ENCOURAGING THE PURCHASE OF SAFER VEHICLES - PART A

BENEFITS AND COSTS OF VEHICLE SAFETY FEATURES

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Encouraging the Purchase of Safer Vehicles – Benefits and Costs of Safety Features

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Abstract

Road safety research shows that there could be substantial benefits arising from encouraging the purchase of safer vehicles. Fleet and private vehicle buyers need to be targeted in such strategies. To assist in the development of effective strategies an analysis was undertaken of the potential benefits and costs of more than 60 safety features that are available or under development.

The analysis identified priority safety features that provide cost-effective reductions in serious injuries and fatalities.

Keywords

PASSENGER VEHICLE, OCCUPANT, INJURIES, AIRBAG, CRASHWORTHINESS

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Executive Summary

There is a wide range of safety features and products available for motor vehicles that can assist in avoiding accidents or making them less severe. Some of these features are only available on luxury vehicles and these vehicles tend to do well in crashworthiness ratings based on real world crashes. The Swedish insurance organisation Folksam has estimated that at least 30% of fatal and serious injuries could be avoided if the average crashworthiness of the fleet was raised to that of the best vehicles currently available.

There would be benefits in Australia arising from making some of these safety features more widely available (that is, encouraging vehicle manufacturers to make them available as standard or optional equipment) and encouraging vehicle purchasers to buy vehicles with these features.

A comprehensive range of vehicle safety features has been evaluated. Road safety research literature has been analysed to determine, where possible, the likely influence of these safety features on road accidents. Economic analysis methodology (as used by the Roads and Traffic Authority of NSW for evaluating items such as proposed roadworks) has been applied to each safety feature to derive an estimate of long term benefits and costs. The resulting benefit/cost ratios contained some surprises - features commonly regarded as cost effective did not rank high in the list. Further analysis suggested that adjusting for exposure (such as higher than average occupancy of certain seats) results in more favourable ranking of these features.

It is recommended that new vehicle purchasers, particularly purchasers of fleets, be encouraged to place a higher priority on safety in the selection process. Greater awareness of safety features that have a significant influence on serious crashes would go some way towards this goal.

Priority safety features are listed below. These either have favourable benefit cost ratios, when compared with a driver airbag or are effective at reducing serious crashes. To arrive at benefit cost ratios above average exposure has been assumed in some cases. This is likely with fleet vehicles. With some features it is sometimes difficult to establish whether a particular vehicle has them as standard or optional equipment.

Features that are readily available

- driver airbag (fortunately most models now have a driver airbag as standard)
- side airbag for driver and front passenger
- ABS brakes
- a cargo barrier in wagons and vans
- a front passenger airbag

Features that are available on some vehicles but are not common

- headlights “on” alarm or automatic headlights or daytime running lights
- seat belt load limiters for front seats

- side airbags for the rear outboard seats
- speed alarm (set by driver)
- seat belt pretensioner for front seats
- anti-submarining seat design
- hazard lights activate in a severe crash

Features that are rarely available in Australia

- top speed limiter (set at 120km/h)
- seat belt interlock (smart alarm)
- high transmittance glazing
- knee bolster/padding
- laminated or shatter-proof glazing for all windows

Introduction

There is a wide range of safety features and products available for motor vehicles that can assist in avoiding accidents or making them less severe. Some of these features are only available on luxury vehicles and these vehicles tend to do well in crashworthiness ratings based on real world crashes. The Swedish insurance organisation Folksam has estimated that at least 30% of fatal and serious injuries could be avoided if the average crashworthiness of the fleet was raised to that of the best vehicles currently available.

There would be benefits in Australia arising from making some of these safety features more widely available (that is, encouraging vehicle manufacturers to make them available as standard or optional equipment) and encouraging vehicle purchasers to buy vehicles with these features.

In addition, there is now considerable information about the relative safety of vehicle models available from the New Car Assessment Program (NCAP) and the Used Car Safety Rating (UCSR) program.

An information package that focuses on safety issues will assist in influencing the purchase of safer new vehicles, particularly fleets. To assist in the preparation of such a package an analysis has been conducted of safety features that are available or are under development. A substantial literature search has been conducted in order to establish, where possible, the likely benefits and costs of these features. The results of the analysis are set out in this report.

This was a project was conducted under the Road Safety Council Research Program (RSCRP) administered by the Research Advisory Group (RAG). The project was managed the Department for Planning and Infrastructure.

Sources of data

Proceedings of conferences associated with vehicle safety and other sources were reviewed for items concerning benefit/cost analyses in general and specific information about the costs and effectiveness of safety features. Results of the literature search are set out in Appendix A. More than 300 documents were covered although not all were subsequently used in the benefit cost analyses

Glass's Guide to Australian vehicle models (Glass's Guide 2001) was used for information about safety features on vehicles and the cost and resale value of some safety features.

Methodology for estimating benefits and costs

In general, information about the benefits and costs of safety features are sketchy and inconsistent. Various methodologies have been applied in an attempt to analyse some safety features but often the methodology is not universally applicable to vehicle safety features.

In 1998 Vehicle Design and Research carried out some related investigations for the Roads and Traffic Authority of NSW (Paine and Gibbs,1998). The RTA's Economic Analysis Manual (RTA 1998) was used as a basis for that work. However, the Manual was primarily intended for assessment of roadworks and it was not directly applicable to vehicle safety features. It was therefore adapted for the 1998 project in consultation with the RTA's economic analysis personnel. In essence, the methodology involved converting the annual cost of road crashes to an annual dollar risk per vehicle. The benefits of applying a safety feature to a particular vehicle could then be estimated, based on the types of crashes that the safety feature was likely to influence, and the effectiveness of the feature in such crashes (the percent that are likely to be saved).

A significant advantage of this approach is that it is independent of the proportion of the fleet fitted with the safety feature.

Briefly, the steps involved were:

1. Identify each safety feature. Estimate the initial cost of the feature, the possible effect on resale value (giving a net installation cost) and the annual cost of the feature (maintenance or amortised replacement)
2. Identify the group(s) of vehicles to which the safety feature is applicable (in this project the analysis was confined to passenger cars but it applies equally to other vehicles such as trucks, buses and motorcycles)
3. Calculate the annual crash risk, in terms of road crash dollars, for fatal, serious injury, minor injury and non-injury crashes for a single vehicle.
4. Determine the types of crashes potentially influenced by the safety feature. For example, driver airbags are generally only of benefit in a frontal crash.
5. Estimate the proportion of the influenced crashes that are likely to be saved by use of the safety feature. This step usually has the greatest uncertainty.
6. Calculate the crash savings, based on steps 3, 4 and 5.
7. Calculate the net annual savings by subtracting the annual (maintenance) cost from the estimated crash savings
8. Determine appropriate financial values to use in the benefit/c cost analysis (7% discount rate and 10 year evaluation period)
9. Calculate the benefit/cost ratio by applying the Present Value formula to the net annual savings and dividing by the net installation cost.

$$B/C = \frac{PV(\text{annual crash savings - annual maintence, 7\% for 10 years})}{(\text{Initial cost - extra resale value})}$$

Further details about the application of each of these steps to the current project are set out below.

List of safety features

A list of safety features that was provided in the project brief was combined with the results of a literature review to produce a list of possible safety features for analysis. The features were categorised into crash factors to aid analysis and to ensure that all aspects of the crash sequence were covered. These factors were:

Table 1

FACTOR
DRIVER'S CONTROL OF VEHICLE
HANDLING AND BRAKING
HAZARD RECOGNITION BY DRIVER
HAZARD RECOGNITION BY OTHERS
OTHER AVOIDANCE FACTORS
OCCUPANT RESTRAINT
VEHICLE INTEGRITY
HAZARD TO OTHER ROAD USERS
HAZARD TO OCCUPANTS
POST-CRASH FACTORS (RESCUE)

Appendix B contains details about each of the safety features included in the analysis.

Cost of safety features

The cost of each safety feature was estimated from the limited information in the literature review, from Glass's Guide and by extrapolation of the cost of similar devices. Details are set out in Appendix D.

In a few cases resale value was available from Glass's Guide. Where available, the 1998 resale value of an option was used to calculate a net cost after three years since many fleets look at disposing of vehicles after about 3 years [Craigen 1992].

There is considerable uncertainty about the cost of safety features, particularly since the cost can vary greatly between models of vehicle. The values used are a best guess for popular vehicles. It has been assumed that each safety feature is reasonably popular and therefore there is an opportunity to spread development costs over a large market. Features will usually be more expensive if they are only supplied in small numbers. Other than this possibility, the benefit/cost methodology is not greatly influenced by the proportion of the fleet having a particular feature.

Cost of road crashes

The RTA Economic Analysis Manual uses generalised crash costs - namely a generic cost of each fatal, serious injury, minor injury and non-injury crash. In most cases no attempt is made to identify the costs for particular types of crashes, although some information is available for crashes involving heavy trucks.

The RTA Manual gives costs per crash. For a safety feature analysis it is necessary to convert this to a cost per car involved. The following table shows the derivation of these costs.

Table 2

ESTIMATION OF CRASH COSTS PER VEHICLE

(Based on NSW crash statistics for 1999)

Cars on register: 2,661,000.00

Crash Type	Car crashes	Cars in crashes	Ratio Car/Crash	Cost per crash#	Cost per car invol.	Rate per 10K cars	Cost per car reg.
Fatal	402	528	0.76	$937,000	$713,398	1.98	$141.55
Hosp Inj*	3,825	5,750	0.67	$175,000	$116,413	21.61	$251.55
Other inj*	13,413	20,386	0.66	$27,000	$17,765	76.61	$136.10
Non-Injury	31,226	52,875	0.59	$12,200	$7,205	198.70	$143.16
						298.91	$672.36

* Estimated from 17238 total with 22% being hospital admissions

Based on RTA Economic Analysis Manual, 1999, Table 8

This analysis indicates that the "average" car represents an crash risk valued at $672 per year. This is the maximum amount that could be saved if all crashes were eliminated. This is somewhat less than the typical amount that vehicle owners pay in insurance premiums to cover personal injury and property losses. Furthermore it does not take into account the traumatic effects that a fatal or serious crash can have on business, family and friends.

Crashes potentially influenced by safety features

Only crashes that clearly had potential to be influenced by a particular safety feature were included in the analysis. For example, driver airbags are generally only beneficial in a frontal crash, which comprise about 60% of all crashes. Other factors for which reasonable crash information was available included severity (fatal, injury of property) day/night time, wet weather, road user movement , speed, alcohol and fatigue.

In some cases factors were combined. For example, side airbags for outboard rear seating positions could be expected to have an influence mainly on side impact crashes (20% of all crashes) where there was a rear seat occupant (13% – see next section). The estimated proportion of crashes influenced was therefore 20% x 13% = 3%.

Appendix C sets out the basis for estimating crashes influenced by each safety feature. Cases involving high uncertainty are indicated in that appendix.

Effectiveness of safety features

An estimate was made of the proportion of influenced crashes that were likely to be saved by a particular safety feature. For example, the literature suggests that front passenger airbags are about 20% effective at reducing fatal and serious injuries. This was applied to frontal crashes with front seat passengers (estimated 12% of all crashes) giving an estimated fatal crash saving of 12% x 20% = 2.4%.

Appendix C includes estimates of the effectiveness of each safety feature and, where applicable, includes the literature references that were used to derive the estimate. As indicated in that appendix, there was uncertainty about the effectiveness of some of the safety features. In these cases the assumptions made in deriving an estimate of effectiveness are stated in the appendix.

Accounting for "Exposure"

The method of calculating benefit/cost treats all vehicles as equal. New vehicles, particularly fleet vehicles, typically travel at least twice the annual kilometres of the "average" vehicle. Their exposure to the risk of serious accidents is therefore at least twice the average and the benefit/cost ratio could be expected to be at least twice that of the average vehicle. For this reason the values used in the graphs have been normalised so that they are expressed relative to that of a driver airbag. In this way consumers can compare various safety features with the priority they assign to a driver airbag. It turns out that the actual benefit/cost ratio for a driver airbag (for an "average" Australian vehicle) is 0.8 - that is, the benefits are slightly less than the costs. Therefore normalisation of this value to 1 has only a small effect.

Safety features that apply to particular non-driver seating positions have the potential to be much more cost effective in cases where the occupancy is higher than average. Average occupancy was based on (unpublished) RTA NSW surveys and accident statistics:

Table 3 - Assumed Average Occupancy

Seating Position	Occupancy
Driver	100%
Front passenger	20%
Rear outboard (L or R)	13%
Centre rear	1%

For example, due mainly to the low average occupancy, a front passenger airbag has a benefit/cost ratio of only 0.2. However, if this seating position is occupied most of the time in a particular vehicle then the benefit/cost ratio reaches 1 (this is better than that of a driver airbag - although passenger airbags are slightly less effective than driver airbags, the net cost of passenger airbags is typically lower).

Another example is cargo barriers. For the "average" station wagon or van it is assumed that significant cargo is only carried 5% of the time. For commercial vehicles this figure could be 100%, suggesting a benefit cost ratio twenty times the "average" value of 0.47. In other words for such cases the benefits exceed the costs by 9 to 1. A more conservative value has been used in the analysis based on a "high use" rate of 20% and giving a benefit/cost ratio of 1.9.

In order to give an indication of the range of benefits arising from above-average levels of exposure, the calculations include a "high use" (HI USE) component.

Results of Benefit/Cost Analysis

Appendix C contains details of the analysis for each safety feature. The following table shows the list sorted by estimated benefit/cost ratio.

Note that the first item, a top speed limiter, shows a very high benefit/cost artio. This is partly because it has been assumed that top speed limiting can be very easily built into modern engine management chips for little or no cost.

For the "average" vehicle only 13 of the evaluated features showed a benefit/cost ratio greater than one - indicating that benefits exceed costs. Several items that were assumed to provide good road safety benefits did not score particularly well. Examples are ABS brakes, driver airbag, side airbags and passenger airbags. This was mainly due to the high installation costs of these devices and the low average occupancy of some seats.

Table 4 - Summary of Estimated Benefit/Cost Ratios

DESCRIPTION	COST (NET)	MAINT.	BENEFIT/ COST (HI-USE)	PAGE APP C
TOP SPEED LIMITER (SET AT 120km/h)	$1.00	$0.00	67.22	C6
HEADLIGHTS ON WARNING/AUTO	$50.00	$20.00	7.79	C15
DAYTIME RUNNING LIGHTS	$50.00	$2.00	7.67	C15
SEAT BELT INTERLOCK	$50.00	$0.00	3.19	C29
SEAT BELT LOAD LIMITERS, FRONT	$20.00	$0.00	1.95	C30
SPEED ALARM	$50.00	$0.00	1.92	C5
HIGH TRANSMITTANCE GLAZING	$50.00	$0.00	1.40	C12
KNEE BOLSTER/PADDING	$100.00	$0.00	1.36	C20
LAMINATED OR SHATTER-PROOF GLAZING FOR ALL WINDOWS	$100.00	$0.00	1.12	C17
SEAT BELT WEBBING GRABBERS, FRONT	$40.00	$0.00	1.12	C33
SEAT BELT PRETENSIONER, FRONT	$100.00	$0.00	1.12	C31
ANTI-SUBMARING SEAT DESIGN	$40.00	$0.00	1.12	C33
HAZARD LIGHT ACTIVATE IN SEVERE CRASH	$50.00	$0.00	1.11	C39
HELMETS/HEAD BANDS FOR OCCUPANTS	$30.00	$10.00	0.90	C19
SEAT BELT BUCKLE MOUNTED ON SEAT (F)	$50.00	$0.00	0.89	C27
PEDESTRIAN FRIENDLY VEHICLE FRONT	$500.00	$0.00	0.85	C22
ABS BRAKES	$400.00	$0.00	0.83	C7
SIDE AIRBAG - FRONT SEAT, THORAX	$400.00	$0.00	0.81	C37
DRIVER AIRBAG	$600.00	$0.00	0.79	C24

