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ABSTRACT

This report estimates the benefits to Australia of the adoption of an ADR on pedestrian protection. It compares the sales-weighted performance of the Australian and European new car fleets in relevant pedestrian impact tests, based on test reports from EuroNCAP and ANCAP. These testing programs use very similar tests to those prescribed by the European Directive on pedestrian safety and a proposed Global Technical Regulation. This comparison showed that the pedestrian protection of the new car fleet in Australia is inferior to that of the new car fleet in Europe, and the difference is associated with the introduction of the first phase requirements of the Directive. The benefits to Australia of an ADR on pedestrian protection were calculated, based on benefit calculations that were estimated for a second phase of European regulation due in 2011. Proportional reductions of fatal, serious and slight casualties were applied to Australian casualty data and the associated crash costs. By examining the current performance of the new car fleet, these benefits were disaggregated into benefits that have already accrued since overseas and international regulation was mooted, and that which is yet to be realised through compliance of the new car fleet with a future regulation. An Australian Design Rule conforming to the proposed Global Technical Regulation with the addition of Brake Assist would reduce, in Australia, fatalities by 28, serious injuries by 947 and slight injuries by 1247 each year, with associated savings in crash costs of $385 million per year. Despite recent improvements in the performance of the fleet, around half of these benefits are yet to be realised.

KEYWORDS

Vehicle safety, Pedestrian, ADR, Crash test, Benefit calculations

Summary

There are moves internationally to regulate at least a minimum level of pedestrian and vulnerable road user protection in the design of passenger vehicles. Europe and Japan have both introduced regulations that apply to vehicles released from Model Year 2006. The relevant European Directive has also timetabled a second phase of regulation that will apply to vehicles from Model Year 2011, but the final prescriptions of this second phase are still being discussed. The most probable outcome of this discussion will be a regulation consistent with a Global Technical Regulation (GTR) being drafted under Working Party 29 of the UNECE. Australia is committed to harmonisation of its vehicle regulations with international regulations wherever possible, and so the most probable course of action for the Australian Government, should they wish to introduce a relevant regulation, would be to adopt the proposed GTR.

The passive safety components of these regulatory options prescribe performance requirements in a series of 'sub-system' impact tests. These tests simulate the impact between the head of a child and an adult pedestrian and the vehicle, and the lower extremities of an adult pedestrian and the vehicle. Phase II of the European Directive will probably also include mandatory use of 'Brake Assist' technology (BAS). BAS assists the driver to stop the vehicle as quickly as possible in an emergency. The final form of the GTR may also include this requirement.

This report compares the sales-weighted passive safety performance of the Australian and European new car fleets in relevant pedestrian impact tests, based on test reports from EuroNCAP and ANCAP. These testing programs use very similar tests to those prescribed by the European Directive on pedestrian safety and a proposed Global Technical Regulation. This comparison showed that the level of pedestrian protection of the new car fleet in Australia is inferior to that of the new car fleet in Europe, and the difference is associated with the introduction of the first phase requirements of the Directive in Europe.

The benefits to Australia of an ADR on pedestrian protection were calculated, based on benefit calculations that were estimated for a second phase of regulation in Europe due in 2011 (Lawrence et al., 2006). Proportional reductions of fatal, serious and slight casualties were applied to Australian casualty data and the associated crash costs. The current performance of the new car fleet in EuroNCAP/ANCAP tests was examined. This quantified the existing level of performance of the new car fleet in pedestrian impact tests. This quantification allowed the benefits associated with an ADR to be disaggregated into benefits that have already been realised to date (as demonstrated by the current performance of the new car fleet), and those benefits that are yet to be realised (those benefits that would accrue by selling only vehicles that fully comply with a future regulation on pedestrian protection).

An Australian Design Rule conforming to the proposed Global Technical Regulation with the addition of Brake Assist would reduce, in Australia, fatalities by approximately 28, serious injuries by approximately 947 and slight injuries by approximately 1247 each year, with associated savings in crash costs of approximately $385 million per year. Despite recent improvements in the performance of the fleet, around half of these benefits are yet to be realised.

Acronyms

EuroNCAP: The European New Car Assessment Programme

ANCAP: The Australasian New Car Assessment Program

UNECE WP.29: World Forum for the Harmonization of Vehicle Regulations; Working Party 29 of the United Nations Economic Commission for Europe

GRSP: Working Party on Passive Safety (A division of UNECE WP.29)

GTR: Global Technical Regulation. These are issued by UNECE WP.29

Informal Group on Passive Safety: A committee of GRSP drafting a GTR on protection of vulnerable road users in case of a collision with a passenger vehicle

ADR: Australian Design Rule for Motor Vehicle Safety

EEVC: European Enhanced Safety of Vehicles Committee

WG7; WG10; WG17: Working Groups of EEVC that have developed test procedures for protection of vulnerable road users in case of a collision with a passenger vehicle

ISO: International Standards Organization

IHRA: International Harmonized Research Activities. IHRA was created in 1997 to examine improvements to road user safety through vehicle passive safety research. It ceased activities in 2006

Contents

1 Introduction

In the 10 years up to July 2007, 2595 pedestrians were killed on Australian roads (ATSB, 2007). A significant proportion of serious and fatal injuries are caused by the impact with the front of the vehicle (Anderson et al., 2004). It follows that considerate design of the front of a vehicle should improve a pedestrian's chance of survival and reduce the incidence and severity of injuries in a collision.

Currently there are no Australian vehicle design standards/Australian Design Rules (ADRs) that consider the protection of pedestrians or other vulnerable road users in the event of a collision. Europe and Japan now mandate a minimum level of pedestrian protection in new models of passenger vehicles sold in those jurisdictions, and one by-product of this is that vehicles designed to comply with pedestrian protection regulations are flowing into the Australian vehicle fleet. Beyond this effect, the Australian new car fleet can only improve through the global nature of vehicle research and development, and/or impetus from new car assessment programs (EuroNCAP and ANCAP).

The Australian Government has a policy to align Australian vehicle standards with global regulations (Newland, 2005). UNECE WP.29 is developing a GTR through GRSP on pedestrian protection (UNECE, 2007) and so expect that Australia will examine any final proposal issued by the UNECE with a view to adopting such a regulation as an ADR for passenger vehicles sold in Australia.

New car assessment programs in Europe, Australia and Japan promote pedestrian-safe passenger vehicles. While manufacturers are not required to design vehicles to do well in these programs, some vehicles have performed well, demonstrating that improvements in vehicle design for pedestrian protection are possible. Consumers' choices are affected by perceptions of safety, including that of pedestrian safety (Hobbs, 2005), but it is likely that perceptions about pedestrian protection influence consumers' choices less than perceptions about occupant protection. The occupant safety ratings (which are separate from the pedestrian safety ratings) of new cars usually comfortably exceed the minimum level required by the relevant ADRs. Similar comments cannot be made for levels of pedestrian protection, with very poor assessments prevalent. Vehicle regulation has a more important role in improving levels of pedestrian protection than the role regulation for occupant protection has in further improving occupant protection.

The importance of a particular model's level of pedestrian protection is proportional to the model's representation in the vehicle fleet – high-selling models of vehicle will be involved in pedestrian crashes more often because of exposure.

This report considers the following questions:

- Does Australia benefit from overseas developments in design in the area of pedestrian protection?
- How does any such benefit compare with countries now subject to the regulation of pedestrian protection?
- What changes in the safety of the fleet would be elicited from the introduction of relevant regulation in Australia?
- What would the benefits be (reduced death, injury and the associated costs)?

1.1 Recent international developments in pedestrian safety

In the late 1970s, the then European Experimental Vehicles Committee (EEVC) was one of the first groups to examine the possibility of developing a test procedure to evaluate the degree of pedestrian friendliness of the fronts of vehicles. Working Group 7 of the

EEVC examined injury patterns and sources of injury among pedestrian casualties and fatalities. The data collected indicated that the most commonly injured regions of the body were (in decreasing frequency) the head, lower limbs, arms, thorax and pelvis. When only severe injuries were examined, the head and lower limbs were most frequently involved (EEVC, 1994). Working Group 10 of the EEVC was formed as a result of a report of an ad hoc group that made further findings following the final report of Working Group 7. Working Group 10 was given the mandate to determine test methods and acceptance levels for assessing the protection afforded to pedestrians by the fronts of cars in an accident. They devised a set of impact tests to measure the risk of injury to the head of adults and children using free flight headforms, the upper leg of an adult using a guided impactor and the knee and tibia of an adult using a free flight leg impactor (EEVC, 1994). Working Group 10 was superseded by Working Group 17 (WG17) in 1997 who further refined the tests and test devices. Their report was released in 1998 (EEVC, 1998).

The International Standards Organisation (ISO) and the International Harmonised Research Activities Pedestrian Safety Working Group (IHRA) also developed test procedures for pedestrian protection. The test methods differ from the EEVC in certain aspects (particularly headform masses, impact speeds and angles) but they remain largely based on the work of the EEVC (Mizuno and Ishikawa, 2001).

Since 1 October 2005 (Model Year 2006), new types of passenger vehicles given type-approval in Europe must comply with Phase I (of II) of a European Council Directive that requires a certain performance level in child headform and full legform impact tests (2003/102/EC). (See Section 2 for more details on the tests.) Existing models of vehicle are not required to comply at this stage. Phase II requirements are more stringent than Phase I, in the number of tests, and the performance requirements of the tests. The European Council intends to introduce Phase II from Model Year 2011 (McLean, 2005).

The EC has not finalised the prescriptions of Phase II of the EU Directive. Prescriptions are given in 2004/90/EC, but they are still being discussed and amendments are likely (EC 2007; EC 2008). The current working document of the EC on the Phase II requirements is aligned with a proposed Global Technical Regulation, with added requirements for 'Brake Assist' systems (EC, 2008).

GRSP has assembled an ad hoc group to propose a draft Global Technical Regulation (GTR) on pedestrian protection. To date, this draft has been based largely on the work of the International Harmonised Research Activities Pedestrian Safety Working Group (McLean, 2005). This GTR is relevant to Australia: Australia is a signatory to the UNECE 1958 Agreement concerning the Adoption of Uniform Technical Prescriptions for Vehicle Safety. Australia intends also to become a party to the UNECE 1998 Agreement on Global Technical Regulations (GTRs) (Infrastructure, 2007).

The 1958 agreement allows reciprocal recognition of vehicle standards. Under the 1998 agreement, there is no reciprocal recognition, but instead the agreement provides a forum for the harmonisation of vehicle safety standards (GFPTT, 2008).

If Australia becomes a signatory to the 1998 agreement, it will have to consider ratifying Global Technical Regulations for adoption under the system of Australian Design Rules administered by the Australian Government. Having said that, since the 1998 agreement was made, only one GTR has been finalised. Nevertheless, any regulation in Australia will probably be modelled on the outcome of the development of a GTR on pedestrian protection.

