedestrians).

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

- Improving 85 per cent of the national land transport network to 3 stars or above. While not a specific measure suggested in Jacobs [16], this would be a significant step towards 5 star safety rated roads over 15 years and;
- Reducing speed limits to improve road safety star ratings.

## Improving the National Land Transport Network to 3 stars or above

The National Land Transport Network 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 [13].

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 [6, 1]. There are important differences between the models:

- 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.

- 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 [1].
- 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.
- Unlike ANRAM, 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.

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 [3]. The AAA present an analysis of investment in the national road network which would upgrade it to a point where 85 per cent of roads are rated at 3 stars or above, and 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 [2].

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 site and traffic conditions. While some issues were identified with AAA's modelling assumptions BITRE's analysis confirms that infrastructure measures can reduce road trauma. The use of ANRAM with Australian parameters and traffic volumes, with programme BCR analysis [6], would help in prioritising infrastructure investments to achieve the best safety and benefit-cost outcomes.

## Reducing 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.

In 2003 BITRE 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. [8]

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.

## Intersection measures

Measures to improve safety at intersections ranked equal third in the final workshop rankings of identified road safety related measures (see Table 1).

The main proposed intersection measures as summarised by Jacobs [16] were:

- More roundabouts and more control over right turning movements (that is, either signalised or an outright ban on filter turns) and;
- Focus on worst rated intersections [16, Table 3.4].

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

BITRE [10] 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. The average benefit cost ratio for single treatment sites was 11.3 at a 4 per cent discount rate. 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 [10, pg. 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. 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. It was not possible to identify the number of intersections where filter turns are currently allowed. While it is not possible to identify the number of crashes of this type, the proportion of fatalities resulting from right-turning intersection crashes is between 2.3 per cent and 3.5 per cent across three jurisdictions. Right-turning intersection crashes also result in between eight to nine per cent of reported injuries (including non-hospitalised).

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.

## Mobile phone distraction

Addressing mobile phone distraction ranked equal fifth place in the final workshop rankings of identified road safety related measures (see Table 1).

It is illegal in all Australian states and territories to use a hand-held mobile phone while driving, or when a vehicle is stationary but not parked. Some jurisdictions have extended these laws to make it illegal for probationary or provisional licence holders to use fixed (hands-free) mobile phones, or to interact with other units that have visual displays while driving (for example, DVD players or tablet computers) that are not driver's aids.

While research shows clear links between mobile phone use and crash events, it is difficult to determine the involvement of mobile phone distraction in real world crashes. The best estimates indicate that seven per cent of casualty crashes may have distraction from mobile devices (including GPS and other in car device use) as a contributory factor. Seven per cent of casualty crashes equates to 83 deaths and an estimated 2300 hospitalised injuries in 2013. However, stopping drivers using a mobile device would not necessarily have avoided all crashes as this may not have been the only contributory factor.

The World Health Organisation suggests that a comprehensive strategy combining legislation, strong and sustained enforcement, and continuing campaigns to support enforcement and increase public awareness of risks and penalties is likely to be effective in tackling mobile phone use [18].

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 [16].

## Autonomous emergency braking

Autonomous emergency braking - a component of emerging vehicle based collision avoidance systems - ranked equal sixth place in the workshop rankings of identified road safety related measures (see Table 1).

Most current light vehicle autonomous emergency braking 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 to reduce collision crashes and - where applicable - crashes involving pedestrians and pedal cyclists. BITRE has modelled low and high speed autonomous emergency braking systems with different subsets of crashes for both low speed and high speed contexts.

BITRE finds that, even without mandating, the technology is expected to save 1200 lives and prevent 54 000 hospitalised injuries by 2033. There is however a significant lag before autonomous emergency braking-equipped light vehicles comprise a significant proportion of the fleet. BITRE modelling of a hypothetical scenario bringing forward autonomous emergency braking to all new light vehicles from 2018 results suggests an additional saving of 597 deaths and 24,100 hospitalised injuries by 2033. Based on the assumed unit costs, autonomous emergency braking in the scenario has a BCR of 1.3.

While autonomous emergency braking 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 in Report 140).

### Report 140 key findings

- 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.
- Autonomous emergency braking systems will save lives as they are introduced to the vehicle fleet: it is expected to save over 1200 lives and prevent 54 000 hospitalised injuries by 2033. Over 400 of these deaths and 10 000 of these hospitalised injuries are pedestrians and pedal cyclists.
- 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, seven 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.