DESCRIPTION	COST (NET)	MAINT.	BENEFIT/ COST (HI-USE)	PAGE APP C
CONSPICUOUS BODY COLOUR	$100.00	$0.00	0.70	C14
LOAD RESTRAINT DEVICES (TETHERS)	$100.00	$0.00	0.67(2.68)	C20
INTELLIGENT SPEED ADAPTION	$800.00	$0.00	0.60	C3
IMPROVED FOOT PROTECTION	$100.00	$0.00	0.55	C16
SPEED SENSITIVE INTERMITTENT WIPERS	$100.00	$0.00	0.51	C14
WIPERS AUTOMATIC	$100.00	$0.00	0.51	C7
ADJUSTABLE HEAD RESTRAINT	$100.00	$0.00	0.50	C26
HEAD PROTECTION PADDING	$200.00	$0.00	0.49	C18
CARGO BARRIER	$300.00	$0.00	0.47(1.89)	C16
EXTERNAL MIRRORS ELECTRICALLY ADJ	$200.00	$0.00	0.47	C13
BONNET AIRBAG FOR PEDESTRIAN PROT.	$500.00	$0.00	0.45	C21
SMART AIRBAG SYSTEM	$500.00	$0.00	0.39	C23
CRASH RECORDER	$500.00	$0.00	0.38	C37
MOBILE PHONE AVAILABLE IN EVENT OF ACCIDENT	$200.00	$0.00	0.38	C40
SEAT BELT LOAD LIMITERS, REAR	$20.00	$0.00	0.37(1.85)	C31
ALCOHOL/DRUG INTERLOCK	$200.00	$0.00	0.36	C1
SEAT BELT D-RING HEIGHT ADJUSTABLE	$100.00	$0.00	0.33	C29
MAYDAY DISTRESS CALL IN SEVERE CRASH	$500.00	$0.00	0.30	C39
CRUISE CONTROL	$150.00	$0.00	0.27	C2
ENGINE IMMOBILISER	$300.00	$0.00	0.25	C38
AUTOMATIC TRANSMISSION	$200.00	$0.00	0.24	C2
ADJUSTABLE LUMBAR SUPPORT	$50.00	$0.00	0.24	C5
ADJUSTABLE STEERING COLUMN	$100.00	$0.00	0.24	C6
ADJUSTABLE DRIVERS SEAT (MULTI-FUNCTION)	$200.00	$0.00	0.24	C4
COOLED/HEATED DRIVERS SEAT	$200.00	$0.00	0.24	C4
SIDE AIRBAG - FRONT, HEAD-PROTECTING (CURTAIN)	$400.00	$0.00	0.20	C34
HEADWAY RADAR FOR CLOSING SPEEDS	$800.00	$0.00	0.20	C8
FRONT PASSENGER AIRBAG	$400.00	$0.00	0.19(0.97)	C25
FUEL AND ENGINE CUT-OFF (SEVERE CRASH)	$100.00	$0.00	0.19	C38
SEAT BELT, CENTRE REAR 3-POINT	$100.00	$0.00	0.19(1.86)	C28
HEAD REST. FOR REAR OUTBOARD SEATS	$80.00	$0.00	0.18(0.70)	C27
POWER STEERING	$300.00	$0.00	0.16	C9
SEAT BELT WEBBING GRABBERS, REAR	$40.00	$0.00	0.15(0.74)	C32

DESCRIPTION	COST (NET)	MAINT.	BENEFIT/ COST (HI-USE)	PAGE APP C
SEAT BELT PRETENSIONERS, REAR	$100.00	$0.00	0.15(0.74)	C32
HEAD RESTRAINTS FOR ALL REAR SEATS	$120.00	$0.00	0.14(0.70)	C26
SIDE AIRBAG, REAR, THORAX	$400.00	$0.00	0.12(0.61)	C36
INFLATABLE SEAT BELT	$200.00	$0.00	0.11	C30
INDEPENDENT REAR SUSPENSION	$300.00	$0.00	0.09	C8
AUTO DIMMING REAR VIEW MIRROR	$200.00	$0.00	0.06	C12
CHILD SEAT INTEGRATED	$500.00	$0.00	0.06(0.28)	C25
HARNESS SEAT BELT FOR ADULTS (4/6PT)	$400.00	$0.00	0.04	C28
SIDE AIRBAG, REAR, HEAD-PROTECTING	$400.00	$0.00	0.04(0.20)	C35
NAVIGATION SYSTEM (GPS)	$1,500.00	$0.00	0.03	C3
TRACTION CONTROL	$700.00	$0.00	0.02	C9
RUN FLAT TYRES	$400.00	$0.00	0.01	C10
ANTI FOGGING (HEATED) EXT MIRRORS	$200.00	$0.00	0.01	C13
TYRE PRESSURE MONITORING	$400.00	$0.00	0.00	C10
DRIVING LIGHTS	$100.00	$5.00	0.00	C11
FOG LAMPS	$100.00	$5.00	0.00	C11
AIR CONDITIONING/CLIMATE CONTROL	$1,200.00	$40.00	0.00	C1

These results are illustrated in the following graphs.