Japan has regulated to ensure that new models of passenger car and their derivatives introduced after 1 September 2005, and all models after 1 September 2010, comply with pedestrian head impact performance requirements. There are no requirements in the Japanese regulation for any legform impact tests (McLean, 2005).

1.2 New Car Assessment Programs (ANCAP and EuroNCAP)

The European New Car Assessment Programme (EuroNCAP) and the Australasian New Car Assessment Program (ANCAP) test selected new passenger vehicles to assess their pedestrian protection performance, and publish the results. A vehicle is awarded up to 36 points, based on the results of a series of subsystem tests in which dummy components are fired at the front of the vehicle (details are given in Section 2). The vehicle is then given a star rating of between 0 and 4 stars based on the number of points it has scored (Table 1.1). In 2002, ANCAP and EuroNCAP adopted revised pedestrian testing protocols (currently version 4.1), which are largely based on the work of Working Group 17 of the European Enhanced Vehicle Safety Committee (EEVC WG17). ANCAP pedestrian assessments are conducted under the same protocol as those for EuroNCAP and so ANCAP also republishes EuroNCAP results. A summary of the assessment methods and full results from previous ANCAP tests has been documented by Ponte et al. (2004). All current and historical assessments are available on the ANCAP (http://www.ancap.com.au) and EuroNCAP (http://www.euroncap.com) websites.

Table 1.1
Relationship between points scored and pedestrian star rating in EuroNCAP/ANCAP tests

Points scored	0 - 0.99	1 - 9.49	9.5 - 18.49	18.5 - 27.49	27.5 - 36
Star rating	0	1	2	3	4

2 Regulatory options and their effectiveness

This Section describes the test methods (the technical prescriptions) that are likely to form the basis of any Australian Design Rule on pedestrian protection based on current considerations by GRSP. All current and proposed passive safety test protocols have their genesis in the work of the European Enhanced Vehicle Safety Program (as detailed in Section 1).

2.1 Passive safety prescriptions

Passive safety is defined as those measures that protect road users during a collision. In occupant safety, passive safety measures include seat belts, airbags, and structural energy dissipation. In the context of pedestrian safety, passive measures are those that reduce the injury potential of vehicle structures that pedestrians and cyclists often hit in a collision.

The most commonly injured body regions in pedestrian collisions are the head and the lower extremities. Anderson (2008) examined injuries caused in pedestrian crashes investigated at the scene in Adelaide between 1999 and 2004. Table 2.1 shows the pattern of injury in those crashes.

Table 2.1
Frequency of injured body regions amongst pedestrians in crashes in Adelaide, South Australia, from in-depth crash studies 1999-2004

Body region	Injury severity			
	AIS 2 and above		AIS 3 and above	
Head	59	(30%)	41	(44%)
Lower extremity	57	(29%)	21	(22%)
Upper extremity	29	(15%)	3	(3%)
Thorax	15	(8%)	14	(15%)
Spine	12	(6%)	8	(9%)
Face	10	(5%)	2	(2%)
Abdomen	11	(6%)	5	(5%)
Neck (exc. Spine)	1	(1%)	-	
Total	194	(100%)	94	(100%)

Similar findings have been made in other countries (EEVC, 1994). Accordingly, test methods have focused on head and leg impacts.

The widely adopted tests developed by the EEVC employ sub-system impactors. Other areas of crashworthiness testing use crash test dummies to represent the occupant of a vehicle in a crash, however pedestrian tests use sub-system impactors to represent the head of an adult pedestrian, the head of a child pedestrian, the upper leg/pelvis of an adult pedestrian, and the whole leg of an adult pedestrian (simulating injury mechanisms in the knee and the lower leg).

2.1.1 Headform impact tests

Headform impactors represent the head of the adult and child pedestrian. The impactors used by EuroNCAP/ANCAP are those specified by WG17 of the EEVC. The adult headform mass is 4.8 kg and the child headform mass is 2.5 kg. The European Automobile Manufacturers' Association (ACEA) proposed an alternative single headform with a mass of 3.5 kg to represent the child/small adult. The draft GTR prescribes an adult headform mass of 4.5 kg and a child headform mass of 3.5 kg. All headforms are equipped with accelerometers to measure the impact severity and all are launched in free flight. Head impact severity is measured by the Head Injury Criterion, with values up to 1000 being considered satisfactory performance. In the proposed GTR (and the current EC proposal for Phase II of the Directive), the requirement is relaxed to 1700 for up to 1/3 of the test area and for no more than half of the child headform test area.

The area of the vehicle tested varies between test protocols. Test areas are defined by 'wrap-around-distances' (WADs) – the distance measured along a trace from the ground in front of the bumper of the vehicle, up and over the bonnet area. Specific WADs define the area to be tested using each type of headform.

Tests are conducted at specific speeds and angles that are intended to reproduce the impact conditions in a real pedestrian collision at a specific vehicle speed. Head impact speeds are 40 km/h in the original Phase II of the EU Directive and 35 km/h in the draft GTR.

The main differences between head impact tests in each regulatory option and in the current EuroNCAP protocol are summarised in Table 2.2. Note that 'Original Phase II' describes the prescriptions laid out in 2003/102/EC. The final form of Phase II is unlikely to resemble those requirements.

Table 2.2
Correspondence between alternate proposals for headform impact tests in Phase II of European regulation and the EuroNCAP protocol version 4.1 (adapted from Lawrence et al., 2006)

	EuroNCAP protocol	Original Phase II of the EU Directive	Draft Global Technical Regulation (EC proposal)
Child headform impactor	2.5 kg headform applied to bonnet area bounded by wrap-around distances of 1000 mm and 1500 mm, 40 km/h. HIC < 1000 for full points.	Similar to EuroNCAP, HIC < 1000	3.5 kg headform applied to bonnet area bounded by wrap-around distances of 1000 mm and 1700 mm, 35 km/h
Adult headform impactor	4.8 kg headform applied to bonnet area bounded by wrap-around distances of 1500 mm and 2100 mm, 40 km/h. HIC < 1000 for full points.	As for EuroNCAP but no points beyond the end of the bonnet are tested. HIC < 1000	4.5 kg headform applied to bonnet area bounded by wrap-around distances of 1700 mm and 2100 mm, 35 km/h 2/3 of the tested area to achieve HIC < 1000, all tests to achieve HIC < 1700, at least half 3.5 kg headform test area to achieve HIC < 1000

2.1.2 Bumper impact tests

Passenger vehicles are tested with a legform that measures the risk of ligament injury to the knee and the risk of tibia fracture. Higher bumpers (>500 mm high) may be tested with the upper legform described in the next Section.

The legform developed by EEVC WG17 consists of two tubular sections joined by a 'knee' structure. Under impact, deformable elements in the knee deform in a manner that simulates the lateral bending behaviour of the human knee joint. The bending and shear response of the legform knee is used to determine the risk of knee injury. Tibia fracture risk is measured by an accelerometer mounted in the lower tube of the legform.

The legform is typically launched at 40 km/h and is in free flight on impact. It is designed to be struck just below the knee joint.

An alternative legform is proposed for the GTR: the Flex-PLI. The intention of the Flex-PLI is to represent the flexibility of the long bones of the leg and the knee joint more faithfully than the EEVC WG17 legform. The Flex-PLI is still under development.

The main differences between the regulatory options and the current EuroNCAP protocol are summarised in Table 2.3

Table 2.3
Correspondence between alternate proposals for bumper impact tests in Phase II of European regulation and the EuroNCAP protocol version 4.1 (adapted from Lawrence et al., 2006)

	EuroNCAP protocol	Original Phase II of the EU Directive	Draft Global Technical Regulation (EC proposal)
Bumper test	EEVC WG17 legform impactor, applied across the bumper face, 40 km/h. Knee bending < 15°, knee shear < 6 mm, tibia acceleration < 150g.	Similar to EuroNCAP, knee bending < 15°, knee shear < 6 mm, tibia acceleration < 150g	GTR: Flex-PLI legform; EC proposal: EEVC WG17 legform, bending < 19°, knee shear < 6 mm, tibia acceleration < 170g with a lower protection zone where the tibia acceleration < 250g (no more than 264 mm of the bumper width)
High bumper tests	EEVC WG17 upper legform impactor, 40 km/h, impact force < 5 kN, bending moment < 300 Nm.	Same as EuroNCAP, but manufacturer can choose whether to test with full legform or upper legform.	Similar to EuroNCAP, but choice where bumper height is between 450 and 500 mm. Impact force < 7.5 kN, bending moment < 510 Nm.

2.1.3 Leading edge impact tests

In a collision, the leading edge of the bonnet of a passenger vehicle typically strikes a pedestrian on the upper leg and/or pelvis. The upper legform sub-system impactor is designed to measure the forces that would be applied to the upper leg and pelvis of a pedestrian.

The test procedure developed by EEVC WG17 uses the geometry of the car to determine the test conditions used in the impact tests. The dimensions of the bumper and leading edge height and their relative position determine the impact energy, mass and hence velocity at which the test should be conducted. (For details, see Lawrence et al., 2006).

At this stage, the informal group under the Passive Safety Working Group (GRSP) of UNECE WP.29 have declined to propose an upper legform to leading edge test. It is not clear whether such a test will be proposed in the final form of the GTR. The European Automobile Manufacturers' Association (ACEA) believes that the test has no merit (ACEA 2004).

A comparison of the regulatory options and the current EuroNCAP protocol are summarised in Table 2.4

Table 2.4
Correspondences and differences between alternate proposals for bonnet leading edge tests in Phase II of European regulation and the EuroNCAP protocol version 4.1

	EuroNCAP protocol	Original Phase II of the EU Directive	Draft Global Technical Regulation and EC proposal
Bonnet leading edge test	EEVC WG17 upper legform impactor applied across bonnet leading edge of vehicle, impact force < 5 kN, bending moment < 300 Nm.	Similar to EuroNCAP	GTR: None proposed at this time (EC proposal similar to EuroNCAP Impact force < 7.5 kN, bending moment < 510 Nm)

2.2 Active safety prescriptions

Brake Assist Systems (BAS) detect emergency braking and maximise braking force as quickly as possible to overcome hesitant or inadequate brake application. It is likely that such systems will have significant benefits for vulnerable road users (Lawrence et al, 2006).

In examining pedestrian protection the GRSP are constrained to develop passive safety requirements, although they recognise the potential of active safety systems to help the driver to avoid pedestrian crashes. ACEA first proposed the mandatory use of BAS in Phase II of the European Directive and presumably they therefore consider it a feasible and effective component of pedestrian protection requirements. Indeed, the European Commission subsequently proposed it become part of the requirements of Directive 2003/102/EC.

