Guide to Road Safety Part 5

Safe Vehicles

Austroads

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Austroads

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Guide to Road Safety Part 5: Safe Vehicles

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Abstract

Guide to Road Safety Part 5: Safe Vehicles considers the vehicle factors and features that impact safety outcomes on the road network.

This part of the Austroads *Guide to Road Safety* covers information relating to the Safer Vehicles element of the Safe System.

This updated version of the Austroads *Guide to Road Safety* compiles existing information on Safer Vehicles from the previous Austroads Guide to Road Safety parts and presents it in a logical restructure.

This guide is intended for road safety practitioners, vehicle manufacturers, as well as organisations with vehicle fleets under their management. The information presented in this guide may also prove useful to individual vehicle owners regarding different safety aspects of vehicles. This guide is produced to cater to a wide audience by providing discussion on subject topics that may be implemented or incorporated beneficially to a variety of activities.

Keywords

road safety, safe system, safer vehicles

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About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Transport for NSW
- Department of Transport Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department for Infrastructure and Transport South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Department of Infrastructure, Transport, Regional Development and Communications
- Australian Local Government Association
- New Zealand Transport Agency.

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1. Introduction

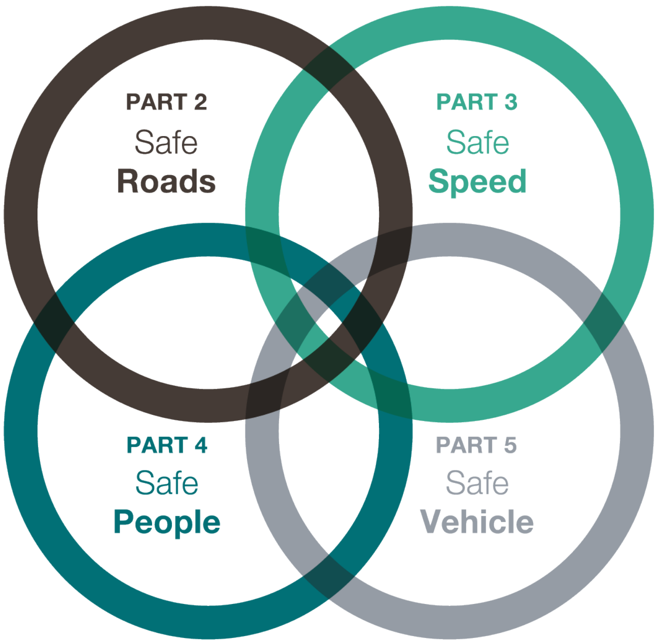
This *Guide to Road Safety* has been structured to reflect the Safe System, which has been adopted by Australia and New Zealand as part of their overall road safety strategy. The Guide consists of the parts as documented in Table 1.1.

Table 1.1: Parts of the Guide to Road Safety

Part	Title	Content
Part 1	Introduction and The Safe System	An overview of the *Guide to Road Safety* and the Safe System philosophy.
Part 2	Safe Roads	Guidance on safe road design.
Part 3	Safe Speed	Guidance on the application of safe speeds.
Part 4	Safe People	Information on safe people and communities.
Part 5	**Safe Vehicles**	**Information on safe vehicles and vehicle safety features.**
Part 6	Managing Road Safety Audits	Guidance on the procurement, management and conduct of road safety audits.
Part 6A	Road Safety Auditing	Guides practitioners through the practical implementation of road safety audits. (Part 6 and 6A will be consolidated)
Part 7	Road Safety Strategy and Management	Guidance on road safety strategies and road safety management.

The four pillars of the Safe System are reflected in this Guide through the aforementioned structure and also through the contents of the Guide. It is noted that each pillar does not stand on its own but, rather, interlinks with other pillars to form the Safe System (Figure 1.1). As such, readers of this Guide are encouraged to refer to multiple pillars when reading this Guide, even though this AGRS Part focusses on Safe Vehicles (Figure 1.2).