Table 2, shown on the following page (page 42) summarises BITRE findings. 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.

### References

1. ARRB Group. ANRAM FAQs, 2014.
2. Australian Automobile Association (AAA). Star rating Australia's National Land Transport Network, AAA, Canberra, 2013.
3. Australian Automobile Association (AAA). Action for road safety, 2014..
4. Australian Institute of Health and Welfare. Unpublished data.
5. Austroads. Review of the National Road Safety Strategy, AP-R477-15, 2015..
6. Bekavac, M., Excell, R., Jurewicz, C. and Winker, E. ANRAM: a case study of integrating asset management into road safety, ARRB Group, 2012.
7. Bradshaw, C.L., Bui, B., and Jurewicz, C. Vehicle Activated Signs: An emerging treatment at high risk rural intersections. Proceedings of the 2013 Australasian Road Safety Research, Policing and Education Conference 28 - 30 August, Brisbane, 2013.
8. Bureau of Infrastructure, Transport and Regional Economics (BITRE). Road speed limits: economic effects of allowing more flexibility, Working Paper 59, Canberra, 2003.
9. BITRE. Effectiveness of measures to reduce road fatality rates, Information Sheet 39, Canberra, 2010.
10. BITRE. Evaluation of the National Black Spot Program, Volume 1, Report 126, Canberra, 2012.
11. BITRE. Road Safety: Modelling a Global Phenomenon, Research Report 141, Canberra, 2014.
12. BITRE. International Road Safety Comparisons Report 2012, Canberra, 2014.
13. BITRE. Traffic on the national road network, 2011–12, Information Sheet 63, BITRE, Canberra, 2014.
14. Chen H.Y. and Meuleners L. The effectiveness of dedicated right turn signals at signalised intersections: Perth Western Australia, Curtin-Monash Accident Research Centre, School of Public Health, Curtin University, 2013.
15. Department of Infrastructure and Regional Development. Overview of project appraisal, Canberra, 2014.
16. Jacobs Group (Australia). National Road Trauma Review: Analysis of Surveys and Workshop Outcomes, 2014.
17. OECD/ITF. Road Safety Annual Report 2014: Summary, 2014.
18. World Health Organisation. Mobile phone use: a growing problem of driver distraction, Geneva, Switzerland, 2011.

**Table 2. Summary of measures, Australia**

<i>Measure</i>	<i>Potential reduction</i>		<i>Average cost (millions)<sup>a</sup></i>	<i>Indicative benefit-cost ratio (BCR)<sup>a</sup></i>	<i>Notes</i>
	<i>Deaths</i>	<i>Hospitalised injuries</i>			
<b>Upgrade national land transport network: 85% 3 stars or above, 20 year timeframe</b>	<b>86/year</b>	<b>2,259/year</b>	<b>\$236.6/year</b>	<b>3.5</b>	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	
<b>Reduce speed limits on national land transport network roads</b>	<b>-17 per cent<sup>c</sup></b>	<b>-17 per cent<sup>c</sup></b>	<b>negligible</b>	<b>1.9</b>	For a hypothetical rural highway with high crash risk.
<b>More roundabouts</b>	<b>-72 per cent<sup>b</sup></b>	<b>-79 per cent<sup>b</sup></b>	<b>\$0.1–0.6/site</b>	<b>11.3 (3.0)</b>	Higher BCR compares safety benefits with implementation costs. Lower BCR includes possible traffic impacts. Negative impact for some road users.
<b>Eliminate filter turns</b>	<b>- (d)</b>	<b>-58 per cent<sup>d</sup></b>	<b>-</b>	<b>2.6</b>	BCR includes traffic impacts
<b>Require Autonomous Emergency Braking in all light vehicles, 16 year timeframe</b>	<b>37/year</b>	<b>1,506/year</b>	<b>\$339.8/year</b>	<b>1.3</b>	<b>Scenario:</b> 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 [15] guidelines for calculating benefit-cost ratios.				
b.	BITRE 2012 [10], Table T6.T01 pg.72.				
c.	BITRE estimates based on Austroads Impact of Lower Speed Limits for Road Safety on Network Operations, Sydney, 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 [14] 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					