2.3 Effectiveness estimates from Lawrence et al. (2006)

Various attempts have been made to estimate benefits and costs of the implementation of effective pedestrian injury countermeasures in vehicles (Lawrence et al. 1993; Davies and Clemo, 1997; Davies, 1998; ETSC, 2000; Lawrence et al, 2002; Lawrence et al., 2006). Lawrence et al. (2006) give probably the most up to date and comprehensive estimate of benefits and costs.

Lawrence et al. (2006) examined three regulatory options proposed as Phase II of the European Directive (described earlier). To summarise, they estimated a percentage reduction in fatalities and casualties for each option. Their starting point was a vehicle fleet with no pedestrian protection built in. They then estimated fatality and casualty reductions across Europe, the associated monetary benefit and a per-vehicle benefit for each option. The latter item was then used to calculate a benefit-cost ratio, which was favourable. They estimated benefits for pedestrians and pedal-cyclists.

Their estimates were based on detailed in-depth crash data. They assumed that the prescriptions would only be effective in a proportion of crashes under 45 km/h and not at all above that speed. They accounted for the proportions of crashes that do not involve vehicle types subject to regulation (trucks, motorcycles, vehicles that weigh more than 2500 kg). They also accounted for the proportion of injuries caused by passenger vehicle structures not subject to the regulation (A pillars, edges of fenders etc.). Assuming that the general pattern of crashes involving pedestrians and cyclists are similar in Europe and Australia, the percentage reductions estimated by Lawrence et al. may be expected in Australia too. This will be assumed later in this report when estimating likely benefits for Australia.

Lawrence et al. estimated a benefit due to a passive safety component (impact protection) and a component due to active safety (BAS). Their estimates are shown in Table 2.5.

Table 2.5
Reduction in pedestrian and pedal cyclist casualties expected from moving from no compliance, to full compliance with proposed regulations on pedestrian protection (Lawrence et al., 2006).

Road user type	Benefit component	Original Phase II			GTR + BAS		
		Fatal	Serious	Slight	Fatal	Serious	Slight
Pedestrians	Passive	0.067	0.158	-0.078	0.039	0.118	-0.058
	Active (BAS)				0.077	0.101	0.157
	Total	0.067	0.158	-0.078	0.116	0.219	0.099
Pedal cyclists	Passive	0.024	0.064	-0.019	0.014	0.047	-0.014
	Active (BAS)				0.042	0.057	0.073
	Total	0.067	0.158	-0.078	0.056	0.104	0.059

Concerning the increase in slight injuries in Table 2.5, Lawrence et al. assumed that minor injuries are not affected by passive vehicle design changes and that the serious casualties saved by passive safety improvements would still sustain minor injuries. Lawrence et al. (2006) increased the number of pedestrian casualties sustaining a minor injury in their passive safety benefit calculations to account for the fact that some injury will still be sustained in serious casualties that are 'saved' by the passive safety protection in any potential regulation. Therefore, as the increase in the number of slightly injured pedestrians and cyclists offsets the decrease in serious casualties, the proportions in the 'serious' and 'slight' columns of Table 2.5 imply a specific ratio of crashes between 'serious' and 'slight'. That is, the number of pedestrians represented by the increase in slight pedestrian casualties under the "Original Phase II" (0.078) must be the same number represented by the decrease in serious casualties (0.158). Therefore the ratio of slight casualties to serious casualties implied by this is about 2.0:1.

One modification to the proportions in Table 2.5, for application in Australia, would be to increase the numbers of slightly injured pedestrians and pedal cyclists that are due to the benefits of the passive component of the regulation by the exact decline in seriously injured pedestrians and pedal cyclists. Alternatively, it may be assumed that the same ratios of slight to severe injuries exist in Europe and Australia; as discussed in Section 4.2.1, in the absence of good data on slight injuries, this assumption is made in this report to allow benefits for Australia to be estimated.

3 Current performance of the Australian new car fleet

This section examines how vehicles sold in Australia compare to vehicles sold in Europe, with respect to their performance in pedestrian impact tests. The reasons for doing this are twofold: first, to examine whether performance in Europe might be being influenced by the introduction of Phase I and the future introduction of Phase II of the European Directive, and second, to estimate how the new vehicle fleet might change in response to any new vehicle regulation relating to pedestrian protection in Australia. We shall examine vehicles sold in Australia primarily through estimating the fleet performance rather than through a general survey of vehicles available for sale in Australia, as it is on the basis of fleet performance that any benefit will accrue.

3.1 Concept of fleet performance

The potential of the crashworthiness of any particular model of passenger car is realised only to the extent that the particular model is involved in crashes. If a model has a high level of crashworthiness, but few vehicles are sold and driven, it will have little effect on the overall level of road safety.

It is difficult to estimate the relative crash involvement of any particular model, taking into account the numbers of vehicles registered, and other exposure related factors. It is possible, however, to examine the relative numbers of any particular model entering the system: sales data by make and model are readily available in Australia and most other motorised countries. As such, it is possible to construct a profile of the new car fleet (that is the new vehicles sold in any period) that describes its crashworthiness. Such a profile can be constructed by weighting a measure of a model's crashworthiness by its representation in the new car fleet, and then creating a distribution of crash performance over all models sold. Useful measures of pedestrian crashworthiness are published by EuroNCAP/ANCAP. By inference, achieving a certain EuroNCAP/ANCAP rating should correspond with compliance to 2003/102/EC.

A cumulative distribution of crashworthiness can be assembled by taking data on sales figures and crashworthiness scores for all models sold in a particular period and ranking each model by its crashworthiness score (from lowest to highest). A cumulative distribution can then be constructed that describes the proportion of the new car fleet that has a certain maximum level of crashworthiness.

In the case of pedestrian crash protection, EuroNCAP/ANCAP award points to a maximum of 36. Using this scale, the pedestrian crashworthiness profile of the new car fleet describes the proportion of vehicles scoring *n* points or less, where *n* is a score between zero and 36.

3.2 New car fleet performance

Fleet performance by model release year

Consider new vehicle sales in a specific period. Sales will comprise vehicle models with varied release dates – only relatively few sales will be of new types released in the sales period being considered, with the bulk having been introduced to the market some time beforehand. This is relevant because vehicle safety standards often apply to vehicles of a new type released after a certain date, and particularly in the context of the current analysis, the technical prescriptions of 2003/102/EC only begin to apply to new types of vehicles released in Europe in Model Year 2006 (i.e. from 1 October 2005). The Japanese regulation came into effect at the same time, also for new types of vehicles. Therefore it would be appropriate to disaggregate the new car fleet into those vehicle models released before a date corresponding to the introduction of a relevant safety standard, and those released after that date.

Fleet performance by market jurisdiction

Similarly, vehicle safety standards vary by market jurisdiction. By disaggregating sales data by market (and by model release year), an examination can be made of any discernable differences in the performance of the fleet that are related to the introduction of a new safety standard in a particular market jurisdiction and at a particular point in time.

3.3 Methods

To assess the relative performance in pedestrian protection of the current Australian and European new-car fleet, two pieces of information were required: the composition of individual models in the new car fleets of each market and a measure of those models' performances in pedestrian impact tests. The fleet composition considered is one that is representative of vehicles being sold currently, rather than an historical one, and so the most recent sales data that was available were used. Twelve months of sales data account for seasonal fluctuations. The Australian new car fleet in this analysis is based on the 12 months of sales to June 30, 2007 (Federal Chamber of Automotive Industries, 2007). For European sales, data to 31 December 2006 were used (MVRIS, 2007; Mavel, 2007).

Where the model had been superseded during the 12 month period, its sales figures were assigned to the replacement model of vehicle (where possible).

While we do not have evidence regarding the compliance of individual models of vehicle with either the European or Japanese regulations, the results of EuroNCAP and ANCAP assessments can serve as a guide. Furthermore, EuroNCAP/ANCAP assessments provide greater differentiation between the performance of different models than the pass/fail assignments of the regulation. It appears that vehicles that just pass Phase I of the European Council Directive would receive around 10 points in a EuroNCAP/ANCAP assessment, (i.e. in the upper one-star to lower two-star range.) This is based on the performance of vehicles released in Model Year 2006. The correspondence between EuroNCAP/ANCAP assessments and future regulations is discussed in Section 4.2.

After assigning the relevant EuroNCAP/ANCAP assessment to each model, the sales volumes of the models of vehicle in each market's new car fleet were ranked by their EuroNCAP/ANCAP assessment, and cumulative distributions were assembled of EuroNCAP/ANCAP performance for each market's fleet. In doing so, a comparison could be made of the proportion of each fleet performing at any specified level.

Finally, each distribution was disaggregated by the period corresponding to each vehicle's model year (pre-2000, 2001-2003, 2004-2005, 2006-2007) to assess trends in the performance of the new car fleet in each country.

3.4 The performance of vehicles in EuroNCAP/ANCAP pedestrian tests

A summary of the ratings for all vehicles tested by ANCAP or EuroNCAP to the current testing protocol is given in Table 3.1. Note that these numbers include assessments of vehicles that are no longer manufactured. It is noteworthy that 68% of ANCAP's vehicle assessments achieved a score of 1 star or less, compared to 45% of vehicle assessments by EuroNCAP.

Table 3.1
Number of vehicles tested since 2002 in EuroNCAP and ANCAP by the rating awarded

Program	0 Star	1 Star	2 Star	3 Star	4 Star	Total
EuroNCAP	7	55	56	20	1	139
ANCAP	1	29	13	1	-	44
Total	8	84	69	21	1	183

Note: The EuroNCAP numbers are those *published* to June 2007 and the ANCAP numbers are vehicles *tested* to June 2007.

3.5 Trends in the performance of passenger vehicles in EuroNCAP/ANCAP pedestrian tests

Figure 3.1 shows the distribution of current results (only those models that are still part of the current new passenger vehicle fleet), split into the years in which the model was released (its Model Year). Figure 3.1 shows that that vehicle models released more recently have performed better than vehicles released in earlier periods. The median assessment of current new cars, released in 2002-2003, is around 8 points, while the median assessment of current cars released in 2006–2007 is around 14 points.

3.6 The composition of new passenger vehicle fleets in Australia and Europe.

While individual vehicle models may perform well or poorly in terms of pedestrian protection, and Figure 3.1 indicates that newer vehicle models perform better than models released four years ago, a vehicle model's performance is relevant to road safety to the extent to which the model is registered and driven on the road. While there have been assessments made of 183 models of vehicle, a relatively low number dominate the overall fleet performance.