Figure 1.1: AGRS Part 2 to Part 5 interlink with each other

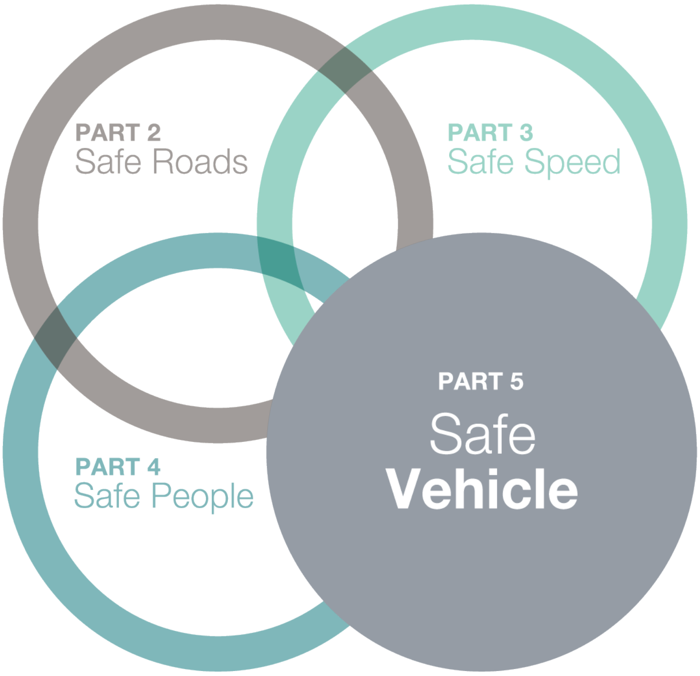


1.1 Purpose of the Guide

The *Guide to Road Safety*, in association with other key Austroads publications, provides road safety practitioners with knowledge and techniques that enable the application of Safe System principles.

Part 5 considers the vehicle factors and features that impact safety outcomes on the road network. Section 2 introduces the types of vehicles that should be considered during road design. Section 3 details factors that influence vehicle safety. Section 4 provides examples of the technologies that help mitigate injuries. Section 5 and 6 will be further developed in the future to provide information about autonomous vehicles and technologies that help to protect vulnerable road users.

Figure 1.2: AGRS Part 5: Safe Vehicles



2. Types of Vehicles

The types of vehicles that use the road network and interact vary markedly (e.g. sedans, 4WDs, motorcycles, bicycles, buses, and rigid and articulated trucks). The design of roads, therefore, needs to take account of the various vehicle characteristics using those roads. Some of the more important vehicle characteristics to consider are manoeuvrability, visibility, cornering and braking (Gardner 1996). These characteristics are considered in Section 3

This section briefly introduces and discusses types of vehicles that should be considered during road design, and as a part of safer vehicles.

2.1 Light Vehicles

Light vehicles refers to the class of vehicles such as utility vehicles, sedans, SUVs, and 4WDs (Austroads 2006) and constitute the largest proportion of vehicles on the road network. This category of vehicles also includes bicycles and motorcycles (Austroads 2006). This class of vehicle is typically used for private transport but can also be used for certain commercial purposes such as company owned private transport, taxi services, and in some instances, delivery services. Utility vehicles can also be retrofitted for specialized commercial purposes.

Commercial use vehicles may be subject to additional restrictions and conditions within the Safer Vehicles and Safer People elements of the Safe System to support Safe System outcomes imposed by governing authorities or organisational standards.

2.2 Heavy Vehicles

Heavy vehicles or include two-axle trucks, buses, or larger vehicles and include articulated vehicles including three-trailer road trains (Austroads 2006). Heavy vehicles are used almost exclusively for commercial purposes. Heavy vehicles generally have reduced braking performance in comparison to light vehicles. Articulated heavy vehicles are also subject to additional risk factors, particularly during turning. Articulated heavy vehicles may be subject to jack-knifing, and have compound forces interacting during manoeuvring, cornering, and braking. Heavy vehicles also constitute a disproportionately large portion of long-distance trips with target timeframes and travel timeframes to cater to commercial goals. As a result, heavy vehicle trips are often subject to extended periods of driving and an increased risk of driver fatigue.