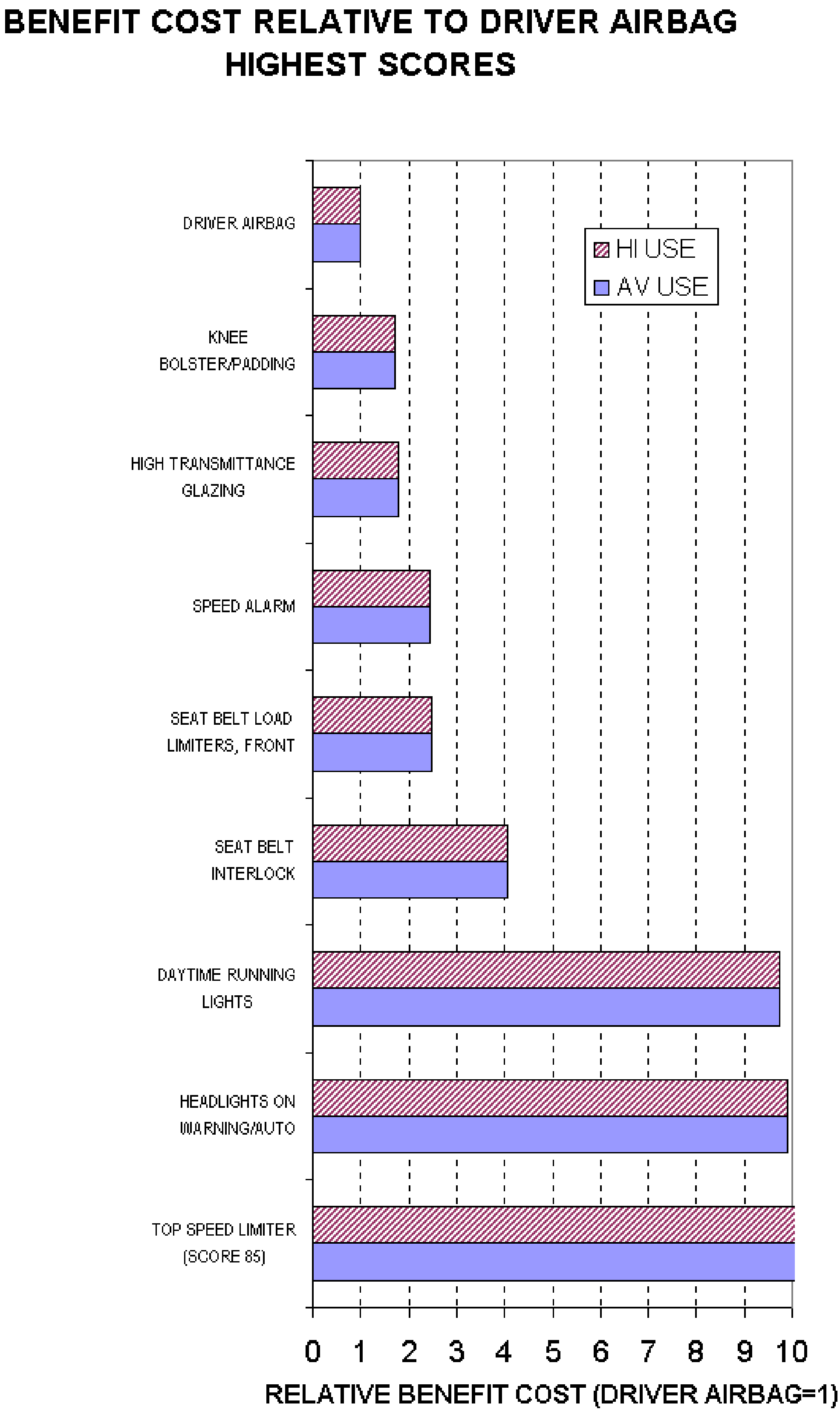

Figure 1. Highest Benefit/Cost (B/C) Ratios

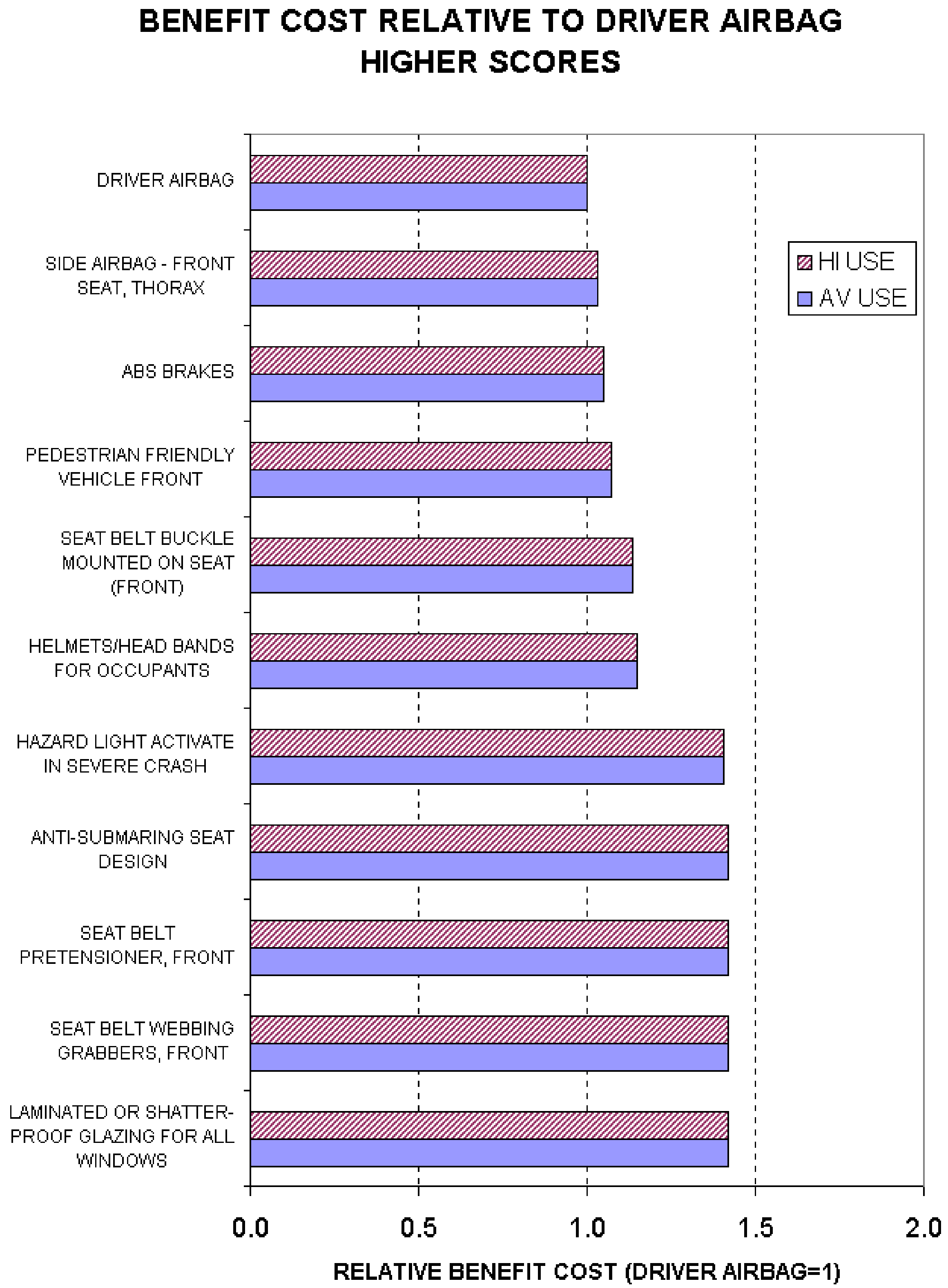

Figure 2. B/C higher than driver airbag

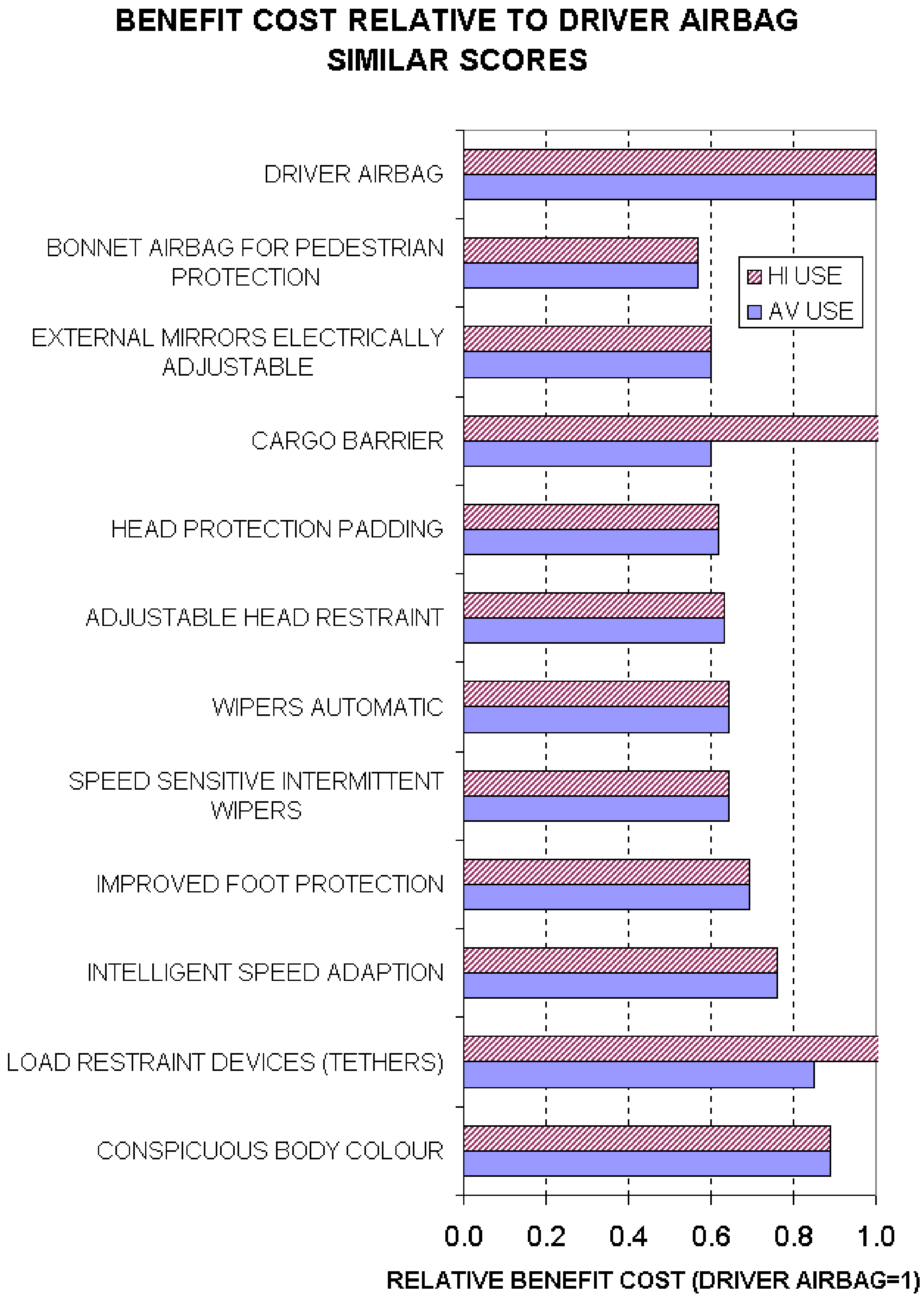

Figure 3. B/C similar to driver airbag

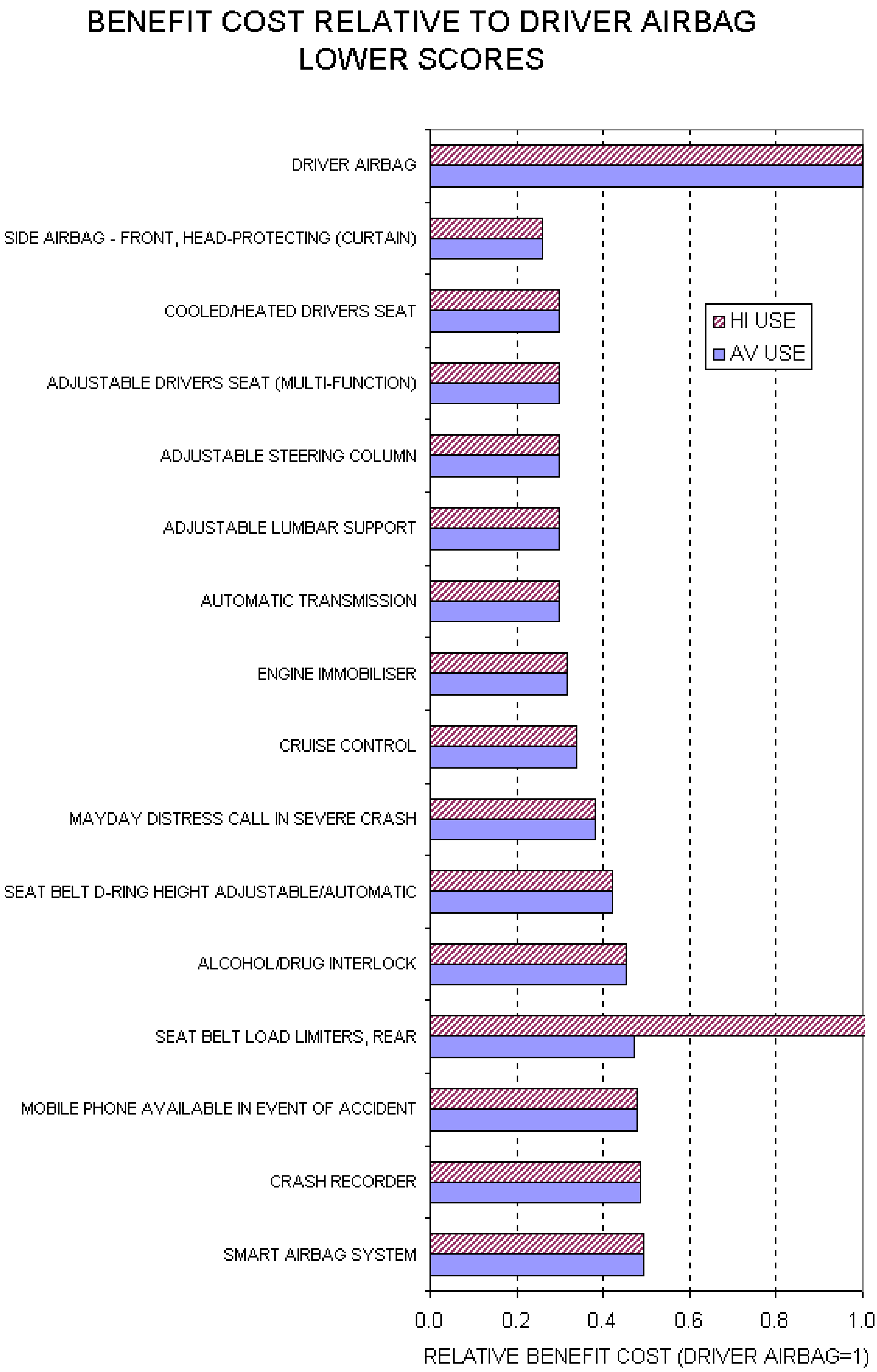

Figure 4. B/C Moderately less than driver airbag

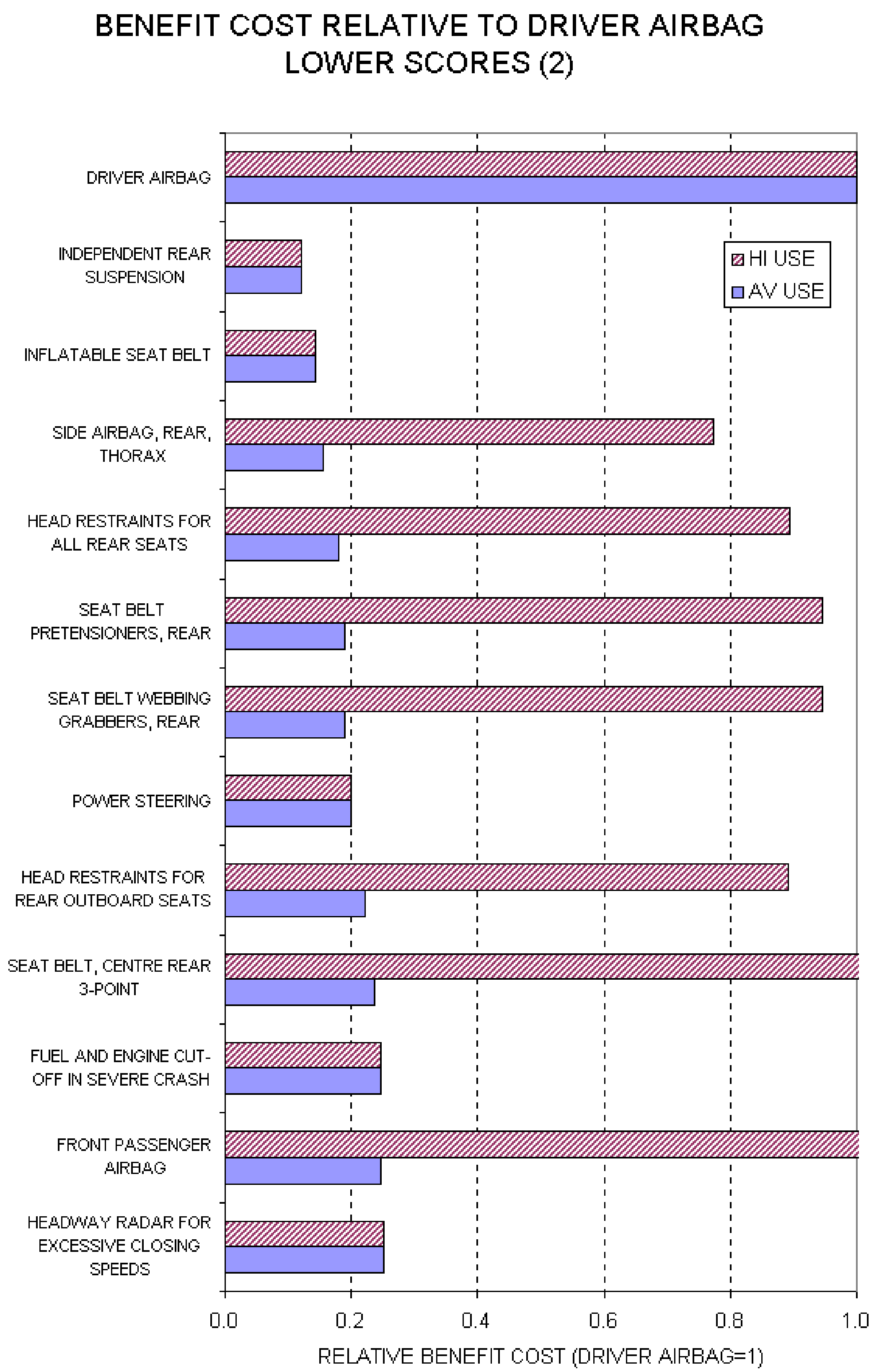

Figure 5. B/C substantially less than driver airbag

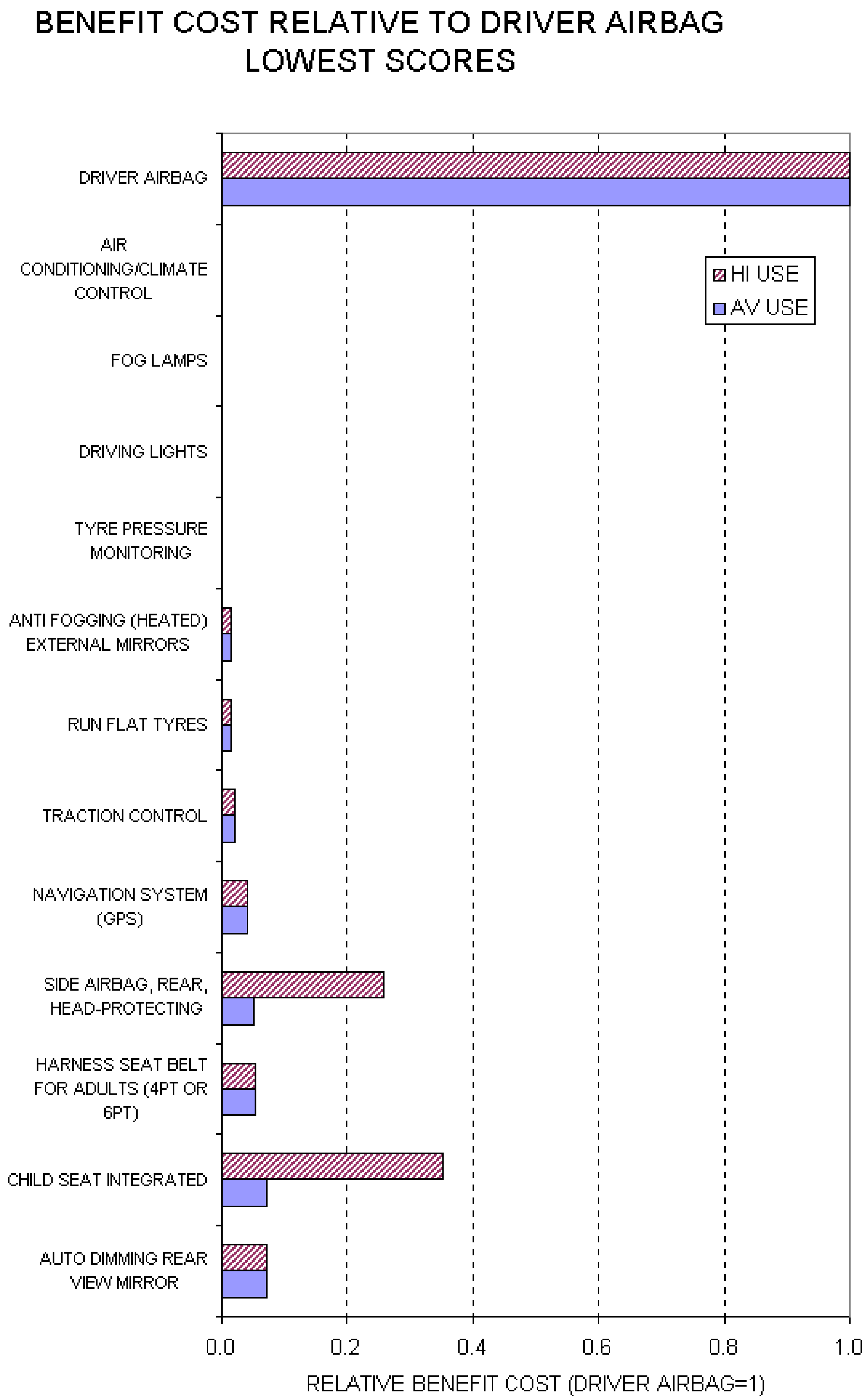

Figure 6. Lowest B/Cs

Effectiveness in reducing serious crash outcomes

Safety features may also be evaluated by considering how they might reduce the number of serious or fatal crashes. This involves two parameters that are documented in Appendix C - the proportion of all serious and fatal crashes that are likely to be influenced by the safety features and the proportion of influenced crashes that are likely to be saved by the particular safety feature. For a driver airbag this works out at 15% (60% of crashes and 25% effectiveness in these crashes). The effectiveness of other safety features that are commonly available as optional equipment are shown in Figure 7. Also shown are the net costs of these items, based on typical initial cost less the extra resale value after 3 years.

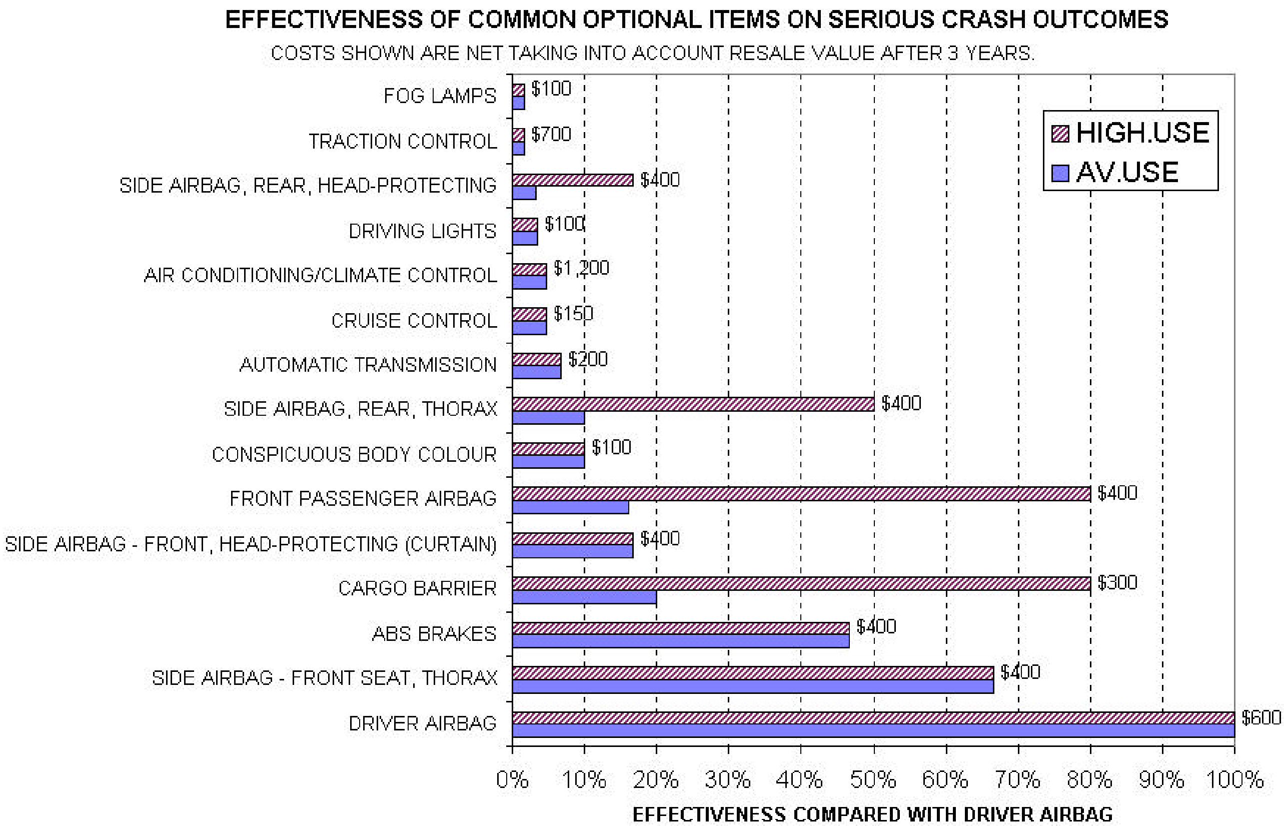

Figure 7. Relative effectiveness in serious crashes

Discussion

Using strict economic analysis techniques and assuming average usage, the benefit/cost ratios of some common safety features are relatively poor. Only 13 (out of 69 evaluated) features exceed unity (benefits exceed costs). Even a driver airbag, which in NCAP tests typically reduce the risk of serious head injury by half, only achieves a B/C of 0.8.

This suggests there are traps in simply using the economic analysis methods. These calculations are for an "average" vehicle. Business vehicles typically travel higher annual kilometres and their "breakeven" point would be a B/C of no more than 0.5. A further 13 safety features have a B/C of 0.5 or more.

Some features are more worthwhile under different usage, such as higher occupancy of non-driver seats. A further 9 safety features exceed a B/C of 0.5 if high usage is assumed.

When faced with a decision on whether to purchase optional safety features, it may be more appropriate to simply consider the effectiveness of the feature in reducing serious/fatal injuries, as set out in figure 7.

The analysis did not take into account non-safety benefits. For example, air conditioners and mobile phones would likely be purchased for non-safety reasons. Also it is important that fleet purchasers recognise the trauma and disruption that a serious or fatal road accident can have on an organisation - these non-tangible effects are not taken into account in the benefit/cost calculations.

Priority safety features

Priority safety features are listed below. These either have favourable benefit cost ratios, when compared with a driver airbag or are effective at reducing serious crashes. In some cases above average exposure has been assumed, as might be expected with fleet vehicles. With some features it is sometimes difficult to establish whether a particular vehicles has them as standard or optional equipment.

Features that are readily available

- driver airbag (fortunately most models now have a driver airbag as standard)
- side airbag for driver and front passenger
- ABS brakes
- a cargo barrier in wagons and vans
- a front passenger airbag

Features that are available on some vehicles but are not common

- headlights “on” alarm or automatic headlights or daytime running lights
- seat belt load limiters for front seats
- side airbags for the rear outboard seats
- speed alarm (set by driver)
- seat belt pretensioner for front seats
- anti-submarining seat design
- hazard lights activate in a severe crash

Features that are rarely available in Australia

- top speed limiter (set at 120km/h)
- seat belt interlock (smart alarm)
- high transmittance glazing

- knee bolster/padding
- laminated or shatter-proof glazing for all windows

It may take pressure from fleet and government purchases to introduce the latter safety features since there would be little consumer awareness (or interest) in them.