Figure 3.2 contains plots of the concentration of top selling models amongst new passenger vehicle sales, by market jurisdiction. Each line shows the proportion of new vehicle sales accounted for by the sales of the top *n* selling models of passenger vehicle; for example, the top selling model of passenger vehicle in France accounts for just under 10 percent of all new passenger vehicle sales in that country. The graph shows that 17 models account for 50% of all new vehicle sales in Australia. Eighteen models account for 50% of new vehicle sales in France and 22 models account for 50% of new passenger vehicle sales in the United Kingdom. For the EU as a whole, 27 models account for 50% of all new vehicle sales.

Most of the vehicles assessed by EuroNCAP are also available in Australia, but for many of these models, their contribution to the new-car fleet varies significantly between Europe and Australia (and also between countries in Europe). Figure 3.3 shows the differences between the new vehicle fleet compositions in Australia and Europe (differences between Australia and France and the UK are also shown); models comprising the top 50% of sales in the EU overall account for 17% of the new car fleet in Australia. Models comprising the top 50% of sales in France and the UK account for around 3% and 14% of the new car fleet in Australia. This lack of correspondence between the new car fleets of Australia and the new car fleets of Europe means that differences in the pedestrian protection performance of the respective fleets are possible.

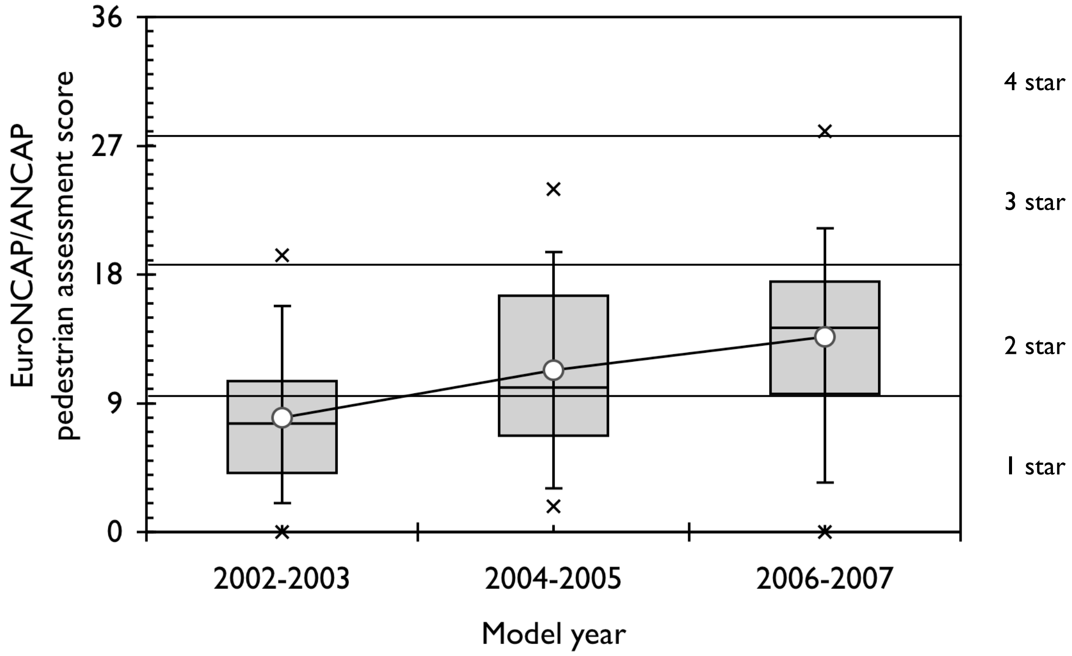

Figure 3.1
Box and whisker plot of current EuroNCAP/ANCAP pedestrian test results by model release year. ("o" indicates the mean, the box covers the interquartile range, the error bars show 10th and 90th percentile values and "x" shows the highest and lowest values.)

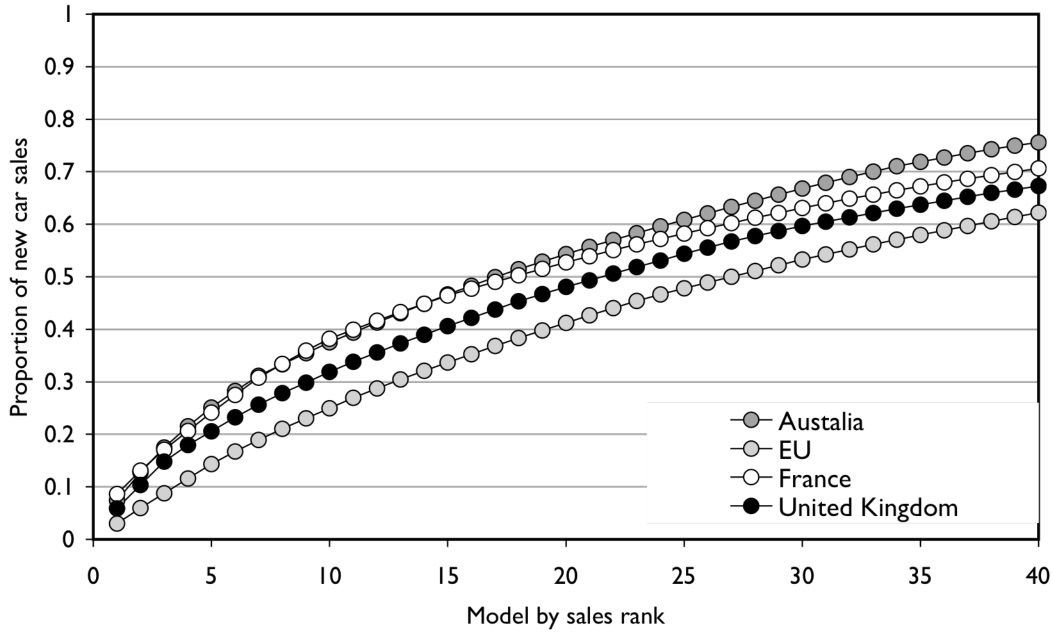

Figure 3.2
Cumulative proportion of new passenger vehicle sales by sales rank
(e.g. the top selling vehicle has sales rank = 1, second top selling vehicle = 2, etc)

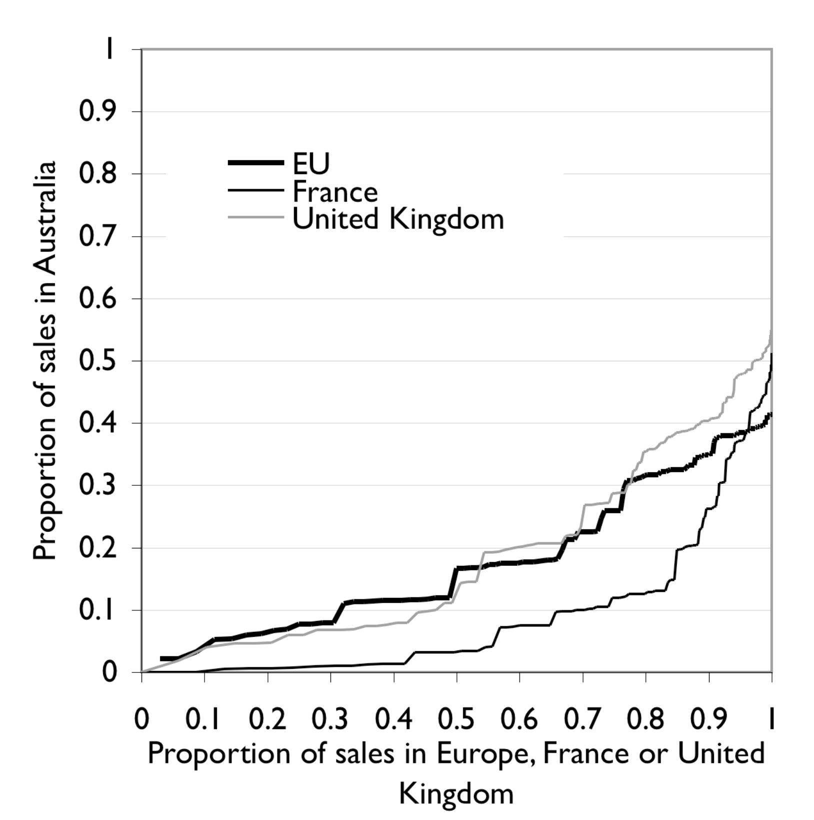

Figure 3.3
The top proportion of the new passenger vehicle fleet in Australia represented by top proportion of the new car fleets in Europe, France and the United Kingdom.

3.7 Assessments of the level of pedestrian protection afforded by the new passenger vehicle fleets in Australia and the Europe

Not every passenger vehicle sold in Australia or the EU is assessed by EuroNCAP/ANCAP. However, as the programs target higher selling models, 82% and 90% of the new car fleets in Australia and EU can be assigned assessment scores. Vehicles are assigned points to a maximum of 36, based on the results of the tests used in the assessment and these are grouped into star-ratings.

Figure 3.4 shows the cumulative distribution of performance in EuroNCAP/ANCAP tests of the new passenger vehicle fleet in each market jurisdiction. Profiles for France, the UK and Germany are also shown. Fifty six percent of new passenger vehicles sold in Australia have a pedestrian safety star rating of less than 2, compared to 32 percent in Europe; this implies that pedestrians struck by new passenger vehicles in Australia are 75 percent more likely to be struck by a 0 or 1 star car than pedestrians in Europe. Note though that most of the differences in the fleet performance occur below 16 points, and so the prevalence of better performing vehicles (pedestrian rating of 3 stars) is similar in each market jurisdiction and relatively small – under 20 percent of the new car fleet.