2.3 Motorcycles, Mopeds and Motor Scooters

Motorcycles, mopeds and motor scooters are a subset of light vehicles (Austroads 2006); however, the characteristics of these vehicles warrant individual discussion in the context of Safer Vehicles. Motorcycles, mopeds, and motor scooters are subject to lateral stability issues as they do not have multiple contact points with the ground perpendicular to the direction of travel. They also expose the rider to the environment and have limited opportunities for the inclusion of restraints, airbags, and crumple zones. Despite their compromised stability and their increased exposure for occupants, these vehicles can operate at typical vehicle operating speeds. As a result, the associated risk factors for these vehicles is greater than that of other passenger vehicles. The significant differences in the design of a sedan and motorcycle also mean that progress in vehicle safety is often not transferable to motorcycles, mopeds and motor scooters.

2.4 Trailers

Trailers can be attached to many light vehicles and cause them to adopt certain additional risk factors typically associated with articulated heavy vehicles. These include potential for jack-knifing, and additional risk for manoeuvrability, stability, and cornering. Drivers of light vehicles with trailers may also be less experienced and less well trained for driving articulated vehicles than drivers of articulated heavy vehicles.

2.5 Fleet Vehicles

Fleet vehicles include vehicles that are owned and / or managed by businesses and organisations. This may include scooters for delivery services, vehicle hire company fleets and company operated sedans for the transport of personnel, and heavy vehicles used for long distance transfer of goods.

Fleet vehicles may be subject to extended use by one or more members of an organisation. Fleet vehicles unite the requirements and considerations of both road safety and workplace health and safety. In the context of fleet vehicles, these two considerations are largely dependent and overlapping.

Vehicle use is by far the most significant contributor to work-related traumatic injury. Safe Work Australia reports that 65% of work-related traumatic injury fatalities since 2003 have involved a vehicle, with 40% of these incidents occurring on a public road. In 2015, there were 53 fatalities recorded. However, this significantly under-states the true situation. Road traffic safety agencies recorded 211 people killed in crashes involving heavy vehicles during 2015. Most of these crashes would have been work-related. Work-related crashes involving light vehicles would have added to this total. The trends are very similar in New Zealand (Austroads 2018b).

As a workplace, there will be numerous other organisational requirements that apply equally in the vehicle as in the office, factory or other location. Ergonomics, particularly seating comfort and position, provision of first aid, and environmental comfort should be considered as well as issues arising from working remotely from the organisation (Austroads 2018b).

2.6 Autonomous Vehicles

Autonomous vehicles is a field of growing interest and development. It is expected that autonomous vehicles will assist in solving a number of human risk factors by replacing them with automated vehicle safety features.

The specific risk factors and countermeasures of autonomous vehicles are unclear and subject for discussion. This section will be updated as relevant information becomes available.

2.7 Motorised Mobility Vehicles

Motorized mobility vehicles such as mobility scooters have a growing presence on the road network to support an aging population. Motorised mobility vehicles typically use off-road facilities such as footpaths (where these are available).

The Safer Vehicles considerations for motorized mobility vehicles is significantly different than other forms of transport and revolve primarily around creating compatibility between infrastructure design and the design of motorized mobility vehicles.

3. Safer Vehicle Factors

The Australian Design Rules (ADR) introduce a set of mandatory standards that must be adhered to by all vehicles. These rules ensure a minimum level of safety is met by all vehicles; however, they do not require safety to be included to the highest possible standard that the industry can offer at any given time. As a result, there is still significant variation between the level of safety offered by different vehicles on the network.

The design of vehicles and decision making around vehicle choice can impact the degree of risk that a road user is subjected to. Awareness of these factors can assist in an improvement in vehicle choice and the development of safer vehicles.

A number of factors that influence vehicle safety are presented in the subsections below.