Conclusions

A comprehensive range of vehicle safety features has been evaluated. Road safety research literature has been analysed to determine, where possible, the likely influence of these safety features on road accidents. Economic analysis methodology (as used by the RTA of NSW for evaluating items such as proposed roadworks) has been applied to each safety feature to derive an estimate of long term benefits and costs. The resulting benefit/cost ratios contained some surprises - features commonly regarded as cost effective did not rank high in the list. Further analysis suggested that adjusting for exposure (such as higher occupancy of certain seats) results in more favourable ranking of these features.

It is recommended that new vehicle purchasers, particularly fleets, be encouraged to place a higher priority on safety in the selection process. Greater awareness of safety features that have a significant influence on serious crashes would go some way towards this goal.

References

References for safety features are set out in Appendix A (bibliography). This section covers additional references in the main report.

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RTA (1998) *Economic Analysis Manual,* Roads and Traffic Authority of NSW

Appendix A - Annotated Bibliography

VEHICLE SAFETY BIBLIOGRAPHY

CATEGORY **K** **Crashworthiness and compatibility**

K01 *Crashworthness research at the NHMRC Road Accident Research Unit*

Anderson R and McLean J 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar

Development of free-flight headform tests and legform tests to evaluate the injury potential of vehicle fronts. Bullbar tests using the free-flight headform impacting at 40km/h. Three positions on the vehicle were impacted. The steel bullbar produced peak deceleration between 593g and 1069g. The aluminium bullbar produced peak decelerations between 319g and 472g. An innovative plastic protection device produced peak decelerations between 168g and 307g and the standard vehicle (Toyota Prado) ranged from 148g to 325g. Other work reported included reconstruction of fatal pedestrian accidents and the effect of padding the upper interior of vehicles (see separate paper by McLean).

K02 *Advanced designs for side impact and rollover protection*

Bloch B 1998

Proceedings of the 16th ESV

Advanced design features considered include: foam-filled tubular member strengthened doors with full perimeter overlap and multiple latches, stronger, wrap-around seats with taller head restraints and intergal seat belts, seat belt pre-tensioners that activate in side and rollover impacts, padded interior surfaces, side airbags and improved side window glazing. Upgrading of several FMVSS are recommended. The objectives of occupant protection are to: (a) encourage deflection of the striking vehicle away from the struck vehicle, (b) minimse intrusion into the occupant's survival space, (c) reduce the velocity differential between the struck vehicle and the occupant kinematic movements and (d) restrain and cushion the occupant's head and torso, or allow contact with energy absorbing materials to maximise distribution of contact forces.

K03 *In-depth analysis of offset frontal crash tests external aggressivity*

Bloch J and Chevalier M 1996

Proceedings of the 15th ESV

Examines the potential for assessing aggressivity based on the deformatio the deformable barrier used in the EEVC offset crash test. It was found that the barrier very often bottomed out and therefore a change to the barrier characteristics may be needed to successfully proceed with this concept.

K04 *The importance of matching restraint systems to the accident severity*

Brambilla L 1996

29th International Symposium on Automotive Technology and Automation

Mercedes Benz approach to restraint system design. Optimum performance requires a smart system. For example, the same airbag trigger threshold is not appropriate in all circumstances and the seat belt tension could be carefully adjusted to optimise protection. Seat belt force limiters need to work in conjunction with pre-tensioners. The next generation of restraint systems will also adjust according to the occupant's characteristics (size, weight, sex and age). The demands on the restraint system increase as the vehicle gets smaller and there is less space for energy absorption. There is the potential to increase injury in lower severity crashes in order to cope with the demands of high severity crashes unless crash and occupant parameters are taken into account in the design and operation of the restraint system.

K05 *Compatibility - the aggressivness of cars in real world car to car crashes*

Byard N, Fails A and Langdon M 1998

Proceedings of the 16th ESV

Injuries to occupants in opposing vehicles are compared in order to assess aggressiveness. Structural features which contribute to injury outcomes are also assessed.

K06 *The Development and Estimation of Aggressivity Ratings for Australian*

Cameron M H, Newstead S V and Le C M 1998

Passenger Vehicles Based on Crashes During 1987 to 1995

Methodology for comparing "aggressivity" by studying the outcome of two vehicle collisions. Analysis of NSW and Victorian crash data and assigned of aggressivity ratings to popular vehicle models (in a similar manner to Used Car Safety Ratings)

K07 *The effectiveness of ADRs aimed at occupant protection.*

Cameron M 1987

Seminar on Structural Crashworthiness & Property Damage Accidents.

This paper summarises various reports by Cameron and others. It provides further cost/benefit information about air bag systems. It was concluded that drivers-side air bags had a potential to save $20.84 per car per annum due to reduced injuries. It was noted that the cost of installation of air bags was falling rapidly. Also the point was made that, in a country with high seat belt usage rates, other countermeasures such as seat belt pre-tensioners might be an effective alternative to air bags.

K08 *Ejection and the effect of ADR 2 for Door latches and Hinges.*

Cameron M 1980

FORS CR 15 September 1980.

This study found a decreased risk of occupant ejection (for both belted and unbelted occupants) for recent model vehicles in the study. These vehicles had improved door latch and hinge design, compared with older vehicles. The most recent vehicles studied were subject to ADR 2. Another conclusion was that ejection doubles the risk of severe/fatal injury compared with being retained in the car under the same crash circumstances. The effectiveness of ADR 2 in roll-over crashes was inconclusive.

K09 *Side impacts and the effect of ADR 29 for side door strength.*

Cameron M 1980

FORS CR 14 April 1980.

The study concluded that there was no statistically significant evidence that ADR 29 reduces the risk of injury to front outboard seat occupants seated on the impact side in side impacts. However, the study was considered to be inconclusive for several reasons. One of the issues was that all types of side impact were studied whereas the ADR could only be expected to be effective in certain types of side impact where loads are concentrated of the door.

K10 *Frontal impacts and the effect of ADRs 10A and 10B for steering columns*

Cameron M 1979

FORS CR 7 July 1979.

This study concluded that ADR 10 is effective in reducing the severity of injury to some types of drivers who strike the steering assembly in frontal impacts, particularly those on rural roads. Possible increases in injuries in certain cases - particularly with small cars were also reported.

K11 *Investigation of the effect of bull-bars on vehicle-pedestrian collision*

Chiam H & Tomas J 1980

dynamics.

K12 *Car crash theory and tests of airbag bumper systems*

Clark C and Young W 1995

Issues in Automotive Safety Technology', SAE

Evaluation of the potential for decreasing crash severity by mounting a large airbag on outside of a car. Tests of a prototype system on an Oldsmobile sedan indicated that the airbag absorbed 19% of the crash energy and reduced the equivalent barrier impact speed from 48.5km/h to 43.5km/h during a front impact. The device was ineffective in a simulated side impact due to the deformation of the car structure. Potential problems include reliable detection of an iminent crash; rapid airbag inflation; airbag storage (and cost of minor collisions?) and controlled deflation of the airbag (to disipate the crash energy).

K13 *3001 The final odyssey*

Clarke AC 1997

Book (science fiction)

At the end of this science fiction novel the author gives background on some of the science concepts raised in the novel: "An 'inertialess drive', which would act exactly like a controllable gravity field, had never been discussed seriously outside the pages of science fiction until very recently. But in 1994 three American physicists did exactly this, developing some ideas of the great Russian physicist Andrei Sakharov. 'Inertia as a Zero-Point Field Lorentz Force' by B. Haisch, A. Rueda & H. E. Puthoff (Physics Review A, February 1994) may one day be regarded as a landmark paper...if [the] theory can be proved, it opens up the prospect - however remote - of anti-gravity, 'space drives' and the even more fantastic possibility of controlling inertia...The good news is that traffic accidents would be virtually impossible; automobiles - and passengers - could collide harmlessly at any speed."

K14 *Side impact protection opportunities*

Dalmotas D, Withnall C and Gibson T 1996

Proceedings of the 15th ESV

3 vehicle models were evaluated for side impact protection. In one case the vehicle was modified to provide enhanced side impact protection in the form of additional padding. It was found that "substantial improvements in side impact protection can be achieved, at minimal added cost and with little encroachment of interior space, through the use of innovative padding schemes".

K15 *Automotive load protection*

Glew J 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar

Review of the development of cargo barrier standards. Loads generated in various types of crashes.

K16 *Activities of the New Car Assessment Program in the United States*

Hackney J, Kahane C and Chan R 1996

Proceedings of 15th ESV

Delta-Vs in real world crashes (median at about 60km/h for fatalities to restrained drivers in frontal crashes 1988-94). Probability of severe head and chest injury. NCAP results and trends. See also 'The New Car Assessment Program - Historical review and effect', Occupant Containment and Methods of Assessing Occupant Protection in the Crash Environment, SAE SP-1045, Warrendale, February 1994.

K17 *Effects of car and seat on the loading of occupant's neck in rear impacts*

Haland Y, Lindh F, Fredriksson R and Svensson 1996

29th International Symposium on Automotive Technology and Automation,

Mechanism of neck injury in low speed rear crashes. It is proposed that the upper end of the cervical spine can be forced into an S-shape when the body and head move by different amounts. The speed and degree to which this happens is related to the risk of neck injury (whiplash). Two small cars which, from Swedish insurance claims, demonstrate a low and high risk of whiplash were analysed, along with prototype seat designs. The horizontal distance between the head and the head restraint was found to be important but an over-rigid seat (as in one of the prototypes) can defeat a good head restraint position.

K18 *Characteristics of fatal single vehicle crashes*

Haworth N, Vulcan P, Bowland L and Pronk N 1997

MUARC Reports 120 and 121

Investigation of 127 single-vehicle crashes occurring within a 200km radius of Melbourne. 75% of crashes involved an impact with a tree or pole or both (similar for urban and rural). Half the tree impacts and one third of the pole impacts were on the offside of the road. For drivers aged 60 or more a pre-existing medical condition was the most likely cause of death (e.g. 7 out of 10 coroners briefs indicated the cause of death was heart disease). 20% of the case vehicles were manufactured prior to 1978 compared to 9% in a control group: risk factor = 2.3 [note these vehicles make up just 4% of the NSW fleet and a smaller precentage of annual VKT]. In 13% of crashes the fatally injured occupant was not wearing a seat belt compared with 2% of controls: risk factor = 8.4. In 36% of crashes the driver was driving someone else's car, compared to 7% of controls : risk factor = 4.5 [familiarity issue, standardisation of controls].

K19 *Passenger car roof crush strength requirements*

Henderson M and Paine M 1995

FORS CR 176

Extensive literature review, analysis of rollover crashes in the FORS fatality file, analysis of the kinetics of rollover crashes and the forces on occupants, recommendations for improvements in vehicle design. FMVSS216 found to be deficient - lateral deformation of the roof may be more important than "roof crush" in some crashes. See extract Extract on WWW at http://www1.tpgi.com.au/users/mpaine/rollover.html.

K20 *Dispelling the misconceptions about side impact protection*

Hobbs C 1995

Advances in Occupant Protection Technologies for

Conventional methods to improve side impact protection, such as strengthening the structure and adding padding are not necessarily correct. Guidelines developed by TRL include: maintain a vertical intrusion profile for the lower part of the door; interaction between door and sill can affect the profile; base of b-pillar can affect the profile; minimise the stiffness and mass of the door components which might contact the occupant; avoid variations in the vertical stiffnes of the system since these can results in load concentrations; a "high door velocity with bounce" (?) can improve the dynamics of the occupant; the optimum stiffness of padding for the chest should be low - padding for the pelvis can be stiffer.

K21 *Compatibility of cars in frontal and side impact*

Hobbs C, Wiliams D and Coleman D 1996

Proceedings of the 15th ESV

Results of TRL research are presented. Car to car crash tests, including side impacts are evaluated. A comparison is made between the EEVC and NHTSA side impact tests. "It is still too early to draw firm conclusions about compatibility".

K22 *NHTSA's vehicle aggressivity and compatibility research program*

Hollowell W and Gabler H 1998

Proceedings of the 16th ESV

An update on NHTSA's research program. "Design modifications which minimise injuries in one vehicle may actually accentuate injury levels in the collision partner" ."...improved vehicle compatibility will result in correspondingly large reductions in crash related injuries". (see also the paper of the same title in the Proceedings of the 15th ESV - a very wide range of "aggressivity" is observed within vehicles of the same class - notable that, in the large car class, the Volvos had the best rating (around 15) and the Mercedes Marquis had the highest (around 60)).

K23 *Improvement of crash compatibility between cars*

Faerber E 1998

Proceedings of the 16th ESV

In-depth crash studies are used to identify the most important problems related to compatibility. Experimental car to car impacts are used to replicate some real-world crashes and computer simulations are used to determine the effects of varying stiffness and mass of the subject vehicles.

K24 *Vehicle Occupant Protection: Four-wheel-drives, utilities and vans*

Fildes B, Kent S, Lane J, Lenard J and Vulcan P 1996

FORS CR 150

Literature review, mass data analysis and crashed vehicle study (144 cases - too small for meaningfull analysis). Almost half of 4WD crashes were rollovers. Mean delta-V was 35.5km/h (compared with 45.4 for passenger cars). Minor upper limb injuries were the most common injury. Leg injuries were also common. Countermeasures developed for passenger cars should also be effective for these vehicles.

K25 *Side impact regulation benefits for Australia*

Fildes B, Dyte D, Carr D, Seyer K and Digges K 1996

Proceedings of the 15th ESV

Harm analysis of the benefits of introducing either FMVSS 214 or ECE 95 in Australia. It was estimated that adoption of either standard would save about $150 per vehicle. The Australian motor industry advised that the average cost of compliance was $100 per vehicle therefore the side impact standard were considered to be (marginally) cost effective. See also FORS CR 154 Side Impact Regulation Benefits.

K26 *Consumer crash test programs - harmonisation and injury reduction*

Griffiths M 1996

Proceedings of the 15th ESV

Comparison of Australian and US NCAP programs. Differences between Australian and US vehicles. Occupational health issues. Based on Driver Protection ratings from analysis of real world crashes, it is estimated that if the all car average was raised to that of the best performing popular vehicles then there would be 46% reduction in the likelihood of serious injury in all crashes.

K27 *United Kingdom - New Car Assessment Program'*

Hobbs C A 1996

Proceedings of the 15th ESV

Description of the development of the NCAP program in Europe. The EEVC decided on offset frontal, side impact and pedestrian impact tests.

K28 *Experimental program of automotive safety assessmentin Japan*

Horigome N and Naito M 1996

Proceedings of the 15th ESV

Description of the development of the NCAP program in Japan. OSA decided on the 56km/h full frontal crash test. Steering wheel and dash movement were assessed as indicators of structural performance.

K29 *Evaluation of frontal crash tests against a deformable barrier*

Klanner W, van West F and Felsch B 1998

Proceedings of the 16th ESV

Modifications to existing offset crash test procedures are considered in order to assess compatibility and aggressivity of the test vehicle.

K30 *Applying Computer Aided Engineering to Improve Vehicle Safety*

Loo M and Brandini M 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar

Use of advanced computing techniques in the design of passenger cars. Integration of vehicle structural models with occupant restraints models. Simulation of regulatory and consumer crash tests.

K31 *The Validation of the EEVC Frontal Impact Test Procedure*

Lowne R W 1996

Proceedings of the 15th ESV

Development of the offset crash test as used by IIHS, Euro-NCAP and ANCAP. Effects of vehicle type, vehicle size and impact speed. Repeatability of crash tests. Good repeatability was found, particularly for upper body parameters (variations in footwell deformation and dummy foot position may account for some variation in lower leg injuries).

K32 *When it comes to the crunch: the mechanics of car collisions*

Murray NW 1994

World Scientific.

A thorough review of the physics of car crashes, with comments on crashworthiness in various types of collisions. Accident statistics relevant to vehicle factors are presented in an appendix.

K33 *Automobile Safety Information*

National Organisation for Automotive Safety 1998

OSA, Tokyo.

Comprehensive layman's guide to safety features on vehicles and the results of full-frontal crash tests of popular cars in Japan. Safety features tabulated are: ABS brakes, Driver and passenger front airbags, side airbags, adjustable sealt belt anchors, seat belt pre-tensioners, seat belts with child seat locking mechanisms and integrated child seats (the latter are standard on Camry Gracia, Chrysler Voyager SE, Volvo S/V70 and Volvo 940 and are optional on a few others).

K34 *Vehicle Crashworthiness Ratings by Year of Vehicle Manufacture*

Newstead S, Cameron M & Le 1997

Monash University Accident Research Centre

Technical report accompanying the brochure "User Car Safety Ratings".