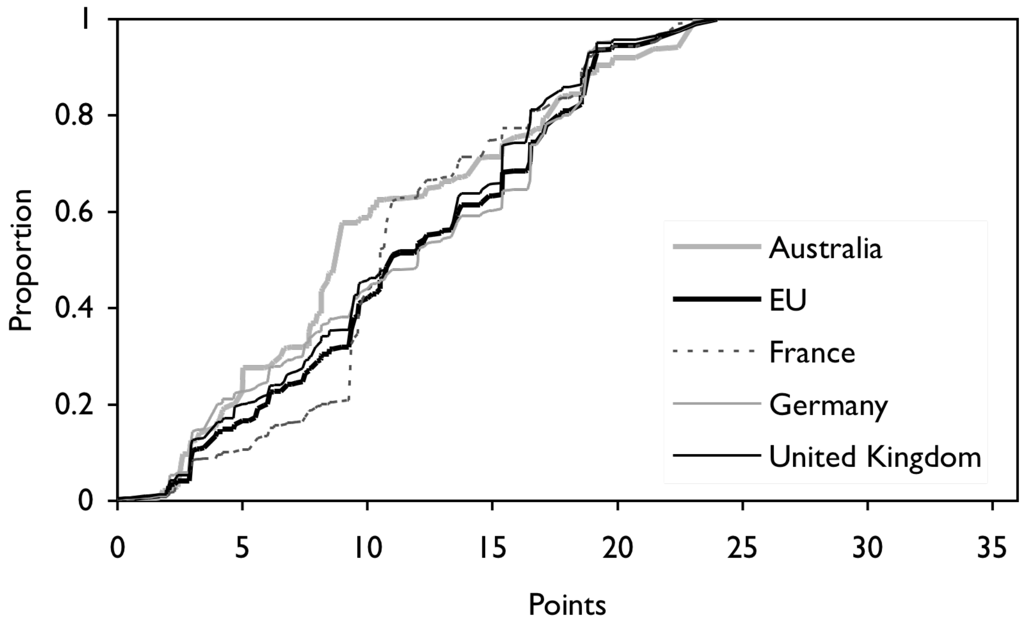

Figure 3.4
Cumulative performance of the new car fleet in Australia, France and the United Kingdom, for models assessed by EuroNCAP/ANCAP

3.8 The performance of the new car fleet by model age

As the previous Section showed, the prevalence of better performing vehicles in the new vehicle fleet is similar in each market jurisdiction. But, as many current models were released in Europe prior to September/October 2005, much of the new car fleet is still not required to comply with Phase I of the European Directive nor the Japanese Regulation. Figure 3.1 disaggregated the EuroNCAP/ANCAP results by the period in which each vehicle model was released and that showed that assessments have generally improved since assessments began to be regularly reported in 2002. Similarly, the fleet performance can be disaggregated according to model release periods. In this analysis, the new car fleet performance shown in

Figure 3.4 will be disaggregated by the model release years corresponding to pre-2001, 2001-2003, 2004-2005 and 2006-2007.

Note that the relative contributions of these groups to each new car fleet are not equal: a greater proportion of the new vehicle fleet is of models released pre-2004 than of new types of model released in the other periods. Relatively few new vehicles sold were released in 2006-2007. Nevertheless, the latest group represents post-Phase I regulation design in Europe and Japan, and as such, indicates the present state of performance amongst this segment in the new car fleet.

Figure 3.5 to Figure 3.9 show the distribution of performance of the new car fleet for various market jurisdictions, split into the period of model release. Figure 3.5 shows the new car fleet performance of Australia. Data for the EU as a whole is shown (Figure 3.6), then data for France (Figure 3.7), the United Kingdom (Figure 3.8), and Germany (Figure 3.9) are shown. In each market, the performance has generally improved in each successive period, as the distribution of each subsequent period lies to the right of the previous period.

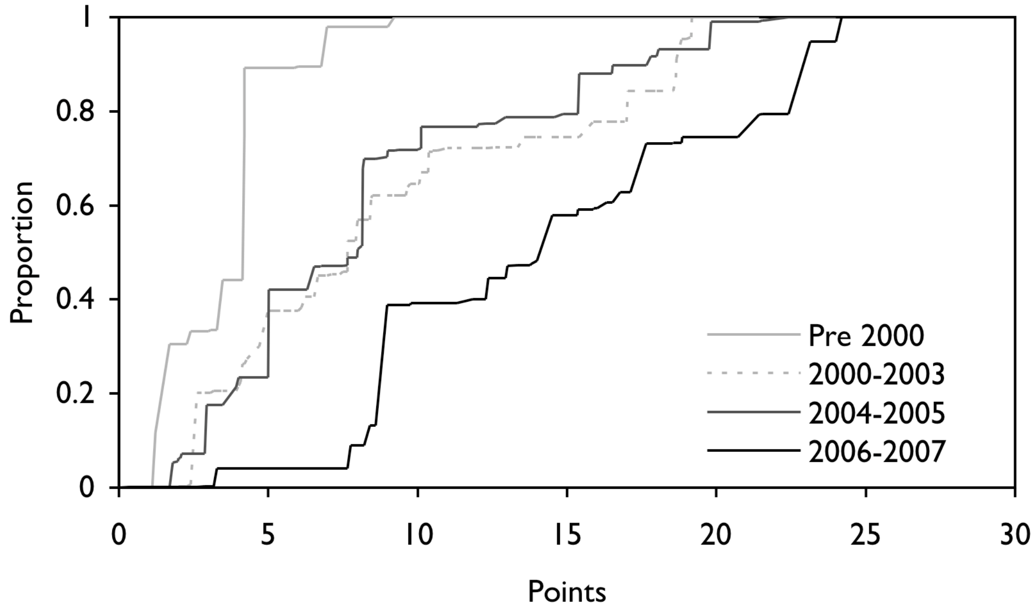

Figure 3.5
Cumulative Australian new car fleet performance by model release year.
Sales volumes from July 2006 to June 2007 are used to define the new car fleet.

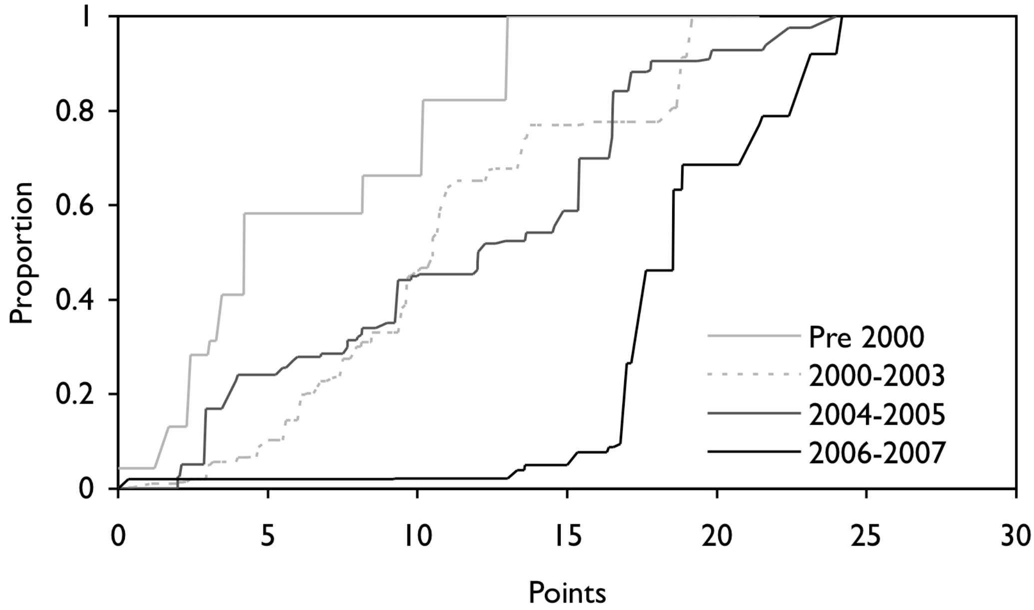

Figure 3.6
Cumulative EU new car fleet performance by model release year.
Sales volumes relate to calendar year 2006.

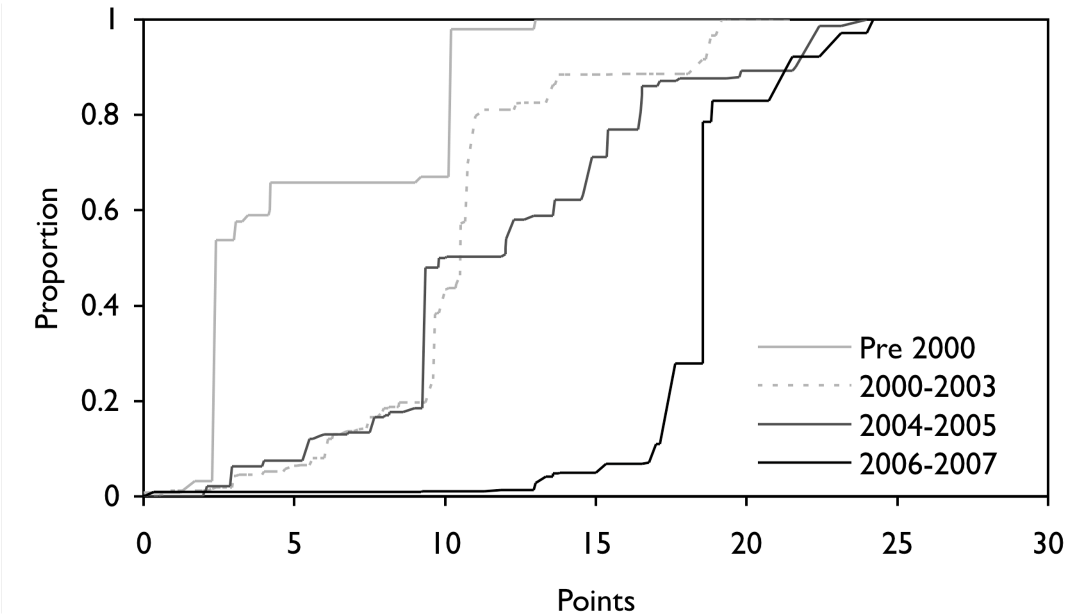

Figure 3.7
Cumulative French new car fleet performance by model release year.
Sales volumes relate to calendar year 2006.

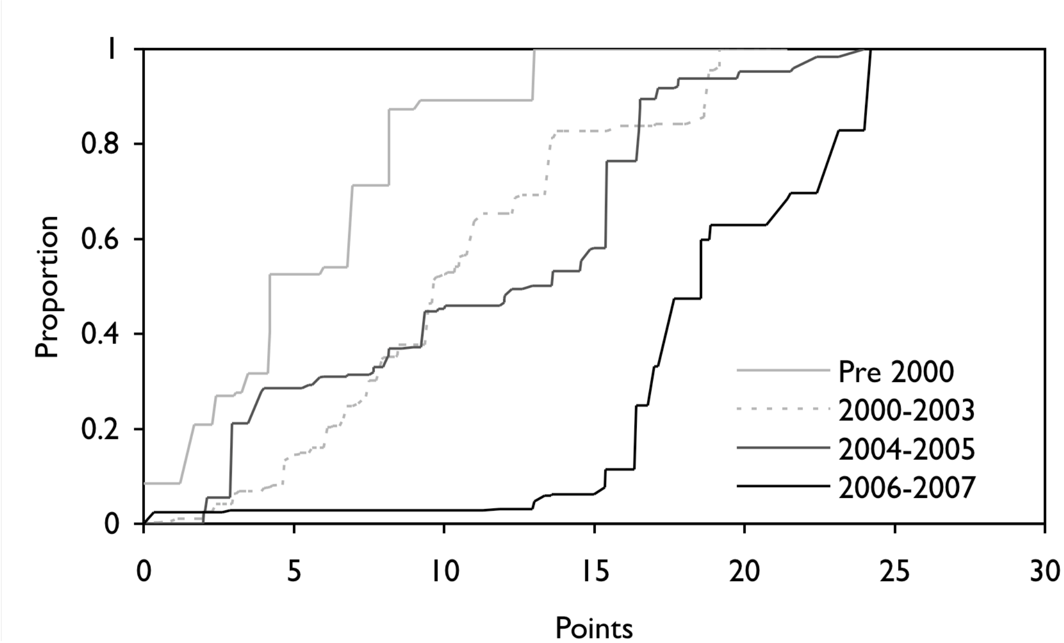

Figure 3.8
Cumulative UK new car fleet performance by model release year.
Sales volumes relate to calendar year 2006.