3.1 Vehicle Age and Safety

Vehicle age and safety are intrinsically linked. Crash data from Australia and New Zealand shows that, for crashes occurring during the period 1987-2014, the risk of a driver being killed or seriously injured has declined by around 75% during a 50-year manufacturing period (Newstead, Watson & Cameron 2016). Other data from the Australian New Car Assessment Program (ANCAP 2017) shows that vehicles manufactured up to and including the year 2000 and during the period 2001-2005 were over-represented in Australian fatality crashes occurring in 2015 for their registered vehicle numbers compared with more recently manufactured vehicles. These two investigations highlight the general premise that in crashes involving occupants of newer, recently manufactured vehicles they are less likely to be seriously injured compared with the same crash involving occupants of older vehicles.

Gradual improvements in the structural engineering of vehicles to create ‘crumple zones or ‘safety cells’ and the introduction of seat belts and airbags to reduce the exposure of occupants to impact forces that result in injury (Khalil 2015), have significantly contributed to a reduction in road injuries. This is especially so in first world, highly motorised countries. In more recent times, these improvements have been supplemented by developments in vehicle technologies that help mitigate the occurrence of crashes in the first instance. These features refer respectively to the secondary and primary safety of the vehicle; vehicles that have a high level of both are known collectively as “safe vehicles”, to use Safe System terms. The use of safe vehicles is especially important in the high-speed road environment of regional and remote areas. This is because primary safety features can help mitigate the increased occurrence of particular crash types that characterise regional and remote area crashes such as single vehicle, run-off road crashes; head-on crashes (Siskind et al. 2011; Palamara, Kaura & Fraser 2013) and fatigue-related crashes (Palamara 2016). Furthermore, safe vehicles with a high level of crashworthiness can also reduce the comparatively high risk of death and serious injury associated with regional and remote area crashes (Siskind et al. 2011; Palamara, Kaura & Fraser 2013).

The safety of vehicles has been improved by more recent advancements in vehicle technologies that mitigate the occurrence of crashes in the first instance. These primary safety features are a mix of both active and passive technologies, meaning that drivers must either actively respond to the technology (e.g., apply the brakes) or that vehicle systems will automatically respond to avoid a forward or lateral collision (e.g., adjust power and braking to the wheels to mitigate a loss of control, run-off road crash or crash with a vehicle in front). Other examples of these passive technologies include, but are not limited to, Electronic Stability Control (ESC); Autonomous Emergency Braking (AEB), and Lane Departure Warning (LDW) and Lane Keeping Assist (LKA) (Palamara 2018). The technologies began to emerge in the Australian new car market in the mid to late 2000’s with ESC and in the last three to five years for the latter technologies. These features are described in more detail in Section 4

In 2017, around 41% of light passenger vehicles registered in Australia were manufactured prior to and including 2007 (Australian Bureau of Statistics 2017) with the average age of the registered light passenger vehicle fleet being 9.8 years (Australian Bureau of Statistics 2017). These figures suggest that many Australian drivers and their occupants are travelling in vehicles fitted with less than optimal primary and secondary safety features. No data has been published to date showing the distribution of the age of the registered vehicle fleet or the distribution of safe vehicle rating by region. Nor has national data been published on the age of crash involved vehicles by region of crash. In the absence of these data it is difficult to quantify the extent to which vehicle factors contribute to the disparity in regional road injury trauma. At a population level, there is some information to show that certain drivers in regional and remote areas, compared with major cities, may be more likely to drive older-age, less crashworthy vehicles with none of the contemporary crash avoidance features. Analysis of crash data and other qualitative research indicates that these drivers are more likely to be younger in age from middle to low socio-economic status (e.g. Raftery & Anderson 2012) and Aboriginal people (Helps et al. 2008; Centre for Accident Research and Road Safety 2016).

3.2 Manoeuvrability

Manoeuvrability is closely related to a vehicle's overall size, length, width, height and mass. Current dimensions of heavy vehicles are provided in the Austroads Design vehicles and turning path templates report AP-G34-13 (Austroads 2013). From a safety point of view, it is important that the various parts of the road network, with different traffic functions, are able to accommodate vehicles with dimensions compatible with those road functions. The arterial road network needs to be able to accommodate the largest on-road vehicles. Even local streets need to be able to accept delivery and fire trucks. Standardised design vehicles and check vehicles and templates describing their swept path during turns are used as tools to assist in the geometric design of roads to ensure safe access is available for the likely vehicles on sections of the road network (Austroads 2013). Other important dimension limits are:

- rear overhang
- ground clearance
- mass limits
- over-dimensional vehicle sizes.