K35 *New vehicle crashworthiness evaluations by the IIHS*

O'Neill B, Lund A, Zuby D and Estep C 1996

Proceedings of the 15th ESV

Description of IIHS offset crash test procedures and evaluation methodology.

K36 *Guidelines for crashworthiness ratings*

Paine M 1998

Report for Australian New Car Assessment Program.

Procedures for assessing crash-tested vehicles and rating structural performance, occupant restraint systems, injuries, head restraint design and overall performance.

K37 *Crash simulation for crashworthiness design of passenger cars*

Pries H, Sinnhuber R and Zobel R 1995

Automotive Passenger Safety,

Volkswagen's vehicle design procedures now include sophisicated computer simulations of a variety of crashes. These can be used to optimise energy absorption, passenger compartment structure and restraint system performance (the latter was not integrated at the time the paper was prepared). An aim is "to optimise the crash behaviour of cars to minimise the total of injury-related costs in traffic [accidents]". The potential for computer simulations to be used in place of (expensive) compliance test is raised by the authors [they may be a case for higher standards in the case of compliance established solely by computer simulation

K38 *Rollover crash study - vehicle design and occupant injuries*

Rechnitzer G and Lane J 1996

Proceedings of the 15th ESV

In-depth investigation of 43 rollover crashes. Ejection and partial ejection were significant factors in fatal rollovers. Broken side windows and roof lateral deformation can contribute to partial ejection of seat-belted occupants. Seat belts are only partially effective in rollovers and some buckle design may allow unlatching during the rollover. Lack of roof integrity, particularly with some 4WDs, is a problem. Unpadded roof structures contribute to scalp lacerations, skull fractures and brain injury. Spinal injuries result from: loss of vertical occupant space (including lateral roof deformation), impact with the ledge at the join between the door and the roof (cantrail) and lack of interior padding. Severe injuries only appeared to occur to occupants seated where significant roof contact with the ground occurred - the severe injuries cannot be ascribed to crash severity alone. Design improvements recommended are: improved side window integrity, increased roof pillar strength (particularly to resist side sway), interior padding, modify the design of the roof cantrail, improved seat belts and improved door integrity. See also MUARC Report 65, December 1994.

K39 *Review of in-depth crash research*

Ryan G & Mclean A 1988

FORS CR 79

This report includes advice and recommendations for establishing in-depth crash studies.

K40 *An in-depth study of rural road crashes in South Australia.*

Ryan G et al 1988

FORS CR 78

Contains detailed information about 80 crashes. Analysis does not cover vehicle factors in detail but information could be derived from the accident descriptions.

K41 *Investigation of factors pertinent to offset-frontal impacts*

Schneider L 1998

Proceedings of the 16th ESV

130 offset frontal crashes were investigated in Michigan. Instrusion of other measurements were made. Particular emphasis was given to the factors which caused disabling injuries to the ankles and feet.

K42 *Australian Design Rules - current and future developments*

Seyer K — 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar

Development of ADRs 69 and 73 (frontal crash testing) and ADr72 (side impact), compatibility and pedstrian safety. Estimated benefits of the offset crash test of ADR73 range from 15% to 23% reduction in "frontal Harm", depending on airbag usage. Problems with using the deformable barrier for higher speed (64km/h) offset tests and tests of heavier vehicles, such as four-wheel-drives, are raised. It is claimed that this can drive manufacturers to produce stiffer and heavier vehicles (recent ANCAP results tend to counter this claim). See also FORS CR 165 Benefits of a frontal offset regulation.

K43 *Vehicle to Vehicle Compatibility in Real-world Accidents*

Shearlaw A & Thomas P — 1996

Proceedings of the 15th ESV

Real world accidents are reviewed to determine how structural differences contribute to injuries. The definition of "compatibility" needs to consider geometric differences in the lateral and vertical planes, as well as stiffness and mass.

K44 *Optimisation of crash pulse through frontal structural design*

Sparke L — 1996

Proceedings of the 15th ESV

The range of real life accidents and computer simulations are used to produce a front structure which will achieve an optimised crash pulse over the spectrum of collision types. Measures which apparently reduce injury risk in some situations may create an increased injury risk in other situations.

K45 *Development a frontal offset test procedure based on real-world crashes*

Stucki S, Ragland C and Hollowell W — 1998

Proceedings of the 16th ESV

Analysis of NASS and FARS data and comparison with several types of offset crash tests. "The population of interest for future safety improvements is drivers in frontal collisions with airbag restraints". "It appears that the oblique impact with over 50% overlap produces the most severe responses...". A moving deformable barrier is being evaluated.

K46 *Bullbar design for airbag equipped vehicles*

Sullivan J — 1996

Proceedings of the 15th ESV

Report on Ford's development work on its "Smartbar". Airbag deployment is assessed. The design is intended to produce similar pedestrian impact kinematics to the standard vehicle, while reducing the risk of immobilisation in the event of a high-speed impact with a large animal. Using MADYMO modelling it is claimed that pedestrian HIC and chest deceleration are similar up to imact speeds of 40km/h (details are not presented). In impact tests with a 75kg kangaroo dummy at 100km/h the Smartbar prevented the disabling damage to the vehicle which occurred with the standard vehicle.

K47 *Current research in rollover and occupant protection*

Summers S, Rains G and Wilkie D 1996

Proceedings of the 15th ESV

NHTSA's research program. Countermeasures include ejection resistant glazing, improved door latches, advanced roof crush testing, dynamic testing of restraint systems and interior padding.

K48 *Modelling of a unique frontal car structure*

Wittman W and Kriens R 1998

Proceedings of the 16th ESV

A range of frontal crashes are evaluated. Conventional frontal structures are found to be deficient if not axially loaded. A new design, incorporating cables to distribute the loads between both longitudinal members is found to produce almost the same stiffness for all overlap percentages and impact angles. (See also Wittman and Kriens 'A cable supported frontal car strucure for offset crash situations' Proceedings of the 15th ESV)

K49 *New perspectives on car crush behaviour in frontal crashes*

Wood D and O'Riordain S 1996

29th International Symposium on Automotive Technology and Automation

Crush behaviour of eight cars is analysed and several stages of crush are noted. A stiffer initial crush region can delay the onset of occupant compartment intrusion [not if it is caused by inertial effects] but care is needed to avoid increasing injury in lower severity crashes.

K50 *Compatibility requirements for cars in frontal and side impact*

Wykes N, Edwards M and Hobbs C 1998

Proceedings of the 16th ESV

Research on the extent to which compatibility might influence injury outcome. Experimental crash test research and accident analysis to examine the influence of mass, stiffness, structural interaction and geometry. An aim is to develop crash test requirements which assess compatibility.

K51 *Improved vehicle frontal protection structure for pole collisions*

Zivkovic G 1998

Proceedings of the 16th ESV

Collisions which produce concentrated loads on the vehicle are 3 times more likely to be fatal than other types of collisions. Structural modifications to better deal with this type of collision are discussed.

K52 *Contribution of vehicle defects to crashes*

Paine M 1994

Project report prepared for National Road Transport Commission

None of the published studies provide sufficient information to determine the contribution of (different types of) defects to crashes. It is evident that the (overall) contribution of defects to crashes is small [more recent work suggest between 10% and 20% causal or severit increasing]. Even though the potential savings might be small the cost of programs to reduce the number of defective vehicles can also be relatively small and the lack of good information about the contribution of defects to crashes should not be taken as an indication that roadworthiness programs are not cost-effective.

K53 *Research and development project summaries*

NHTSA 1998

NHTSA web site

Descriptions of NHTSA's current research projects on crashworthiness. Notable projects are: door latch integrity, imporved glazing, improved frontal protection, upgrade of rollover protection, child safety, upgrade fuel system integrity, seat back strength, injury mechanisms in children, neck injury, lower extremity injury, upper extremity injury from airbags, out-of-position occupants, vehicle agressivity and fleet compatibility, upgraded side crash protection, pedestrian and bicylist safety, motorcycle safety.

K54 *Road safety strategy: current problems and future options*

UK Dept of Environment, Transport and the Regi 1997

UK DETR

Outline of road safety problems in the UK. Description of current activities. Future measure:
Pedestrians - 1038 fatalities (25% of all road fatalities), EU requirements should reduce pedestrian fatalities by 10% by 2005 and 20% by 2010, if implemented by 2002. Estimated $20-30 per car. This would effectively bai (rigid metal) bullbars. Speed limit alarms in cars would help.
Bicyclist - 213 fatalities Claimed casuality rate per km is 13 times that of car occupants. Under-reporting is a problem. Could be a large increase in cycling over next few years. Helmets main measure - increasing wearin rate from 16% to 80% could save 24% of fatalities ans serious injuries. Improved vehicle braking and lighting, plus truck side guards could reduce cyclist casualities by 10% by 2010. Bells and lights could be made compulsory. Reflective clothing recommended.
Car occupants - 1749 fatalities (reductions are to car occupants casualties by 2010). NCAP (15-20%, $40-$60 per car), front-underrun guards on tru (6%, cost $200/truck), seat belt interlocks (8%, $4 per car), rear impact protection (rear structure, seats and head restraint) (slight injuries 10%), smart restraints (4-8%?), fire protection (1%).
Motorcyclists - 445 fatalities. Improved helmets (20%), leg protection (40%, $200), airbags (20%, $600), NCAP for motorcycles (25%), daytime running lights (4%)
Trucks - 597 fatalities. Stronger cabs + seat belts used (47% of truck occupant fatalities)
Buses and Coaches - 35 fatalities. No evaluated measures.
Estimated that vehicle defects contribute to 5% of all accidents.
Medical services - 17% of fatalities were judged to have been potentially preventable by more timely medical treatment.

K55 *Safety benefits of improvements in vehicle design since ANCAP*

Hendrie D, Lyle G and Haley J 2001

Proceedings of 17th ESV

Injury cost database applied to ANCAP dummy injury measurements. Significant safety benefits between 1992 and 1997. Expected injury costs by 54%. Some models showed much greater improvement.

K56 *A systems modelling method. for estimatiation of HARM*

Kuchar A 2001

Proceedings of 17th ESV

Modelling injury risk for collisions between large and small vehicles. Predic reduced stiffness of larger vehicle can reduce AIS3/4 injuries by 21%. Hig severities unaffected.

K57 *VEHICLE PROPERTIES AFFECTING AGGRESSIVITY*

LES M 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

K58 *DAYTIME RUNNING LIGHTS - A NORTH AMERICAN SUCCESS STORY*
BERGKVIST P 2001
PROCEEDINGS OF THE 17TH ESV
VEHICLE TO VEHICLE - 5% REDUCTION, PEDESTRIANS 9%. ALSO RESULTS OF OTHER STUDIES.

K59 *NHTSA'S RESEARCH PROGRAM FOR AGGRESSIVITY AND COMPATIBILITY*
SUMMERS S 2001
PROCEEDINGS OF THE 17TH ESV

K60 *EEVC RESEARCH ON COMPATIBILITY*
FAERBER E 2001
PROCEEDINGS OF THE 17TH ESV

K61 *DEVELOPMENT OF CRITERIA AND STANDARDS FOR COMPATIBILITY*
ZOBEL R 2001
PROCEEDINGS OF THE 17TH ESV

K62 *TEST PROCEDURES TO EVALUATE COMPATIBILITY*
MIZUNO K 2001
PROCEEDINGS OF THE 17TH ESV

K63 *ADVANCED ROOF DESIGN FOR ROLLOVER PROTECTION*
FRIEDMAN D 2001
PROCEEDINGS OF THE 17TH ESV

K64 *COMPARISON OF EURO NCAP RESULTS WITH FOLKSAM RATINGS*
LIE A, KULLGREN A AND TINGVALL C 2001
PROCEEDINGS OF THE 17TH ESV

K65 *COMPARISON OF EURO NCAP WITH INJURY CAUSATION IN ACCIDENTS*
FAILS A AND MUTON R 2001
PROCEEDINGS OF THE 17TH ESV

K66 *AGGRESSIVITY VARIABLES AND THEIR SENSITIVITY IN RATINGS*
LAINE V, ERNVALL T, CAMERON M AND NEW 2001
PROCEEDINGS OF THE 17TH ESV

K67 *HOW SON TO BRAKE AND HOW HARD TO BRAKE*
WILSON B 2001
PROCEEDINGS OF THE 17TH ESV

K68 *DISTANCE BEHAVIOUR ON MOTORWAYS WITH REGARD TO ACTIVE SAFTEY*
FILZEK B AND BREUER B 2001
PROCEEDINGS OF THE 17TH ESV
ADAPTIVE CRUISE CONTROL

VEHICLE SAFETY BIBLIOGRAPHY

L01 *Chest and abdominal injuries suffered by restrained occupants*

Augensten J et al 1995

Advances in Occupant Protection Technologies for the mid-1990s

Comprehensive analysis of US crash data and medical information targeting liver and spleen injuries. HARM analysis. Correlation between use of the sash portion of a seat belt without the lap portion and liver injury. Indicators of potential for liver injury for the information of rescue personnel.

L02 *Injury patterns among airbag protected occupants*

Augenstein J, Perdeck E, Williamson J, Stratton J 1998

Proceedings of the 16th ESV

Investigation of 70 cases of seriously and fatally injured motor vehicle occupants who were protected by airbags. Patterns of injury to the heart, lungs and liver have been observed.

L03 *Reduction of head rotational motions in side impacts - inflatable curtains*

Bohman K, Haland Y and Aldman B 1998

Proceedings of the 16th ESV

"Diffuse head injuries are very common in side impacts". Investigations have shown that they often originate from contact with the side window and are believed to be caused by quick head rotational motions. A test rig was developed to measure the accelerations on an Hybrid III head during impacts with the side window with and without and inflatable curtain. The curtain has the potential to substantially reduce the risk of diffuse brain injuries (peak angular acceleration was reduced by 60% or more).

L04 *Effect of seat belts and head restraints on neck injury.*

Cameron M 1981

FORS CR 19

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L05 *Effect of seat belts on minor and severe injuries...*

Cameron M 1979

FORS CR 4

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L06 *Air bag deployments in Canada*

Dalmotas D, Hurley J, German A and Digges K 1996

Proceedings of the 15th ESV

409 crashes involving airbag depolyments were studied. Data were also compared with US NASS. Airbags were found to substantially reduce the risk of serious head injury but risk of injury in moderate severity collisions increased particularly for the face and arms. Female drivers are at a higher risk of sustaining injury. "A significant improvement in the overall level of protection afforded by belted occupants by airbags could be achieved by increasing the deployment threshold". The authors suggest that frontal crash tests (regulation and/or NCAP) should include 5th percentile dummies with the seat set in the full forward position.

L07 *Aging process and safety enhancement of car occupants*

Dejeammes M and Ramet M 1996

Proceedings of the 15th ESV

Impact biomechanics in relation to the age of the occupant. Addresses some of the resarch issues associated with protection of aged occupants. Osteoporosis makes bones more vulnerable to fracture. Rib fractures from belt loading are more likely over the age of 40. Chest deflection may be an important parameter in crash tests. Abdominal injuries are more likely for car occupants aged 70 or more.

L08 *The prevention of head and neck injuries in motor vehicle crashes*

Digges KH 1994

George Washington University,

Estimated benefits, in terms of lives and serious injuries saved, are presented for a range of occupant protection measures. The concept of HARM is explained (a method of costing by the most severe injury) . Based on NASS data (and remembering that many US vehicle occupants do not wear seat belts) the distribution of HARM by body region is: head/neck 37% of severe injuries, and 51% of HARM. The components of head/neck HARM are: brain 33%, neck 5%, head 6% and face 7%. Distribution of HARM by crash type is: frontal 46%, side 34%, roll 16% and rear 3% - it is noted that 70% of HARM is suffered by unrestrained occupants. Several countermeasures are evaluated for mitigating HARM associated with head/neck injuries (these data are for restrained occupants and assume 100% effectiveness): airbags 10%, upper interior padding 9%, combined airbags and upper interior padding 18%, glazing 6% and seat design/head restraints 5%. Comments are made about the effectiveness of each countermeasure and methods of analysing potential benefits. NHTSA has estimated that fatalities could be reduced by 3% through the use of upper interior padding. Ejection resistant glazing also shows "surprisingly large opportunities for injury abatement among both restrained and unrestrained occupants".

L09 *Patterns of abdominal injury in frontal automotive crashes*

Elhagediab A and Rouhana S 1998

Proceedings of the 16th ESV

An anthropomorphic device to assess potential for abdominal injury is under development. NASS crash data between 1988 and 1994 is analyzed to identify the frequency and severity of injury to abdominal organs.