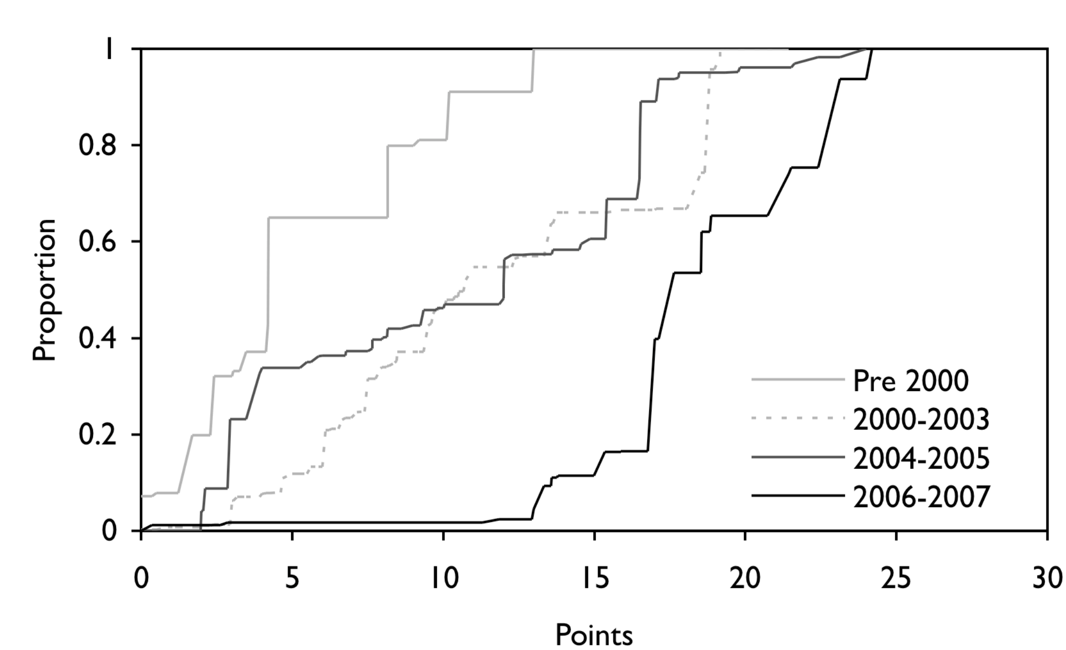

Figure 3.9
Cumulative German new car fleet performance by assessment period.
Sales volumes relate to calendar year 2006

The new-car fleet performance of models assessed in 2006-2007 in Europe shows much greater improvement over previous periods than the improvement of the equivalent segment of the Australian fleet. Figure 3.10 shows the new car fleet performance for new vehicles released in Model Years 2006 and 2007, by market jurisdiction. While 60% of the passenger vehicles sold in Australia released in MY2006 and MY2007 are rated at 2 stars or greater, vehicles of the same performance constitute almost all passenger vehicles sold in Europe released in MY2006 and MY2007. More 06-07 vehicles in Europe are rated at 3 stars (more than 18.5 points) than in Australia. It is clear from these data that the performance in pedestrian tests of the recently released vehicle fleet in Australia is lower, on average, than the equivalent segment of the new car fleet in Europe.

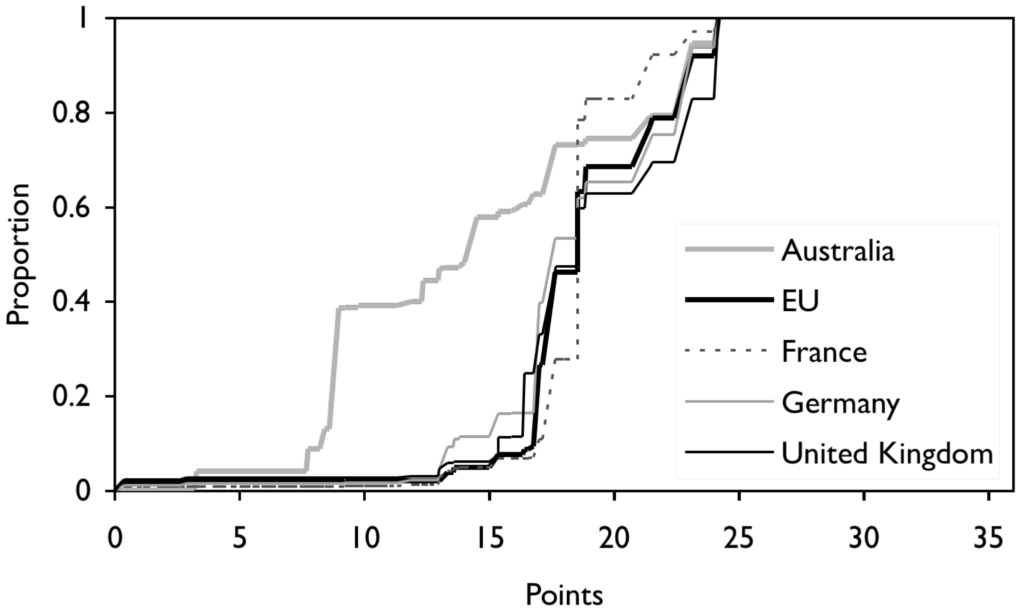

Figure 3.10
New car fleet performance (2006 sales for Europe and 06/07 sales for Australia) of models released in MY2006 and MY2007 in Australia and Europe.

3.9 Deployment of Brake Assist into the current Australian new car fleets

Brake Assist Systems (BAS) are become more common in new cars. To determine the prevalence of BAS in the new car vehicle fleet for this study, a survey was undertaken. The technical specifications of the models comprising the top 80% of sales were checked. In this survey the specification of either "Brake Assist" or "Electronic Brake Assist" was used to indicate a system of BAS that would deliver the benefits provided in Table 2.

Sales data used to construct the list were for the 12 months to the end of June 2007 (Federal Chamber of Automotive Industries, 2007). Information on the technology used came from websites and brochures of the current specifications (as at 25th June 2008) of the vehicles in the list. Therefore, the analysis is of current models, but based on sales data to the end of June 2007. The prevalence of BAS was weighted by the model's sales.

The result of the survey was that, of the sales representing 80% of all new car sales, 63% are equipped with BAS and 37% have no BAS. These proportions are estimate of the proportions of all new cars with and without BAS.

4 Methodology for calculating benefits of improved pedestrian protection

In this section a methodology is developed to estimate the potential benefit of the implementation of an ADR on pedestrian protection using the benefit estimates made by Lawrence et al. (2006) and the current performance of the Australian new car fleet described in the previous section. This method relies on an estimate of the correspondence between a vehicle's EuroNCAP/ANCAP rating and the potential benefit of replacing that vehicle with one that complies with a proposed ADR on pedestrian protection. An assumption must also be made about how a complying vehicle would fare in a EuroNCAP/ANCAP assessment.

4.1 Correspondence between EuroNCAP tests and the passive component of regulatory proposals

In assessing any potential benefit to vulnerable road users in Australia, it should be recognised that, since European and Japanese regulation in the area was mooted, new vehicles have demonstrated improving pedestrian protection. The estimates of benefit in Lawrence et al. (2006) assume a 'standing start', but such an assumption may no longer be appropriate. The Australian fleet has been improving, probably in response to regulatory activity overseas and consumer testing programs. Fortunately, EuroNCAP/ANCAP assessments provide some quantification regarding the performance of vehicles in tests similar to those prescribed by regulations in Europe and Japan. It is therefore useful, when estimating future benefits, to estimate the correspondence between EuroNCAP/ANCAP performance and proposed regulation, and use this estimate to examine benefits already accruing, and those yet to be realised.

A general description of the correspondence between proposed regulatory test protocols and the EuroNCAP test protocol is given in Table 4.1. Given the general correspondence of the test protocols in Table 4.1, the following observations can be made:

- In the original Phase II proposal, approximately the rear half of the adult headform test area specified by EuroNCAP would not be tested on most vehicles, and the base of the windscreen would not be tested. Hence, at minimum, a vehicle complying with the original Phase II regulation would score half of the available points for the adult headform tests under EuroNCAP.
- In all other respects, a vehicle complying with the original Phase II proposal would approximately comply with EuroNCAP requirements for full points.
- Under the GTR and EC proposal, headform impact severities would be less than when tested under the EuroNCAP protocol because of the heavier child headform and the lower impact speed. Moreover, only two-thirds of the headform tests would have to satisfy EuroNCAP criteria (HIC < 1000) to pass the regulation. An approximation of the performance of such a vehicle under EuroNCAP would be such that around half of the child and adult headform impact tests would satisfy EuroNCAP criteria for full points. (But see comments below.)
- An upper leg test is currently proposed by the European Commission (EC, 2007) but not for the GTR. As such, a vehicle could fail the EuroNCAP assessment but still pass the draft GTR. Also, given the misgivings of the automotive industry (UNECE, 2005) it is not clear that this test will survive in the final version of Phase II of the EU Directive, or whether it will be included in the final draft of the GTR.
- Even though slightly different requirements are specified for the bumper tests, it will be assumed that a vehicle complying with the GTR would also satisfy EC and EuroNCAP requirements.

An estimate of the number of points that a complying vehicle might need, in a EuroNCAP/ANCAP assessment, to comply with each alternate regulatory proposal, is given in Table 4.2. Later Sections of this report in which potential benefits of an ADR are estimated will partly rely on Table 4.2. Conservative estimates of EuroNCAP/ANCAP performance of complying vehicles in Table 4.2 will also produce conservative estimates of the benefit of moving the current new passenger vehicle fleet to a minimum level of compliance with candidate regulations. Nevertheless, the values contained in Table 4.2 are estimates based on experience only, and it may turn out that EuroNCAP/ANCAP performance levels required to pass the GTR are somewhat less than we have estimated. The combination of a lower test speed and heavier child headform under the GTR may produce much lower HIC values that the equivalent EuroNCAP/ANCAP test.