3.3 Visibility

Visibility of the road and roadside is dependent on vehicle design as well as road design, positioning of road furniture, etc. (Gardner 1996). Driver eye height is taken to be 1.1 m in cars, 2.4 m in trucks and in the range 1.3 to 1.6 m for motorcyclists.

Due to the driver's position within the vehicle, there are directions in which the driver's vision can be difficult or virtually impossible without looking over a shoulder. A truck driver's view to the rear or side is usually severely restricted and there is no opportunity for a view over one shoulder. This has implications for the angles at which intersections are designed (they should not be at angles more than 20º off right angle) and for the layout of merge and diverge areas, for example. Similarly, truck driver visibility may be obscured by things such as tree foliage or high-mounted signs.

3.4 Cornering

The relationships between suspension characteristics, wheel track, wheelbase and centre of gravity location of most vehicles is such that the limiting factor on cornering is the tendency to slide, rather than overturn. Modern vehicles generally have the ability to utilise all the side friction available and will overturn only when the sideways sliding wheels contact an obstruction on the road surface. However, this is not the case with large, high-sided goods-carrying vehicles which have a high centre of gravity (Gardner 1996). This has implications for the application of adverse crossfall at road intersections and curves.

3.5 Braking

The major effect of braking characteristics on road design is in the evaluation of stopping sight distance. While the stopping ability of most vehicles is better than the distances used for standard design purposes, such a degree of braking is associated with significant occupant discomfort and would be regarded as unreasonable for normal design purposes. Trucks take a longer distance to stop under braking and their stopping distance can often be the critical factor for sight distance.

3.6 Vehicle Safety Features

A number of vehicle safety features are available as either standard or optional accessories in passenger vehicles. These include adaptive cruise control, speed limiters, speed alerts, and emergency brake assist. The specific vehicle safety features and impacts on crash risk are discussed in Section 4.

3.7 Vehicle Safety Rating Systems

Two important sources of information about safe vehicles are the Australian New Car Assessment Program (ANCAP) (www.ancap.com.au) and the Used Car Safety Ratings (UCSR) guide (www.howsafeisyourcar.com.au). The star ratings provided by these programs define the safe vehicle status of new and second-hand crash involved vehicles in Australasia. They provide important consumer-level information that can be used to guide the purchase of a vehicle by government, corporates and personal buyers alike.

ANCAP crash results and the UCSR are widely publicized by government road safety and transport agencies and state-based motoring organisations. The program ratings also feature in the Victorian government sponsored websites: www.howsafeisyourcar.com.au and www.howsafeisyourfirstcar.com.au. Historic and current ANCAP ratings can also be found for used cars advertised for sale on www.gumtree.com/cars and www.carsales.com.au websites, though there are issues with the appropriateness of using historic ratings generated by previous testing criteria. ANCAP ratings similarly provide foundation information for the selection of 5-star vehicles promoted by safe vehicle fleet purchasing policies (see below). In the regional and remote area context, there appears to be minimal use of ANCAP and UCSR to promote the uptake of safe vehicles. One notable exception is the Road Safety Commission of Western Australia which has produced a consumer guide on safe vehicles suitable for remote and regional Western Australia (https://www.rsc.wa.gov.au/RSC/media/Documents/Resources/Publications/consumer-guide-safer-vehicles.pdf). The document provides some guidelines regarding the selection of suitable new and second-hand vehicles using ANCAP/UCSR material and the suitability of the vehicle for the driving conditions of WA.