L10 *Dummy kinematics in offset frontal crashes*

Estep C and Lund A 1996

Proceedings of the 15th ESV

An evaluation of dummy kinematics in offset crash tests conducted by IIHS. Substantial differences were observed between the crash tests. Seat belt effectiveness and timing of airbag deployment were important but seat stability, door integrity and dash and steering column movement were also factors. In addition to absorbing the occupants initial kinetic energy the restraint system must continue to keep the occupant's kinematics under control during rebound.

L11 *Epidemiology of the older driver - some preliminary findings*

Evans L and Taheri B 1998

Proceedings of the 16th ESV

The study is intended to address how the risks older drivers face change as they age. The risks to other road users are also considered.

L12 *Passenger cars and occupant injury*

Fildes B, Lane J, Lenard J and Vulcan P 1991

FORS CR 95,

Literature review, third party insurance data analysis and investigation of 227 crashes. Potential countermeasures included: padded steering wheels; belt pretensioners; airbags; ADR10 to include limits on lateral and vertical movement of steering column; elimination of steering wheel; improved belt geometry; webbing clamps; improved seat design; seat belt stalk located to minimise abdominal injury; seat belt interlocks; research on webbing width and stiffness and load limiters; inflatable belts; improved energy absorption by instrument panels; fewer protrusions from instrument panel; improved knee protection; structural improvements to footwell and instrument panel; improved interior padding; improved laminated glass. There were several cases where a bullbar increased the severity of injuries to occupants of other vehicles.

L13 *Older road user crashes*

Fildes B, Corben B, Kent S, Oxley J, Le T and Ry 1994

MUARC Report 61

Mass crash data analysis and trends and literature review. Older road users appear to be over-involved in intersection crashes, particularly those with stop or give-way signs. Countermeasures include: improved protection from chest injuries; improved intersection design and improved education about the special problems encountered by older road users. The authors also point out there is a trade-off in crash and injury risk when a person ceases driving and becomes a pedestrian.

L14 *Lower limb injuries to passenger car occupants*

Fildes B, Lane J, Lenard J, Vulcan P and Wenzel 1994

FORS CR 137

501 urban crashes were investigated to determine the causes of lower leg injuries. The most frequent causes were contact between: ankle/foot and floor/toepan; lower leg and floor/toepan; knee and instrument panel; knee and steering column. 50% of lower limb fracture injuries occurred in crashes with a delta-V of 50km/h or less. Occupants of smaller cars were more at risk. Countermeasures include: more forgiving instrument panels; knee bars (bolsters); removing injurous fittings; use of less brittle materials in dashboards; innovative pedal designs and structural improvements.

L15 *Lower limb injuries to passenger car occupants*

Fildes B, Lenard J, Lane J, Vulcan P and Seyer K 1997

J. Accident Analysis and Prevention

In-depth study of 280 cases where occupants sustained lower leg injuries. More than half the cases were in crashes with a delta V less than 48km/h. Ankle dislocations and foot fractures from the floor and toe pan were the most common type of injury. The study pointed to a need for further regulation and identified several possible countermeasures.

L16 *Foot and leg injuries in frontal car collisions*

Foressell J, Jakobsson L, Lund A and Tivesten E — 1996

Proceedings of the 15th ESV

Accident data, simulations and crash tests are analysed to determine the factors involved in foot and leg injuries. Suggested countermeasures are: Geometry - make footwell as smooth and flat as possible, design lower instrument panel to reduce the chance of legs becoming jammed; Acceleration - avoid having solid objects in front of footwell, shock-absorbing design of footwell, design so feet are close the firewall (limit delta V by reducing forward movement); Pedals - place pedals as close to footwell as possible, design to avoid intrusion of brake booster unit; Intrusion - design to limit intrusion but if intrusion is unavoidable design to avoid folding and deformation that may trap feet.

L17 *Upper interior head, face and neck injury experiments*

Friedman D — 1998

Proceedings of the 16th ESV

Crash analysis and simulations were used to identify factors leading to head, face and neck injuries in rollover crashes. It was concluded that upper interior padding, in combination with modifications to existing components can substantially reduce the risk of injury.

L18 *Head restraint measuring device*

Gane J and Pedder J — 1996

Proceedings of the 15th ESV

Description of a test device used to determine the positional geometry of head restraints and developed by the Insurance Corporation of British Columbia (now used by IIHS and Australian NCAP).

L19 *Truck seat belts*

Haworth N, Bowland L, Foddy Band Elliot B — 1996

Proceedings of the 15th ESV

Interviews and surveys. "Very few drivers of articulated trucks wear seat belts". About 16% of rigid truck drivers wear seat belts "all of the time". Reasons for non-wearing are: uncomfortable, "no safety benefits", "dangerous". Improvements to the ADR have probably improved wearing rates. Further research into the benefits of seat belts in real world truck crashes is suggested. Communictations stratgies are discussed: imprved enforcement, employer lobbying, safety measure (e.g. risk of loss of control if unrestrained).

L20 *The design of car safety belts to reduce injuries*

Herbert DC — 1961

Snowy Mountains Hydro-Electric Authority Engineering

Pioneering work on the use of seat belts to reduce injuries.

L21 *Seat belt limitations in collisions with no compromise of passenger compartment*

Hill J, Mackay GM and Henderson S 1997

Occupant Protection and Injury Assessment in the Automotive Crash Enviro

Main types of injury to drivers in frontal collisions were: head to steering wheel (8%), head to other forward structure 1%, neck without contact (5% AIS2+), torso to steering wheel 3%, leg/pelvis to forward structure 13%, lower leg to footwell 6%. Passengers had similar proportions. "A major challenge, and priority, could be to provide advanced load limiting, selectively for older people, without compromising protection through increased ride-down."

L22 *Development of side impact airbag system for head and thorax protection*

Igarashi T, Uchimura T and Ehama M 1998

Proceedings of the 16th ESV

Nissan recently introduced a side airbag system which provides improved protection for the head. The system is mounted in the seat back.

L23 *Inertial seatbelt release*

James M, Allsop D, Perl T and Struble D 1993

Frontal Impact Protection: Seat Belts and Airbags,

Investigations of real-world crashes and engineering analyses indicate that inertia release is not a safety concern. The loadings are substantially different from those which cause the buckles to open in "parlor tricks". The lateral acceleration required to cause release even when the seat belt is not under tension is generally well in excess of 100g for several milliseconds. The authors note that humans are significantly softer than dummies therefore buckle decelerations resulting from dummy contact with the buckle are unlikely to be reached with a human occupant.

L24 *Injury mechanisms and field accident data in rollover accidents*

James M, Allsop D, Nordhagen R and Decker R 1997

Occupant Protection and Injury Assessment in the Automotive

US NASS/CDS data for the period 1988 to 1994 were analysed for rollover crashes. The authors found that no correlation exists between roof crush and occupant injury and there were few serious injuries associated with roof intrusion. In most cases the head is already in close proximity to the roof and "..peak neck compression loads occur prior to any substantial roof deformation.". They also point out that if head to roof contact (mainly from "vertical" occupant motion) can be eliminated by restraint systems then there could be an increased risk from lateral motion and partial ejection.

L25 *Strategies for passenger car designs to improve side impact protection*

Kanianthra J, Rains G and Trella T 1993

Strategies for Side Impact Protection,

Modelling side impacts. Injury measures such as the Thoratic Trauma Index. Effect of various countermeasures applied to several vehicle models.

L26 *Upper interior head impact protection of occupants in real world crashes*

Kanianthra J, Fan W and Rains G 1996

Proceedings of the 15th ESV

NHTSA's research program and rulemaking for interior head protection. Th additional cost, to consumers, of providing suitable padding in new vehicles is estimated to be US$33 and the cost per equivalent life saved is US$542. There is a high potential for reducing serious injuries (c.f. McLean, 1996).

L27 *Field study on the potential benefit of different side airbag systems*

Kompell K, Habert J and Mebner G 1996

Proceedings of the 15th ESV

Investigations of severe side-impact collisions involving BMW cars revealed that 75% involved head injuries. The paper discusses side airbag designs (Inflatable Tubular Structure or ITS) which protect the head in these circumstances. Design issues include: assuming that the side window is shattered so the airbag must bridge the gap, providing a system which is triggered in rollover crashes and which remains inflated for a longer period (7 seconds), provision for a variety of occupant sizes and avoiding aggressive inflation. Methods of testing side airbag systems are discussed.

L28 *Whiplash associated disorder - factors in rear-end collisions*

Krafft M. Thomas A, Nygren A, Lie A and Tingve 1996

Proceedings of the 15th ESV

A study of the relationship between seat belt geometry and neck injuries. The risk of neck injury in females is twice as high as that for males. 64% of the Swedish whiplash injuries are sustained in rear end collisions and is typically less than 20km/h delta V.

L29 *Injuries to different body regions in new and old car models*

Kullgren A, Krafft M and Tingvell C 1998

Proceedings of the 16th ESV

"The expected number of permanent dissabilities for injuries to different body regions are shown for new and old car models based on the injury outcome of real life accidents in Sweden". "For new car models there is a dramatic improvement of the dissability risk for some body regions".

L30 *The effect of airbags to injuries and accident costs*

Langwieder K, Anselm D and Redlich J 1998

Proceedings of the 16th ESV

Results of 500 crashes are presented, with emphasis on the effects of airbags. The combination of lap/sash belt and airbag reduced driver serious/fatal injuries by 40%. Early results on the effects of side airbags are also presented. Problems with unintended firings, rescues, out-of-position occupants, child restraints and intentional deactivation of airbags are discussed. Repair costs are also considered (the authors are from the German Insurance Association). Prospects for reusable airbag components and intelligent airbags are discussed.

L31 *Human tolerance to impact - the basis of design for protection*

Lowne R 1992

Interior Safety of Passenger Transport,

Mechanisms of injury to femur, knees, abdomen, chest (compression, deceleration, viscous criterion, 'blast' injury), face, skull and brain. Permanent disability (particularly brain injury) is not assessed by AIS which is an estimate of likelihood of survival. Includes performance criteria for frontal impacts: HIC 1000, neck flexion 190Nm, neck extension 57Nm, chest deflection (compression) 50mm without airbag, 65mm with airbag, chest deceleration (3ms) 60G, chest viscous criterion 1m/s, femur compression 9kN peak, 7.6kN over 10ms, tibia axial compression 8kN, tibia index 1.0 (Moment/225Nm + Compression/35.9kN).

L32 *Guidelines for car seats for improved protection against neck injuries*

Lundell B et al 1998

Proceedings of the 16th ESV

"The exact mechanism of (neck) injury has not yet been established". However, in-depth crash investigations show that a high, fixed head restraint close to the back of the head is favourable. Requirements/guidelines should address the performance of the whole seat, not just the head restraint. Results of tests of new concepts are presented.

L33 *Vehicle design and injuries sustained by female drivers*

McFadden M 1998

Proceedings of the 16th ESV

"In 1995 female drivers were 17% more likely to be seriously injured in a road crash for every kilometre travelled on Australian roads". Female driving patterns and the characterisitcs of the cars used were analysed to identify vehicle characteristics that contribute to the higher injury rate.

L34 *Smart seat belts - some population considerations*

Mackay GM 1994

Occupant Containment and Methods of Assessing Protection in the

The anthropometric characteristics of the population may vary considerably from that used in crash tests and regulations:Adult

	Height (mm)	Sitting Ht (mm)	Mass (kg)
1%ile female	1450	720	37
5%ile female	1500	750	41
95%ile male	1850	930	102
99% male	1900	960	107

In addition, observational studies have shown that the actual sitting position can be significantly closer than that of the relevant dummy (5%ile females typically 70mm closer). Obese occupants may have difficulty locating the lap portion of the seat belt across the (load bearing) iliac spines of the pelvis. Studies of crashes involving fatalities to restrained occupants indicate that the characteristics (design) of the restraint system were irrelevant in 80% of the cases, mainly due to massive intrusion. Advanced systems such as airbags could be expected to have only a small effect in those cases. Intelligent restraint systems should allow for: variable biomechanical properties; variation in body weights; different sitting positions and different crash severities. Head position relative to the steering wheel is probably the most critical parameter. particularly with smart airbags. Other design measures include: variable seat belt pretensioning; variable seat belt load-limiting; discretionary web clamps and, for airbags, variable firing threshold, inflation rates and gas volumes. Studies of side impacts indicate that 90% of lateral collisions involving AIS 3 injuries or more could be successfully detected by a sensor located in the lower quadrant of the door. Consideration should be given to seat belt pretensioning in the event of a rollover crash, although prevention of head impacts with the upper interior is unlikely. See also Mackay GM (1995) 'Smart seat belts - what they offer', Automotive Passenger Safety, IMechE, London, November 1995.

L35 *An historical perspective on impact biomechanics*

Mackay GM unda

(book source unknown - copy held by Staysafe)

Describes pioneering research on impact biomechanics and physics of crashes. It is noted that Dr John Lane from Melbourne coined the term crashworthiness in association with aircraft safety in the 1940s.

L36 *The role of the upper car interior in car occupant brain injury*

McLean AJ, Kloeden C and Farmer M 1996

Proceedings of the 15th ESV

137 accidents were investigated. There was a low number of cases where the known head impact was with a part of the car that could be padded and therefore the effects of introducing padding were difficult to determine. Subject to this precaution, it was predicted that padding would have changed the outcome in 39% of the cases of minor brain injuries, 61% of the cases of moderate brain injuries and 7% of severe brain injuries. "...there is considerable potential for reducing the severity and consequences of brain injuries by padding the upper interior of the passenger compartment."

L37 *Head and neck injuries in passenger cars: a review of the literature*

McLean A et al 1987

FORS CR 59 September 1987.

The review was undertaken to assess the potential for the reduction of the frequency and severity of head injuries in Australia. Amongst other devices, seat belt clamps and pre-tensioners were considered. It was estimated that "the increase in cost of these devices, compared to a standard inertia-reel belt system" was 1.5 times for webbing clamp and 2 times for pre-tensioners (the basis of this cost estimate is not clear from the paper). A comparison of "passive" and "active" seat belt systems is also discussed but this was based on a USA study and therefore it was not directly applicable to Australia. Air bags systems are discussed but costs and effectiveness (in terms of injury reduction) are not covered.

L38 *Protective headgear for car occupants*

McLean AJ and Kloeden C 1998

Proceedings of the 16th ESV

The likely benefits of the use of protective headgear by car occupants are evaluated. The benefits from using a soft-shell pedal cycle helmet are shown to be much greater than that previously estimated for padding the interior of the car. An energy absorbing headband which protected the forehead and sides of the head would have influenced 44% of the cases studied and this type of device is proposed as a first step to encouraging the use of protective headgear by car occupants.

L39 *New requirements and solutions on head impact protection*

Menking M 1998

Proceedings of the 16th ESV

Describes how Porsche are developing occupant protection systems to cater for NHTSA's new interior head strike requirements (FMVSS 201 Part 571). Computer simulations are used to help optimise the systems while minimising the additional space necessary for enegry aborbing materials.

L40 *Brain injury risk assessment of frontal crash test results*

Mertz H amd Irwin A 1994

Occupant Containment and Methods of

Warrendale, February 1994.
Background on the derivation of HIC.
A case is made for evaluating HIC over 15ms rather than 36ms (as in FMVSS 208). The authors were particularly concerned about the prolonged moderate decelerations produced by airbags - the HIC36 can be quite high but the risk of injury is claimed to be low.

L41 *Fitting and wearing of seat belts in Australia.*

Milne P 1985

FORS OR 2 April 1985.

Documents the history of seat belt initiatives in Australia and reviews literature on the effectiveness of wearing seat belts. One Victorian study estimated that urban drivers wearing seat belts were 30% less likely to be killed or injured than unrestrained drivers. For rural crashes the comparable figure was 22%. A brief analysis of the impact of seat belt legislation is also given.

L42 *A study of soft tissue neck injuries in the UK*

Morris A and Thomas P — 1996

Proceedings of the 15th ESV

A retrospective study of UK crashes found a the overall soft tissue neck injury ("whiplash") rate was 16%. Over 50% of these occurred in frontal crashes and 25% in side impacts. The study found no evidence of benefit from head restraints in rear crashes. The authors note that poor adjustment of head restraints might have contributed to this result. However, females who are probably in a "better" situation in terms of head restraint position sustained a higher rate of neck injury. The concept of yielding seats should be explored further. Some self-reported claims of injury could be fraudulent.