Table 4.1
Correspondence between alternate proposals for Phase II of European regulation and the EuroNCAP protocol version 4.1

	EuroNCAP protocol	Original Phase II of the EU Directive	Draft Global Technical Regulation
Bumper test	EEVC WG17 legform impactor, applied across the bumper face, 40 km/h	Similar to EuroNCAP	Same as EuroNCAP protocol, but acceptance criteria slightly relaxed
Bonnet leading edge test	EEVC WG17 upper legform impactor applied across leading edge of vehicle.	Similar to EuroNCAP	None at this time (EC proposal includes a test similar to EuroNCAP, but with relaxed requirements – would not be required to meet EuroNCAP requirements)
Child headform impactor	2.5 kg headform applied to bonnet area bounded by wrap-around distances of 1000 mm and 1500 mm, 40 km/h.	Similar to EuroNCAP	3.5 kg headform applied to bonnet area bounded by wrap-around distances of 1000 mm and 1700 mm, 35 km/h, at least half the area would have have to satisfy HIC < 1000 to pass regulation.
Adult headform impactor	4.8 kg headform applied to bonnet area bounded by wrap-around distances of 1500 mm and 2100 mm, 40 km/h.	As for EuroNCAP but no locations beyond the end of the bonnet are tested. Effectively, approximately only half the EuroNCAP Adult headform zone is tested, avoiding A-pillars and base of windscreen.	4.5 kg headform applied to bonnet area bounced by a wrap-around distances of 1700 mm and 2100 mm, 35 km/h. 2/3 of the child and adult headform tests overall to achieve HIC < 1000, but note that fewer might pass at the EuroNCAP speed of 40 km/h.

Table 4.2
Estimated equivalent EuroNCAP/ANCAP pedestrian assessment performance for regulatory options for pedestrian protection

	EuroNCAP/ANCAP – full points	Original Phase II compliance	GTR/Current EC proposal
Adult head	12	6	6
Child head	12	12	6
Upper leg	6	6	0
Full leg	6	6	6
Total	36	30	18

4.2 Estimating benefits of a compliant new car fleet

Lawrence et al (2006) estimate reductions in fatal and injurious pedestrian and pedal cyclist crashes that should accrue from moving the passenger car fleet from offering no protection to vulnerable road users, to a fleet complying with a regulation on pedestrian protection.

As Section 3 showed, performance in pedestrian impact tests has been gradually improving, notwithstanding the gap between the Australian new car fleet and those of Europe. Hence, any benefit estimate of a new ADR needs to take account of the benefit already accrued. Improvements to date have not occurred as a result of an ADR in Australia. One might not choose, therefore, to assign benefits from improvements to-date to future benefits arising from an ADR on pedestrian protection.

What kind of EuroNCAP performance would a vehicle designed with little or no pedestrian protection built in have? Figure 3.5 showed that the new car fleet consisting of pre-2000 released vehicles has a EuroNCAP score of around 4 points or less. This might be considered the ‘standing start’ from which the benefit calculations of Lawrence et al. (2006) apply. Table 4.2 suggests the minimum EuroNCAP performance of vehicles that might comply with each alternate proposal for Phase II of the European Directive. These levels of performance correspond to the level at which benefits cut out. (Although further benefits would accrue with further improvements in safety, such improvements are not required under either proposed regulation and do not form part of the benefit estimates made by Lawrence et al., 2006.)

For the passive component of the original Phase II requirements, benefits would be maximised if a vehicle scoring around 30 EuroNCAP points replaces a vehicle scoring around 4 EuroNCAP points. But, if a car that complies with regulation replaces a car that already has some level of performance in the tests, the benefit will not be as great. For the purposes of the present analysis, this ‘sliding’ benefit can be approximated by a linear function. Such a function is illustrated in Figure 4.1: the benefit of complying with the original Phase II of the Directive is shown by the line labelled ‘A’. The line ‘B’ indicates the benefit arising from the passive component of the GTR and current EC proposal. Here the benefit is not as great and a complying car is estimated to score 18 EuroNCAP points (Table 4.1).

As detailed earlier, the EC proposal includes the mandatory use of the active safety feature, BAS. As this component is independent of the passive component of the EC proposed regulation, an alternative approach is needed to estimate benefits of further improvements to the new car fleet: When assessing benefits yet to accrue, the benefits listed in Table 2 are applied only to vehicle sales for which there is no BAS; that is, 37% of new car sales.

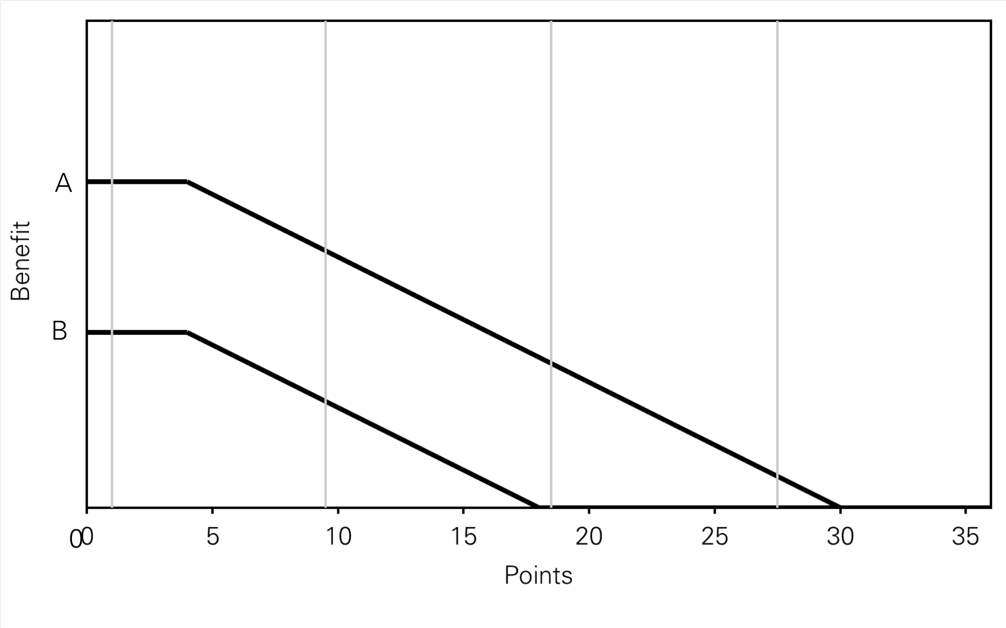

Figure 4.1
Benefit as a function of EuroNCAP/ANCAP performance, applied to the new car fleet to estimate benefit arising from improvements in pedestrian safety. "A" is the maximum benefit of implementing European Directive Phase II protection, "B" is the benefit of the passive safety component of the EC recommendation.

The potential benefit of replacing any model of vehicle sold in Australia with a complying vehicle can be estimated by applying the functions shown in Figure 4.1 to that model's EuroNCAP/ANCAP score. This benefit can then be weighted by the model's sales volume. In this way, the benefit of making the entire new car fleet compliant can be estimated.

4.2.1 Pedestrian and cyclist injury in Australia

The benefit calculation described above will produce an estimate of the proportion of deaths and casualties saved by the introduction of an ADR on pedestrian protection. To estimate benefits in absolute terms, the benefits must be applied to the number of pedestrians killed and injured on Australian roads. In doing so, it is important to remember that such an estimate will rely on an assumption that the pattern of pedestrian and pedal cycle injuries are broadly similar in Europe and Australia. That is, the proportions of casualties hit by the fronts of passenger vehicles at certain speeds are similar in Europe and Australia.

An estimate of the numbers of pedestrians and cyclists killed and injured (hospitalised) in traffic accidents is given in Table 4.3. Fatality data are taken from ATSB (2007) and serious injury data are taken from Harrison and Berry (2007) and are based on hospital separation data from the National Hospital Morbidity Database of the Australian Institutes for Health and Welfare.

Slight injury data are more difficult to estimate. Minor pedal cycle and pedestrian injuries are probably grossly underreported in traffic accident statistics. Data in Watson and Cameron (2006) give an indication of this. They collated traffic accident statistics from four states in Australia (Victoria, Queensland, Western Australia and South Australia) for the 5 years 2000-2004. Over this period, 12,471 injury crashes were reported to police, including 3,362 crashes in which the rider was hospitalised or killed. From the data in Watson and Cameron, it is possible to estimate national figures for reported crashes by recognising that the four states examined account for 62% of the Australian population (ABS, 2007a). This produces a national estimate of 1080 reported pedal cycle crashes annually, in which the rider was hospitalised or killed. Comparing this to hospital separation data in Table 4.3 indicates that around 2/3 of pedal cycle serious casualties are missing from police reported data.

Slight injury data are not collected by the National Hospital Morbidity Database. The South Australian Traffic Accident Reporting System indicates that slightly injured pedestrians are about three times as common as seriously injured pedestrians. Similarly, slightly injured pedal cyclists are about six times as common as seriously injured pedal cyclists. However, as Lawrence et al. (2006) note, under-reporting in police crash data is unlikely to be uniform by crash severity: some serious injuries are mistakenly coded as slight. Anderson (2008) also found indications that this coding error might also occur commonly in South Australia. Lawrence's et al. (2006) estimates of the ratio of slight to serious casualties in Europe are 2:1 for pedestrians and 3.4:1 for pedal cyclists. These ratios are consistent with TARS data for South Australia, allowing for potential unevenness in under-reporting rates by severity, and so will be used in this report in the absence of reliable Australian data.

Table 4.3
Fatality (ATSB, 2007) and injury (Harrison and Berry, 2007) numbers used to represent pedestrian and cyclist injuries in Australia

Road user type	Fatalities (2006)	Serious (2003-04)	Slight
Pedestrians	227	2,578	5,150*
Cyclists	40	3,676	12,500*

*Estimates from serious casualty numbers scaled by ratios inferred from Lawrence et al. (2006)

4.2.2 Costs of death and injury in Australian road crashes

Baldock and McLean (2005) examined the economic costs of road crashes in South Australia. Their estimates were based on costs estimated by the Bureau of Transport Economics (BTE, 2000) updated using CPI figures to costs in 2004. It should therefore be noted that the costs were current as at the time of the publication of Baldock and McLean. The costs associated with avoiding a single road traffic casualty (from Baldock and McLean) are given in Table 4.4. These figures will be used to represent costs for Australian casualties.

A further point should be made about these costs: The BTE estimates are based on the value of human capital, rather than a "willingness to pay" method. The results are therefore conservative. Willingness to pay methods can produce an estimate of crash costs that is 25% to 60% higher than the valuation of human capital is used (BTE, 2004).

Table 4.4
Savings in road crash costs (AUD) in South Australia associated with reductions of a single fatality, a single serious injury and a single minor injury, separately for each crash injury level

Fatality	Serious injury	Minor injury
1,747,522	331,107	16,965

5 Benefit estimates

5.1 Benefits from a 'standing start'

Benefits from a 'standing start' are an estimate of all pedestrian protection arising from conformance of the fleet to regulation, both realised and unrealised. In other words, the benefit of replacing a fleet of vehicles with almost no level of performance in pedestrian impact tests whatsoever, with a fleet that fully complies with a candidate regulation. An estimate of the benefit to Australia from pedestrian protection can be estimated by using the approach used by Lawrence et al. (2006) and substituting Australian data where relevant.