3.8 Fleet Purchasing Policies

In recent years there has been increased recognition that vehicles serve as the ‘workplace’ for many workers. This appreciation is formally acknowledged in Australasian work health and safety legislation (Austroads 2018b). The implication of this is that employers should provide their employees with vehicles that are safe as well as fit for purpose and, secondly, that employers and employees alike have a responsibility to promote and maintain safe use of the workplace vehicle to reduce the risk of crashing and injury. The latter issue is the focus of the Austroads (2018b) report. The importance of 5-star fleet purchasing policies and guidelines is exemplified in the *A Guide to Applying Road Safety Within a Workplace* (NRSPP / ACC 2013). In 2017, the Australian Government adopted a 5-star fleet purchasing strategy (https://www.finance.gov.au/vehicle-leasing-and-fleet-management/fleet-guidance-and-related-material.html). Australian jurisdictions have similarly mandated or committed to safe vehicle purchasing. For example, the Western Australian Government has mandated that public sector bodies purchase 5-star rated vehicles (Department of Finance 2017), while the Victorian Transport Accident Commission has developed mandatory specifications for their vehicle fleet (Transport Accident Commission n.d.). Five-star fleet purchasing strategies of this kind are expected to inevitably contribute to a faster uptake of safe vehicles in the private sector through the eventual on-sale of these government and corporate fleet vehicles (Australian Transport Council 2011; NRSPP / ACC 2013).

3.9 Promoting Safer Vehicles in Regional and Remote Areas

Increasing the use of newer, more costly safer vehicles among regional and remote area residents, particularly younger age and Aboriginal people, may be difficult because of the social disadvantage and diminished financial means that characterises the low socio-economic status of residents of these areas (Australian Bureau of Statistics 2011). Consequently, innovative initiatives to address the financial barrier of purchasing a safer vehicle must be considered for these ‘at risk’ populations. This could include reduced vehicle stamp duty and registration fees, and priority access to the purchase of safe vehicles retired from the government and corporate fleet. The latter is currently being investigated by the Western Australian Government.

A number of countermeasures are available to reduce the prevalence of older vehicles in regional and remote areas. These include:

- increase use of safer, newer vehicles by regional area residents
- regulate new technologies through Australian Design Rules (ADRs) on all vehicle types (e.g. ABS for motorcycles, ESC and AEB for heavy vehicles, side airbags for light commercial vehicles)
- 5-Star crash performance and safe driver assist technology vehicle policies for industry and government fleets
- implement a scheme in which a proportion of government fleet vehicle sales are directed to regional/remotes areas.

A number of factors outside of the Safer Vehicle element that can also assist in the reducing the prevalence of older vehicles include:

- community-based education/promotion campaigns
- financial assistance via vehicle purchasing, registration and insurance incentives to facilitate purchase of newer, safer vehicles.

4. Vehicle Safety Features

Vehicles are being increasingly fitted with an array of technologies that assist the driver to maintain and regain control over the vehicle in a potentially hazardous situation, or even take control over the vehicle if the driver fails to do so. Examples of the technologies that would help mitigate injuries are briefly described below.

4.1 Electronic Stability Control

Electronic stability control (ESC) has the potential to reduce the incidence of vehicle loss of control and run-off road crashes (Tracy 2013). It recognises when driving conditions have become unstable and the driver is at risk of losing control and the direction of the vehicle. It applies corrective action, independent of the driver, to assist the driver to return to the correct and intended direction of travel (Phan 2017). ESC is an effective technology; it has been shown to have resulted in a 28% reduction in single vehicle crashes of all injury severities and a 32% reduction in driver injury crashes of all severities, with the biggest reduction observed for rollover crashes involving four-wheel drive vehicles (Scully & Newstead 2010). One limitation of the technology however, is that it is likely to be less effective in circumstances where the driver is not sufficiently able to take back control over the vehicle, for example, when adversely affected by an impairing substance or fatigue/sleepiness (Scully & Newstead 2010).

As of 2013, ESC has been mandatory for all light passenger vehicles. The technology was also made compulsory for light commercial vehicles in 2017.

4.2 Adaptive Cruise Control

Adaptive cruise control (ACC) automatically adapts the vehicle's speed to maintain a constant, safe headway behind the lead vehicle (Dickie & Ng Boyle 2009). ACC differs from autonomous emergency braking in that it will not perform emergency braking, though may undertake moderate braking to maintain a safe headway time (Mehler et al. 2014). ACC maintains speed and distance and thus has the potential to reduce the risk and incidence of rear-end crashes (Xiao & Gao 2010) and the incidence of speed-related crashes in rural areas (Organisation for Economic Co-operation and Development 2016). Field testing has shown that drivers who use ACC, compared with those who do not, maintain longer headway distances to the vehicle ahead (Kessler et al. 2012). Longer headways are likely to be protective against involvement in a forward collision with wandering animals in the regional and remote context (AAMI 2018).