L43 *Feasibility of Occupant Protection Countermeasures*

MUARC — 1992

FORS CR 100, June 1992

Comprehensive review of a range of occupant protection countermeasures. Estimates of costs and benefits, using Harm analysis. Priority should be given to reducing vertical and lateral steering column intrusions and footwell intrusions. Key benefit/cost results were:

Countermeasure	Benefit/Cost	% Trauma Saved
1.Improved belt geometry & seat design	7.3	1.7%
2. Energy-absorbing steering wheel	3.2-16	1.9%
3. Seat belt warning device	4.1-7.2	3.4%
4. Knee Bolsters	2.9-4.3	5.3%
5. Improved lower instrument panels	1.8-18	2.6%
6. Fullsize drivers airbag (elct/mech)	1.2	14.9%
7. Webbing clamps	1.1-3.5	1.2%
8. Seat pretensioner	0.8-1.1	2.7%
9. Shoulder pretensioner	0.46	1.6%
10. Padded upper interior(see McLean 1996)	0.3-0.4	0.7%
11.Passenger airbag	0.18	2.4%
Package of 1,2,4,6,7,8 (drivers airbag)	1.4-1.6	25%
Package of 1,2,3,4,7,8 (no airbag)	2.1-3.4	17%

L44 *New restraint technologies for vehicle safety*

Nordin S and Herrmann B — 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar

Autoliv's occupant restraint research program. Effects of belt pretensioners, load limiters, "gentle" airbags, "smart" airbags, radially deploying airbags.

L45 *Effectiveness of Occupant Protection Systems and Their Use*

NHTSA 1996

NHTSA 3rd Report to Congress, December 1996.

Estimated effectiveness of airbags and seat belts in reducing the likelihood of moderate and greater injury to vehicle occupants. Key findings were: Airbags provide fatality reducing protection. In car frontal crashes (between 10 and 2 o'clock) the risk of a fatality is reduced by 19%. The risk is reduced by 11% in all crashes (estimated 1198 lives saved between 1987 and 1995). The effectiveness is similar in light trucks. For front passengers 13 and over the fatality-reducing effectiveness of a passenger airbag is 27% in purely frontal crashes (compared with 31% for a drivers airbag in these crashes). Limited data indicates that children under 13 are at a higher risk of a fatality with a passenger airbag (but investigations revealed that out of 31 cases 11 involved rear-facing child seats and 19 involved unrestrained children: only 1 case was wearing a seat belt). Lap/sash seat belts reduce the risk of an AIS2+ injury in all crashes by 49%. With the addition of a drivers airbag the effectiveness is 60%. There is an increased risk of arm injury with airbags but airbags reduce the likelihood of injury to head, neck, face, chest and abdomen and these are more likely to be life-threatening.

L46 *NHTSA's frontal offset research using different size dummies*

Park B, Morgan R, Hackney J, Lee J and Stucki S 1998

Proceedings of the 16th ESV

A series of crash tests at 60km/h into deformable barrier, 40% offset overlap. Neon, Camry and Taurus tested. 5th percentile dummy also used.

L47 *Restraint use regulations: 1993/94 exemption review*

Preece R 1994

Discussion paper issued by NSW RTA.

Covers exemptions for taxi drivers and heavy vehicle drivers ("compelling evidence to support the removal of the exemption").

L48 *Rollover ejection while wearing lap and shoulder harness*

Renfroe D 1996

Technologies for occupant protection assessment

Several cases where the retractor mechanism locked during the initial impact and then released a subsequent rollover are detailed. The author recommends that a delay mechanism (at least 10 seconds) be incorporated in the retractor design to prevent inadvertent release during a rollover crash.

L49 *Injuries sustained by older drivers in motor vehicle crashes*

Rood D 1998

Proceedings of the 16th ESV

L50 *The medical consequences of car crashes*

Siegel J and Dsichinger P 1992

DOT HS 808 156, July 1992.

Study of injuries suffered by 145 patients receiving severe injuries (ISS 16+) in crashes. A large proportion required extrication from the vehicle (mainly due to the injuries suffered). Most injuries resulted from contact with intruded structure. Brain injuries in lateral crashes were significantly assocaited with head contacts with side windows and a-pillars. Injuries to the lower extremities and pelvis were found to be especially costly due to orthopedic, plastic surgical and critical care services and also prolonged the length of stay, complicating recovery from other injuries. Countermeasures include: improved structural integrity of passenger compartment and side airbags designed to protect the head.

L51 *Head and neck injury in side impacts*

Sparke L 1996

Proceedings of the 15th ESV

"There has been a dramatic increase in brain injury in the last decade, not as a result of increased accidents, but because of increased survival". Optimisation of restraint systems in side impacts is expected to be a more difficult process than that for forntal impacts. The author cautions that evaluation of performance by a single measure, such as a regulatory crash test will not necessarily maximise community benefits - an injury cost model is more appropriate.

L52 *The optimisation of an airbag and seat belt system*

Sparke L, Hou J and Tomas J 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar,

Computer modelling of occupant restraint systems. Validation of the modelling through experimental investigations. Societal harm approach to evaluating occupant restraint systems. A 33% reduction in overall injury risk can be obtained through optimisation of the seat belt and airbag systems. The simple installation of an airbag into an existing (non-airbag) restraint system cannot guarantee the best protection for occupants in a frontal collision.

L53 *The risk of skull/brain injuries in modern cars*

Tingvell C, Lie A, Kullgren A and Krafft M 1998

Proceedings of the 16th ESV

The influence of car design, including airbags, is discussed, based on real world crashes. A risk function for skull/brain injuries based on change in velocity is presented.

L54 *Optimizing seat belt usage by interlock systems*

Turbell T et al 1996

Proceedings of the 15th ESV

Measures to improve seat belt wearing rates are discussed. Problems with the (failed) US attempt in 1973 to introduce seat belt interlocks are discussed (infringement on personal freedom, existing seat blets were uncomfortable and difficult to use, the interlock did not allow low speed driving or engine idling). Various solutions are discussed: the engine interlock (not favoured), external visual signals (lights illuminated or flash when the seat belt is not used), more "aggressive" internal warning lights/alarms, disabling air conditioner or radio, throttle pedal feedback, maximum gear level and maximum speed. At staged approach such as audible warning followed by speed limiting may be the best approach. It is pointed out that the last 10% of seat-belt non-wearers probably represents the most accident prone group and therefore the benefits of addressing this group are greater than normally expected. It is estimated that seat-belts would have saved 50% of the fatalities involving unrestrained occupants.

L55 *Evaluation of advanced side airbags for head protection*

Vaidyaraman S, Wallner J, Abraham M, Cherry R 1998

Proceedings of the 16th ESV

Lateral collisions comprise about one third of all automobile crashes. A majority of fatalities are due to injuries to the head and neck. Head/thorax side airbags and inflatable curtains are evaluated, using computer modelling and experiments.

L56 *Significance of intersection crashes for older drivers*

Viano D and Ridella S 1996

Technologies for occupant protection assessment

Older drivers are more likely to be involved in intersection collisions - a time of complex information processing and decision making.

L57 *Optimisation of an intelligent total restraint system*

Voorhies K and Narwani G 1996

Proceedings of the 15th ESV

The system is designed to take into account occupant position, weight and size, crash severity and seat belt usage in order to optimise the protection for that occupant. Two-stage airbag inflators, controllable airbag vents and controllable seat belt load-limiters, pre-tensioners and upper-anchorage mounts are included in the system.

L58 *Glazing effects of door or frame deformations in crashes, Part 2*

Yudenfriend H and Clark C 1997

Occupant Protection and Injury Assessment

Analysis of the uniformity of tempered glazing used in automotive side windows. Experimental evaluations of th effects of non-uniformity. The authors refer NHTSA conclusion that 1300 lives could be saved per year through improv glazing. The window may shatter from strain induced by impact at other locations and presents a hazard to occupants from fast-moving shattered glass. Once the window shatters occupant ejection is more likely. It is clain that BMW, Audi, Volvo, Toyota, Nissan and Honda are about to introduce laminated glazing on the side windows of some of their models. The are benefits of noise reduction and improve theft resistance v laminated glass.

L59 *The reduction of the risk of lower leg injuries in offset crash tests*

Zeilder F, Scheunert D, Breitner R and Krajewsk 1996

Proceedings of the 15th ESV

Mechanisms of lower leg injuries are discussed. "Impact shock sydrome" is presented as frequent injury caused by a small intrusion but very high intrusion velocity [this has implications for assessment lower leg injury risk by intrusion alone]. Another source of injury is the secondary impact of the foot against the footwell or pedal.

L60 *Optimized restraint systems for rear seat passengers*

Zellmer H, Luehrs S and Brueggemann K 1998

Proceedings of the 16th ESV

The standard lap/sash seat belt in rear seats can produce excessive neck moments. The authors note that airbags do not seem to be practical for rear seating positions. They investigated the benefits of seat belt pretensioners and load limiters. The resulting optimized restraint system produced acceptable dummy measurements even at crash pulses of 40g or more.

L61 *Head injury risk assessment and prevention in automobile accidents*

Ziernicki R, Jacobson O and Hamernick J 1996

29th International Symposium on Automotive Technology and Automation,

Methods of testing for head injury potential. Relationship between HIC, deceleration, impact speed and the probability of head and brain injury. A North Carolina survey of 215 drivers who experienced an airbag deployment during 1991 found: 76% consider the airbag protected them from injury "a lot", 13% "somewhat" or "a little" ; 2% considered that it increased their injury; 96% said they would want an airbag in their next car and 2% said they wouldn't.

L62 *Lower extremity loads in offset frontal crashes*

Zuby D and Farmer C 1996

Proceedings of the 15th ESV

Results of 17 offset crash tests by IIHS are evaluated to determine the effects of intrusion on lower leg injuries. "Lower extremity loads measured by crash dummies in crash tests are strongly influenced by the magnitude of intrusion in the occupant compartment".

L63 *Unexpected deaths in airbag equipped cars: case reports*

Zuppichini F, Trenchi G, Rigo C and Marigo M 1994

Advances in Occupant Restraint Technologies

Analysis of three fatalities involving airbags but no significant intrusion. The two drivers and one passenger were unrestrained and all appear to have been close to the airbag at the time of inflation. Possible injury mechanisms related to airbags are: direct loading of the inflating airbag; interposition of arms or objects between airbag and head; contact with steering wheel through airbag; secondary thoratic perforations by broken ribs; inertial loading of organs; pressure waves (hypothetical); burning form hot gases; chemical injury to hands or eyes. Causes of out-of-position movements are: short stature; unusual driving posture ("advanced driving"?); pre-impact braking; initial impact below airbag threshold; occupant leaning forward (eg adjusting radio volume); hands across steering wheel ("claxon reflex") or in front of face; stretching arms, legs or back. In the associated discussion Murray Mckay points out that, unlike medical research for new drugs, systematic evaluation of vehicle safety initiatives in actual crashes is relatively under researched and that field studies are not an integral part of the process of design and development or rulemaking. In the case of airbag injuries it is important that occupant characteristics are recorded. More research is also needed into occupant seating positions.

L64 *Neck and spinal injuries: injury outcome and crash characteristics in Aust.*

Fildes B and Vulcan P 1995

Proceedings of The Biomechanics of Neck Injury Seminar

Incidence of neck and spinal injuries in passenger car crashes in Australia Outcome of injuries in terms of treatment, rehabilitation and costs. Sources of neck and spinal injuries. Whiplash injuries. Insurance claims, mass crash data and in-depth studies were analysed. Countermeasures include roof and header rail padding (taking care not to increase the risk of the head "socketing" in the padding); front and side airbags; better designs of head restraints (subject to further research); helmets for car occupants; improved rear crumple zones; prevention of rollover crashes and prevention of head ejection.

L65 *What happens to the cervical spinal cord during neck injury?*

Bilston L 1995

Proceedings of The Biomechanics of Neck Injury Seminar

Biomechanical description of neck injury. Development of a physical model to better understand the injury mechanisms (computer modelling was foun to be too difficult at the time).

L66 *An overview of ergonomic issues in neck injury amelioration*

Svensson N 1995

Proceedings of The Biomechanics of Neck Injury Seminar

Incidence of neck injuries. Misuse of head restraints (observational survey of 2004 motorists showed widespread misuse). Countermeasures include improved rear end collision energy absorption; improved seat design and improved head restraint design. Factors such as seat back stiffness were invetsigated through computer modelling.

L67 *The measurement of neck injury risk*

Sparke L 1995

Proceedings of The Biomechanics of Neck Injury Seminar

Limitations of current test dummies in the determination of the risk of neck injury. Relationship between dummy measurements (moments and forces) and injury risk. The injury threshold for a 5th% female is about half of that for a 50th% male. Computer simulations can help to optimise restraint systems to reduce the risk of neck injury. "Neck injury resulting from car crashes is potentially a more serious problem than is currently recognised in Australia".

L68 *Neck injury severity and vehicle design*

McLean AJ 1995

Proceedings of The Biomechanics of Neck Injury Seminar

Report on research conducted in the USA during the 1970s. The study showed that there are large differences between males and females in neck injury susceptability in rear end collisions. There are also large differences associated with age.

L69 *Neck injury in children*

Brown J 1995

Proceedings of The Biomechanics of Neck Injury Seminar

Research to quantify the effects of child restraint design and adjustment on neck loads produced in child dummies. Accident investigatio suggest that the incidence of neck injury from vehicle accidents is quite low in children. No cases of serious neck injury have been reported in correctly restrained children in Australia where the child seats have a 6-point harnesses and a top tether. Preliminary results suggest that a child's neck might be more vulnerable to axial loads [than flexion]

L70 *An overview of manual lap belts in the centre rear*

Brown J 1995

Proceedings of The Lap Belt Safety Conference

Deficiencies of lap belts, compared to lap/sash belts. Injuries patterns. Pointed out that the strength requirements for child restraint anchorages provided in centre rear seats since 1977 are similar to those of an upper anchorage for a lap/sash seat belt therefore arguments that the car structure is unsuitable are unfounded.

L71 *Spinal cord injury associated with lap only seat belt usage*

Middleton J 1995

Proceedings of The Lap Belt Safety Conference

NSW has about 50 new cases of spinla cord injury resulting from vehicle accidents each year. The lap belt contributes to a localisation of forces in a region of the spinal cord that is vulnerable to injury through hyperflexion. Abdominal injuries may be difficult to diagnose due to the consequent neurological deficit [(paralysis]. Case studies show the severe injuries that may result from lap only seat belts.

L72 *A study of seat belt syndrome in the centre rear seating position*

Lane J 1995

Proceedings of The Lap Belt Safety Conference

"The weight of evidence is that lap belts provide substantial protection to car occupants, through less than 3-point lap/sahs seat belts". A specific injury - the seat belt syndrome - is associated with lap belts. Roadside observations were compared with insurance claims to calculate relative risk. The centre rear lap belt wearer has about twice the risk of a person wearing a lap/sash seat belt in an outboard rear seat and about five time the risk of a front passenger wearing a lap/sash seat belt. [this suggests deficiencies in rear seat design and rear seat restraint design]

L73 *Retrofitting of lap sah seat belts in centre rear seating positions*

Judd R 1995

Proceedings of The Lap Belt Safety Conference

Restraint system manufacturer discusses the difficulties and solutions to retrofitting lap sah seat belts to centre rear seating positions. Vehicles with rear parcel shelves provide the simplest solution.

L74 *Effectivenss of ADR69*

Morris A, Barnes J, Fildes B, Bentivegna and Se 2001

ATSB CR 199

Case controlled study of crashes with and without airbag deployments.Puzzling that deltaV with airbags less than those without. HAI per driver 60% more with no airbag. Passenger airbag effectiveness inconclusive.

L75 *Benefits of the inflatable tubular structure*

Kompass K, Digges K and Malliaris A 1998

Proceedings of 16th ESV

4.6% of the 4 million injuries sustained by car occupants in the US could be influenced by a head protecting tube or curtain. Severe injuries (AIS3+) are reduced by 49%. Minor injuries (AIS2) are reduced by 27%.

L77 *Ford focuses on safety*

Mateja J

http://cnnfn.cnn.com/2001/09/24/home_auto/q_fordsafety_krt/

L78 *VEHICLE OCCUPANT SURVEY 1994*

RTA NSW 1994

RTA UNPUBLISHED DATA

SEATING POSITION
DRV 66%, MID-FRONT 0.3%, NS FRONT 21.8%,
OS REAR 4.3%, MID REAR 2.3%, NS REAR 4.9%,
THIRD ROW 0.2%
VEHICLE TYPE: CAR 83%, TAXI 2.6%, VAN 14.3%
NUMBER OF OCCUPANTS: 1-66%, 2-24%, 3-7%, 4-2%

L79 *EFFECTIVENESS OF AIRBAGS IN AUSTRALIA*

BARNES J 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

L80 *SAFETY BENEFITS RESULTING FROM VEHICLE DESIGN CHANGES SINCE THE INTRO OF A*

HENDRIE D 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

L81 *NARROW OBJECT CRASHES AND INJURY OUTCOMES*

MORRIS A 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

L82 *TIMBER POLE CRASHES*

GRZEBIETA R 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

L83 *EFFECT OF OCCUPANT CHARACTERISTICS IN INJURY RISK - ACTIVE RESTRAINTS*

MCCARTHY 2001

PROCEEDINGS OF THE 17TH ESV

L84 *PRELIMINARY EVALUATION OF PASSENGER AIRBAG EFFECTIVENESS IN AUSTRALIA*

MORRIS A, BARNE J AND FILDES B 2001

PROCEEDINGS OF THE 17TH ESV

INCONCLUSIVE

L85 *FACTORS INFLUENCING LOWER EXTREMITY INJURIES*

HESSE S 2001

PROCEEDINGS OF THE 17TH ESV

FOOTWELL AND PEDAL INTRUSION MAIN FACTORS. AIRBAG AND BOLSTER HELP IN MORE SEVERE CRASHES.