The performance of the pre-2000 fleet (Figure 3.2), which would largely not have made any progress toward pedestrian protection, approximates a baseline from which benefits might be estimated. It appears that few vehicles scored more than 4/36 in EuroNCAP/ANCAP assessments. More recent models show better level of performance, as does the new car fleet considered as a whole.

Note that most of these benefits are still to be realised in the whole passenger car fleet – the median age of registered vehicles in Australia is 9.7 years (ABS, 2007b) Therefore, although the new car fleet displays better level of performance in the results of pedestrian impact tests, the overall performance of the registered passenger car fleet will be considerably worse. Improved performance is 'in the pipeline' as new vehicles gradually replace older vehicles in the fleet. Furthermore, because the predicted reduction in casualties due to regulation is not large, an estimate of the total benefit of pedestrian protection that is based on current crash numbers will not be greatly affected by any benefits that have already been realised.

Table 5.1 shows the estimated annual reduction to pedestrian and pedal cyclist injuries that would result from a passenger vehicle fleet that complied with either the current Phase II of the EU Directive, or the GTR. These figures were produced by multiplying the expected reductions estimated by Lawrence et al. (2006) by the estimate of current Australian pedestrian and pedal cyclist injuries in Table 4.3. Lawrence et. al.'s estimates are reproduced in Table 2.5 of this report.

Table 5.1
Estimated total reduction in Australian road casualties due to pedestrian protection measures according to alternate regulatory proposals

Road user type	Benefit component	Original Phase II			GTR + BAS		
		Fatal	Serious	Slight	Fatal	Serious	Slight
Pedestrians	Passive	15	407	-407	9	304	-304
	Active				17	260	823
	Subtotal	15	407	-407	26	565	519
Pedal cyclists	Passive	1	235	-235	0.6	173	-173
	Active				1.7	210	901
	Subtotal	1	235	-235	2	382	728
Total		16	642	-642	28	947	1247

By multiplying these casualty reductions by the costs associated with road crash casualties estimated by the BTE (Table 4.4), the monetary benefit associated with crash reductions can be estimated (Table 5.2).

Table 5.2
Estimated total reduction in Australian road casualty costs due to pedestrian protection measures according to alternate regulatory proposals (millions of dollars)

Road user type	Benefit component	Original Phase II				GTR + BAS			
		Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total
Pedestrians	Passive	$27	$135	$(7)	$155	$15	$101	$(5)	$111
	Active					$31	$86	$14	$131
	Subtotal	$27	$135	$(7)	$155	$46	$187	$9	$242
Pedal cyclists	Passive	$2	$78	$(4)	$76	$1	$57	$(3)	$55
	Active					$3	$69	$16	$88
	Subtotal	$2	$78	$(4)	$76	$4	$126	$13	$143
Total		$29	$213	$(11)	$231	$50	$313	$22	$385

The figures in Table 5.1 and Table 5.2 can be interpreted in two ways. They can be considered the annual benefit of moving the entire passenger car fleet from non-compliance to compliance with the proposed regulations. Alternatively, assuming a steady state in the number of pedestrian collisions, they can be thought of as the lifetime benefit of the new passenger vehicle sales from one year in which all such vehicles comply.

In summary, with fleet compliance to the current GTR proposal with the addition of mandatory BAS, Australia stands to benefit from the regulation by 28 fatalities, 947 serious casualties and 1247 slight casualties per year. This represents a savings of M$385 annually in crash related costs.

5.2 Benefits already accrued and those remaining to be realised

As mentioned previously, despite no pedestrian protection regulation in Australia, the performance of the passenger car fleet has been improving, as indicated by EuroNCAP/ANCAP ratings. Although better performing cars are making up a larger proportion of the new car fleet, they still represent a minority of the total registered passenger vehicle fleet overall. Hence, the benefits that have already been accrued, which are estimated below, refer to the lifetime benefit of the current level of protection offered by new passenger vehicles sold in 2006/2007. The benefits yet to be realised are the lifetime benefits of improving the new car fleet to the point of compliance with a candidate regulation. With this interpretation in mind, benefits already accrued are actually benefits that will be felt more as time goes on as current models supersede the existing older models in the vehicle fleet.

Further improvements in the pedestrian protection performance of the new car fleet, in the absence of an ADR, are likely given the trend in performance of cars in EuroNCAP/ANCAP tests. Therefore an estimate of the benefits yet to be realised may overstate the benefits of any ADR; the following analysis will assume a steady new passenger vehicle fleet performance in the absence of an ADR. This performance is characterised by vehicle sales from 2006/07.

The benefit function described in Section 4.2 was applied to models of passenger cars sold in 2006/07, based on each model's EuroNCAP/ANCAP pedestrian test score. (Models that had not been rated were assumed to be represented by the models for which there was a rating.) The potential benefit of replacing each model with one that complied with the regulation was multiplied by the sales volume of the model, and summed over all models for which a EuroNCAP/ANCAP pedestrian test score exists. This sum was divided by total sales of all models considered. The resulting number is an estimate of the benefit of replacing the current new car fleet with one that complies with each candidate regulation.

For the active safety component, it was assumed that 37% of all new vehicles are yet to be equipped with BAS technologies. It also assumed that for those vehicles that currently do have BAS, the benefit is fully realised (that is, no additional benefit would be realised from these vehicle sales from the inclusion of BAS in the ADR).

The results of these calculations for each of the proposed regulations are given in Table 5.3 and Table 5.4.

Table 5.3
Estimated reduction in Australian casualties from pedestrian protection measures yet to be realised according to alternate regulatory proposals

Road user type	Benefit component	Original Phase II			GTR + BAS (current EC proposal)		
		Fatal	Serious	Slight	Fatal	Serious	Slight
Pedestrians	Passive	11	297	-297	5	164	-164
	Active				6	96	299
	Subtotal	11	297	-297	11	260	135
Pedal cyclists	Passive	0.7	172	-172	0.3	93	-93
	Active				0.6	78	338
	Subtotal	0.7	172	-172	1	171	245
Total		12	469	-469	12	431	380

Table 5.4
Estimated reduction in Australian casualty costs from pedestrian protection measures yet to be realised according to alternate regulatory proposals (millions)

Road user type	Benefit component	Original Phase II				GTR + BAS (current EC proposal)			
		Fatal	Serious	Slight	Total	Fatal	Serious	Slight	Total
Pedestrians	Passive	$19	$98	$(5)	$112	$8	$54	$(3)	$59
	Active					$11	$32	$15	$48
	Subtotal	$19	$98	$(5)	$112	$19	$86	$2	$107
Pedal cyclists	Passive	$1	$57	$(3)	$55	$0.5	$31	$(1.6)	$30
	Active					$1	$26	$6	$33
	Subtotal	$1	$57	$(3)	$55	$1.5	$57	$4.4	$63
Total		$20	$155	$(8)	$167	$21	$143	$6	$170

By comparing Tables 5.1 and 5.2 with Tables 5.3 and 5.4 it can be seen that slightly under half of the benefits of either of the regulatory options are to come from future improvements in the new car fleet: 12 of 28 fatalities to be saved over the lifetime of one year's new car sales would come from future improvements of the new car fleet in line with the proposed GTR plus BAS, with 16 of 28 already being saved due to the improved performance of the new car fleet; $170 million of $385 million in crash cost savings would similarly come from future improvements. This result is a consequence of the widespread deployment of BAS in the existing new car fleet (approximately 63% of all new vehicle sales). Over half of the benefit of the passive safety prescriptions of the GTR are still to be realised in the Australian new car fleet.

6 Discussion

The most likely form of an ADR on pedestrian protection will be a GTR adopted under the UNECE 1998 Agreement. Although GRSP are currently restricted to the consideration of passive safety measures, BAS may still form part of the GTR, given that it is likely to be included in Phase II of the European Directive.

It appears that the improvement in pedestrian protection in the Australian new car fleet to date is only around half of what might be achieved under a future ADR consisting of the GTR plus BAS. The potential reductions in death and injury are significant: pedestrian protection to the proposed GTR with BAS on all vehicles should eventually bring with it a reduction of 28 fatalities and around 950 serious casualties per year, and concomitant savings in crash related costs of around 385 million dollars per year. A willingness to pay approach to estimating crash costs would produce a higher estimate of related savings. Around half of these benefits are already in the pipeline, based on the performance of the newest models on the market. Note that over half of the benefit of the passive safety prescriptions of the GTR are still to be realised in the Australian new car fleet.

Note that most of the accrued benefit of existing pedestrian protection is still to be realised in the *whole* passenger car fleet – the median age of registered vehicles in Australia is 9.7 years (ABS, 2007). Therefore, although the new car fleet displays some level of performance in the results of pedestrian impact tests, the overall performance of the registered passenger car fleet will be considerably worse. Improved performance is 'in the pipeline' as new vehicles gradually replace older vehicles in the fleet. Note that, because the predicted reduction in casualties due to regulation is not large, an estimate of the total benefit of pedestrian protection that is based on current crash numbers will not be greatly affected by any benefits that have already been realised.

This analysis has shown a gap in pedestrian safety performance between the new car fleets of Australia and the new car fleets of Europe. One implication of these differences is that pedestrians who are struck in Australia by a new vehicle are around 75% more likely to be struck by a zero or one-star vehicle than pedestrians in Europe. The prevalence of 3-star cars in the new car fleet is similar in Australia and Europe and is relatively low: under 20%.

The mechanism of introducing a new ADR is complex (Newland, 2005) and the position of the Australian Government is not to consider revisions of the Australian Design Rules outside of international considerations. The Australian Government has also stated that, "regulatory intervention is balanced against the extent to which the market is able to drive the desired safety objective" (Truss, 2005). There is no evidence that the market will 'drive the desired safety objective' in the area of pedestrian protection – the new car fleet performance of Australian passenger cars is currently inferior to the new car fleets of Europe.

Pedestrian safety may not be effectively promoted through the same market mechanisms that have produced levels of performance that exceed minimum standards in the area of occupant safety. To date, a minority of vehicle sales would satisfy an ADR on pedestrian protection, whereas many of these vehicles comfortably exceed the minimum benchmark standards for occupant protection. As such, an ADR would provide an important mechanism for manufacturers to improve safety levels provided by vehicles to vulnerable road users.

The proposed GTR on pedestrian and vulnerable road user protection will not necessarily produce the highest level of protection that is feasible. The passive safety component of the GTR corresponds to around 18 EuroNCAP/ANCAP points, and already there have been vehicles that offer better protection; ANCAP recently reported on its first assessment of a 4-star car, awarding it more than 27.5 points (ANCAP, 2007). ANCAP and EuroNCAP may provide additional impetus for safety conscious manufacturers to exceed the minimum requirements of an ADR.

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