4.3 Intelligent Speed Adaptation / Assist

As stated in the *Guide to Road Safety Part 2: Safe Roads* (Austroads 2021), failure to comply with the posted speed limit has been identified as a risk factor for severe injury crashes in regional and remote areas. Intelligent speed adaptation (ISA) has the potential to influence a driver's compliance with the posted speed limit in these regions, particularly where road infrastructure treatments and police enforcement is less feasible to manage drivers' speeds. ISA systems, which typically consist of a GPS connected to a speed zone database, determine the position of the vehicle in a road network in relation to the posted speed limit at that point. If the vehicle is found to be exceeding the speed limit, the system may either provide an advisory warning/alert or autonomously adjust/limit the vehicle's speed (European Commission 2019). Recently, a pilot study examining the potential of a limiting ISA system, using US crash data, suggested that the system could reduce the incidence of serious injury crashes by some 62% (Doecke & Ponte 2017).

Another form of ISA is Traffic Sign Recognition (TSR), an in-vehicle technology which uses camera vision systems to detect, read and interpret roadside traffic signs, including speed signs. TSR is available in some new cars and can be added as an aftermarket system (e.g. Mobileye). There are a number of issues with the accurate reading of signs and it is likely that vehicle manufacturers will continue to rely on spatial databases of speed zones to supplement TSR systems (Austroads 2018c). More broadly, the use of ISA may be problematic in regional and remote areas where the appropriate speed may be heavily influenced by road and weather conditions rather than reflecting the posted speed.

4.4 Autonomous Emergency Braking

Autonomous emergency braking (AEB) has the potential to mitigate forward collisions through the detection of, and emergency braking in response to, a detected object such as a vehicle ahead, cyclist, or even a pedestrian. ANCAP requires 5 star rated vehicles to contain an AEB system, including detection of vulnerable road users. Early iterations of AEB were essentially 'low-speed' variants and particularly useful in the city or urban environment. In the regional and remote area context, high speed AEB systems utilise long range radar to detect vehicles and other objects up to 200 metres ahead. Taking into account the driver's speed, it will determine the risk of an imminent collision before autonomously reducing vehicle speed and applying brakes as required.

4.5 Lane Departure Warning / Lane Keeping

Lane departure warning (LDW) and Lane keeping assist (LKA) technologies are often packaged together to alert and/or assist drivers in maintaining lane position, primarily to avoid a potential lateral collision. LDW alerts drivers that they are drifting or departing from their lane without having signalled their intention to do so (Jansch 2017). LKA will automatically take corrective action to move the car back into the lane if the driver has not already done so (Mehler et al. 2014). These technologies have the capacity to reduce the incidence of lateral collisions, such as single vehicle, run off road crashes; hit object crashes; rollover crashes; and even head-on collisions (Vehicle Safety Research Group n.d.) commonly occurring on regional and remote roads.

4.6 Fatigue Warning and Monitoring Systems

The use of vehicles fitted with systems to monitor the driver for alertness or drowsiness has the potential to reduce the incidence of fatigue related crash types (Vehicle Safety Group n.d.) that frequently occur on regional and remote roads. These systems are less likely to be effective, however, when the driver is affected by alcohol or other impairing substances (i.e., unable to respond appropriately) (Vehicle Safety Research Group n.d.). At this stage, fatigue warning and monitoring systems are most often fitted to commercial transport and haulage vehicles, often with back-to-base notifications (Lupova 2018). Dawson, Searle and Paterson 2014 conclude that there is currently limited scientific evidence regarding the effectiveness of fatigue warning and management systems. They suggest that technologies currently in use by the road transport industry fail to meet regulatory requirements for a legally and scientifically defensible device and are not capable of providing a comprehensive fatigue management solution. More recently, vehicle manufacturers such as Mercedes Benz have introduced drowsy driver management systems in the light passenger private vehicle fleet to counter fatigue driving (https://www.auto123.com/en/news/mercedes-benzs-attention-assist-system/41639/). The Mercedes Benz system is particularly oriented to continuous driving on high speed roads (i.e., over 80km/hour), which are known roads for fatigue-related crashes (Palamara 2016).

4.7 Automatic Crash Notification Systems

The primary purpose of Automatic Crash Notification Systems (ACN) is to reduce the time taken for appropriate assistance to reach the victims of motor vehicle crashes, and by doing so to reduce the incidence of death and the level of impairment from injury. A secondary purpose is to provide, where possible, some indication of the severity of the crash and of the injuries that are likely to result from it, and to also provide some information about the occupants of the vehicle or vehicles involved, so that emergency services will be better prepared to deal with the situation they find on arrival at the scene of the crash (Austroads 2004).

The introduction of ACN systems started from the luxury end of the car market, in vehicles commonly equipped with navigation systems and often also equipped with security systems providing vehicle tracking and notification of emergency breakdown services. The United States of America has led the way, followed by Japan and Europe. It is only very recently that ACN has become a feature of some in-vehicle security and safety systems in Australia (Austroads 2004).

Studies of systems operating overseas have shown significant reductions in crash notification times and in the time taken for emergency services to reach the scene. It is believed that these reduced times are already resulting in lives saved and improved injury outcomes (Austroads 2004).

A potential weakness of existing ACN technology in countries like Australia, with its large sparsely populated areas, is the relatively poor coverage offered by the cellular phone network. The degree of this limitation cannot be estimated at this stage, as the proportion of severe crashes that take place in areas without cellular phone coverage is not known. This limitation may be removed with the use of satellite communications technology in the future, but this solution is prohibitively expensive at this stage. However, even with this weakness, it is clear that the potential exists for significant reductions in death and injury by the utilisation of existing ACN technology (Austroads 2004).

5. Autonomous Vehicles

There is much speculation about the impact that increasing automation will have on society and operationally on safety. The most optimistic outlooks consider the possibility of fully automated vehicles that do not require operator input and refuse to crash. While technologically this scenario is currently possible in a closed controlled environment, there are several technological and societal transformations required before such a scenario can occur on a widespread basis on open public roads (Austroads 2018a). Austroads (2017) provides an up-to-date assessment of the potential benefit of automated vehicles and Cooperative Intelligent Transport Systems in Australia and New Zealand given certain deployment scenarios.

The more realistic short to medium term scenario is that automated technologies will continue to be developed to assist core driving tasks. It is conceivable that some of these technologies will virtually eliminate death and injury from certain crash types yet there are likely to be situations and circumstances where the systems cannot protect road users. In other words, considerable crash residuals may still exist as a result of technological limitations, operator error, environmental conditions (such as smoke, fog, sun glare and heavy rain), or variability in implementation between manufacturers. In this scenario safe infrastructure and vehicle design will still have an important role to play in providing the necessary safety redundancy when the driver-assist systems fail or cannot perform optimally (Austroads 2018a).

6. Safer Vehicles and Vulnerable Road Users

Vehicle technology can reduce the likelihood and severity of a collision with vulnerable road users, such as pedestrians, bicyclists and motorcyclists, through new technology such as ACN, AEB, LDW, and LKA. Further, ANCAP crash testing also incorporates pedestrian and cyclist crash testing in the calculation of a vehicle's overall crash rating. This has resulted in vehicle manufacturers focussing more on designing vehicles that reduces the likelihood of a pedestrian or cyclist sustaining a fatal or serious injury if they are impacted by a vehicle. Although both vehicle active and passive safety measures have been implemented over the years to reduce the likelihood of a vulnerable road user being fatally or seriously injured, there is still a significant amount of research being conducted in this area to improve the safety of vulnerable road users.

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Austroads' **Guide to Road Safety Part 5: Safe Vehicles** consider the vehicle factors and features that impact safety outcomes on the road network.

Guide to Road Safety Part 5

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