L86 *EFFECTIVENESS OF (DRIVER) AIRBAGS IN AUSTRALIA*

MORRIS A, BARNES J AND FILDES B 2001

PROCEEDINGS OF THE 17TH ESV

HARM 60% GREATER WITHOUT AIRBAGS

L87 *SIDE AIRBAGS: BENEFITS AND RISKS FOR CHILDREN*

TYLKO S 2001

PROCEEDINGS OF THE 17TH ESV

SOME PROTECTION. NO HAZARDS IF CORRECTLY SEATED.

L88 *CRASH AND FIELD PERFORMANCE OF SIDE AIRBAGS*

DIAMOTAS D 2001

PROCEEDINGS OF THE 17TH ESV

CURTAINS ALOS EFFECTIVE FOR SUV INTO CAR SIDE IMPACTS.

L89 *COMPARISON OF EURONCAP ASSESSMENTS WITH INJURY CAUSATION IN ACCIDENTS*

FAILS A AND MINTON R 2001

PROCEEDINGS OF THE 17TH ESV

GOOD AGGREEMENT. HEAD EJECTION IN SIDE IMPACT NEEDS MORE WORK.

L90 *STEERING COLUMN MOVEMENT IN SEVERE FRONTAL CRASHES - EFFECT ON AIRBAG*

ZUBY D AND ONEILL B 2001

PROCEEDINGS OF THE 17TH ESV

REGULATIONS THAT LIMIT STR COL MOVEMENT IN OFFSET TEST DESIRABLE

L91 *LOWER EXTREMITY INJURIES AND ASSOCIATED INJURY CRITERIA*

KUPPA 2001

PROCEEDINGS OF THE 17TH ESV

INJURY RISK FUNCTIONS. FUNCTIONAL LOSS ISSUES

CATEGORY M Child restraints

M01 *Risk of death among child passengers in front and rear seating positions*

Braver E, Whitfield R and Ferguson S 1997

Proceedings of the 2nd Child Occupant Protection Symposium,

Data from the US FARS are analysed to determine impact severity, direction of impact and other factors. "Children are at significantly lower risk of dying in rear seats of passenger vehicles whether or not these vehicles are equipped with a [front] passenger airbag... Children were at a lower risk in rear centre than rear outboard positions".

M02 *A comparison of anchorage systems for child restraints in side impacts*

Brown J, Kelly P and Griffiths M 1997

Proceedings of the 2nd Child Occupant Protection Symposium

Three child restraint sytems were subjected to side impact tests. The systems were CAUSFIX (two rigid lower anchorages and top tether), UCRA (flexible lower anchorages with and without top tether) and "conventional" Australian (adult belt and top tether). The CAUSFIX system performed best. The UCRA system performed well with top tether but poorly without the top tether. The authors point out that it is important to analyse the kinematics of the dummy in addition to measuring head excursion and deceleration because the head may come close to potentially injurous surfaces without showing up in the measurements. Concern is expressed that spacing the the lower anchorage in the ISOFIX system would not allow the installation of three child restraints in the rear of most vehicles.

M03 *Universal anchorage systems for child restraint devices*

Brown J and Kelly P 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar

Review of the progress in the development of an international standard for child restraints. Compares rigid (ISOFIX) and conventional child restraint anchorage systems. The latest concensus involves two rigid lower anchorages and provision for an optional top tether. This will provide a significant countermeasure to misuse (a problem when adult seat belts are used for restraining the device) and it will improve side impact protection. The authors are concerned that the spacing of the ISOFIX anchorage will preclude the installation of three child restraints across the rear seat.

M04 *Passive security for wheel-chair users travelling in motor vehicles*

Cordes J, Burger H and Schrimpf H 1998

Proceedings of the 16th ESV

Requirements for wheel-chair restraint systems are markedly less than those applying to passenger car restraint systems. Possible safety improvements are discussed. An "impact cushion" which is secured by a lap belt is evaluated. Force limiting devices on the wheel-chair restraint system also increase safety for the occupant.

M05 *Use and misuse of child restraint devices in Michigan*

Eby D and Kostyniuk L 1998

Proceedings of the 16th ESV

A statewide direct observation study of child restraint use and misuse, including random-sample driver interviews at day care centres. 75% of children under 4 years of age used child restraints, but this reduced to 51% if the driver was unbelted. 87 driver interviews were conducted. 97% believed that the child restraint was correctly installed and used. 71% learned how to install the device by reading the manufacturers instructions but none used this information in learning how to secure the child in the restraint bacuse it was "obvious". The overall misuse rate was 89% (vehicle containing at least one incorrectly installed or incorrectly used restraint). Errors in placing the child in the seat were more common than installing the restraint in the vehicle. Most common problems were slack in the adjustment for the child or attachment of the restraint to the vehicle.

M06 *Child restraint device use and misuse in Michigan*

Eby D, Kostyniuk L and Christoff C 1997

University of Michigan Transportation Research Unit

Detailed report on the project summarised in the ESV paper. See also UMTRI Research Review April-June 1997, Vol 28, No

M07 *Optimisation of the wheelchair tiedown and occupant restraint system*

Gu J and Roy P 1996

Proceedings of the 15th ESV

Tests of restraint systems built to proposed ISO standards. It was concluded that b-pillar mounted restraints offer superior protection to floor-mounted restraints.

M08 *Children in car crashes*

Henderson M — 1994

Child Accident Prevention Foundation of Australia (CAPFA now Kidsafe).

An in-depth study of car crashes in which child occupants were injured. The study covered 247 children in 131 vehicles. Intrusion, collapsing seats, broken glass and loose objects were found to be the most likely causes of injury to properly restrained children. For infant capsules the advantages of the move from body bands to harnesses was confirmed. Properly used forward-facing child seats provided exceptionally good protection and no significant neck injury, even in severe crashes. The one child seat fatality was a case of gross misuse. Performance of booster seats was found to be good, except where mis-used with a lap belt only (the only booster seat fatality). Adult lap/sash seat belts were found to provide good protection for children, even in high speed crashes and neck injury was not found to be a problem. The problem of the lack of a lap/sash seat belt in the centre-rear seat of most vehicles was noted - lap only seat belts were found to be an incomplete restraint with significantly greater incidence of abdominal injuries. Four-wheel-drives and passenger vans comprised a high proportion of the vehicles in the study.

M09 *Adult seat belts:how safe are they for children?*

Henderson M, Brown J and Griffiths M — 1996

Proceedings of the 15th ESV

The CAPFA study (see above) recorded 121 cases of children wearing lap-sah seat belts and 35 cases of children waering lap only seat belts. Sled tests were conducted to simulate some of the crashes. "To obtain maximum protection, children should be restrained in dedictaed child seat, or adult seat belts with booster seats, until they are of a size appropriate to use adults belts. However, field data... show that (children) were generally well protected (by adult lap/shoulder seat belts) even in severe frontal crashes and none sustained belt-induced inertial neck injury...Lap-belted children sustained a higher proportion of abdominal injuries and a similar proportion of head injuries despite almost all being seated in the centre position...". "...adult lap/shoulder belts do not present a significant risk of severe injury to young children".

M10 *Injuries to restrained children*

Henderson M, Brown J and Paine M — 1994

Proceedings of the 38th Annual AAAM.

Analysis of the cases from the CAPFA Study where there was injury to children in child restraints or booster seats. When properly fitted and adjusted these devcies worked exceptional well, even in crashes regarded as "unsurvivable" for adult occupants. The principal threats are from impact intrusion, collapsing seats, broken glass and loose objects.

M11 *Children in adult seat belts and child harnesses: crash sled comparisons*

Henderson M, Brown J and Griffiths M 1997

Proceedings of the 2nd Child Occupant Protection Symposium,

Three types of restraint system were evaluated adult lap/sash, lap only and lap belt with child harness. Three child dummies (18months, 3 years and 6 years) were used. The results of an in-depth field study indicated that, while a dedicated child seat offerred the best protection, adult lap/sash belts provide acceptable protection, even in severe crashes. The sled test results confirmed this observation: the lap/sash belt minimised head excursion and risk of head and abdominal injury and there was nothing in the results to suggest that the lap/sash system increases the risk of neck injury compared to the lap only seat belt. The addition of a harness to a lap seat belt reduces head excursion but increases neck forces and head accelerations, compared with a lap/sash seat belt. Also the harness tends to pull the lap belt upwards - increasing the risk of submarining. The 18 month dummy was not well restrained in by either the lap/sash or lap only seat belts - this emphasises the importance of using child seats up to at least two years of age.

M12 *Injury risks, misuse rates and the effects depending child restraint system*

Hummel Th, Lanwieder K, Finkbeiner F and Hell 1997

Proceedings of the 2nd Child Occupant Protection Symposium

Real world accident data covering 593 restrained children in car crashes was analysed. It was found that the frequency of injury and risk of severe injury were significantly higher when the children were restrained solely by an adult seat belt. "Misuse" was observed in 63% of the cases were installation of child restraints was observed and serious misuse was observed in one third of all cases. Sled tests confirmed that misuse can substantially reduce the protection provided by the restraint. The ISOFIX system displayed a decisive improvement in the number of mistakes made during installation. "ISOFIX" appears to be a central element in the improvement of future child restraint systems".

M13 *Trends and effects of child restraint systems based on Volvo's Database*

Isaksson-Hellman I, Jakobsson L, Gustafsson C 1997

Proceedings of the 2nd Child Occupant Protection Symposium

Rearward facing child restraints were found to be especially effective, with a calculated injury reducing effect of 96% (compared with no restraint?). The findings for other systems were 77% for booster seats with adult belts and 59% for adult seat belts alone. Forward-facing child seats were not evaluated (uncommon in Sweden?).

M14 *Child restraint evaluation program*

Kelly P et al 1996

Proceedings of the 15th ESV

Background and initial results of a consumer testing program for child restraints available in Australia.

M15 *Crash tests with forward facing child restraints & passenger airbags*

Krafft M, Kullgren A, Malm S and Ydenius A 1998

Proceedings of the 16th ESV

Crash tests show there is a large injury risk for forward facing systems in front of a passenger airbag in a collision with pre-impact braking (note the child restraints are unlikely to have had top tethers and therefore the adult interia reel seat belt might have allowed excessive forward movement of the cild restraint).

M16 *Side impact to children in cars - accident analysis and safety tests*

Langwieder K, Hell W, Lowne R and Huijskens C 1996

Proceedings of the 15th ESV

Comprehensive report of research into side impacts involving child restraints. Severe and fatal injuries were found to be overrepresented in lateral collisions. Head contact against the child restraint or inner door structure was important. A sled test needs to simulate a 50km/h side impact and must reproduce door intrusion. Forward movement of the head in pre-impact braking may contribute to injuries in the case of

M17 *Towards improved infant restraint system requirements*

Legault F, Stewart D and Dance M 1998

Proceedings of the 16th ESV

Crash data files and crash tests were conducted to compare the protection provided by different devices at various ages. "Infants and young toddlers are provided with a higher level of saftey when restrained by in a rear-facing infant restraint system as long as possible rather than not being restrained, being restrained in a forward facing restraint or restrained by a seat belt".

M18 *A comparison of the performance of child restraint attachment systems*

Lowne R, Roy P and Paton I 1997

Proceedings of the 2nd Child Occupant Protection Symposium

Five types of child restraint systems were subjected to user trials and dynamic tests. The systems were: A-rigid four point ISOFIX, B-rigid two points with top tether, B'-rigid two points with a device that pushes the restraint against the seat back (pre-tensioning), C-flexible lower attachments and top tether (similar to Australian system) and a "conventional" British installation using only the adult seat belt. The conventional system was more likely to be incorrectly fitted than the other systems and performed worst overall in the front impact dynamic tests. Scheme A provided the least head excursion (desirable), followed by B, C and B'. B' was little different to the conventional system. The systems with rigid attachments performed much better in the side impacts. Scheme C (flexible lower attachments) produced greater head displacement and chest deceleration than the conventional system. Schemes B' and C were particularly sensitive to slack in the top tether. With more than 25mm slack in the top tether Scheme C deteriorated to greater head displacement than the conventional system in both the front and side impacts. The importance of eliminatig slack in the top tether is emphasised.

M19 *Child restraint tether straps - increasing safety for children*

Lumley M 1997

Proceedings of the 2nd Child Occupant Protection Symposium

Four child restraint systems were tested according to FMVSS213 to asses the effect of the top tether and slack in the top tether. It was concluded that the addition of a top tether provided a substantial reduction in head excursion in child restraints which normally comply with FMVSS213 and HIC tends to be lower. A top tether can reduce the disadvantages of not tightening the adult seat belt correctly. Retro-fitting of top tethers to child restraints in the USA is recommended. It is also noted that the FMVSS test requirements that the adult seat belt be tightened to 60N is unrealistic - finger tight (20N) would be more appropriate.

M20 *Australian child restraints lead the world*

Lumley M 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar,

Review of the history of child restraint development in Australia. International developments. Benefits of the top tether.

M21 *The frontal impact performance of ISOFIX child restraint systems*

Paton I, Roy P and Roberts A 1996

Proceedings of the 15th ESV

A series of sled impact tests were conducted to assess the performance of ISOFIX and CANFIX (with top tether) child restraints. The CANFIX system, comlete with properly adjusted top tether, provided a level of performance similar to the ISOFIX system when tested to ECE R44 02 in a frontal impact. The authors point out the importance of top tether use and adjustment.

M22 *Development of a sled side impact test for child restraint systems*

Paton I and Roy P 1998

Proceedings of the 16th ESV

The Australian/NZ standards test does not include the effects of intrusion. The authors conducted a (TRL) research program in a (partially successful) attempt to reproduce intrusion effects.

M23 *Usability trials of alternative child restraint attachment systems*

Pedder J, Gane J, Pasco D, Deibert M and Lumley 1997

Proceedings of the 2nd Child Occupant Protection Symposium

Five systems were evaluated in user trials: The "conventional" Australian system using adult seat belts and a top tether, ISOFIX with four "rigid" attachment points, CAUSFIX with two "rigid" lower attachment points and a top tether, UCRA with two lower webbing attachments and a top tether and a development of the UCRA system. The conventional system was found to be most likely to be misused and the "rigid" systems were found to be best overall. CAUSFIX and UCRA were the systems preferred by most participants but the ISOFIX attachments were used without difficulty (contrary to concerns of some vehicle manufacturers). Simple pictograms were found to be adequate for informing users about the installation of each type of restraint system.

M24 *Effect of harness mounting location on child restraint performance'*

Sampson D, Lozzi A, Kelly P and Brown J 1996

Proceedings of the 15th ESV

Sled tests to determine the effects of using different harness slot positions. The optimum mounting height is level with the child's shoulders. If this is not possible then the next higher slot should be used. The Australian Standard should require that the highest slot be no lower than the average shoulder height of the oldest users for which the restraint is intended.

M25 *Evaluation of aftermarket devices to reposition shoulder belts*

Sullivan L and Chambers F 1996

Proceedings of the 15th ESV

Sled tests on 3 brands of aftermarket devices for improving the fit of the sash portion of a seat belt when worn by small adults or children. "All of the devices evaluated in this study produced some degradation in the performance of the lap/shoulder belt system as compared to baseline conditions...". The authors note that the 1994 amendments to FMVSS 208 to improve seat belt fit and comfort should reduce demand for these devices.

M26 *A comprehensive surveillance system for child occupant protection*

Winston F et al 1998

Proceedings of the 16th ESV

Limitations of current crash databases are described. A new system which utilises insurance claim settlements has been developed in Philadelphia. Telephone surveys follow up on notifications and some crash investigations are conducted. MADYMO modelling is used to simulate some crashes and to determine the possible effects of changes to the restraint system.

M27 *Airbags - Consumer information on airbag on-off switches*

NHTSA 1998

NHTSA web site

Description of the US policy and procedures concerning passenger airbag switches.

M28 *Lap-only seat belts: findings from the CAPFA study*

Henderson M 1995

Proceedings of The Lap Belt Safety Conference

Of the 247 cases in the CAPFA STudy 35 children used a lap-only seat belt and one used a lap-only seat belt in conjunction with a booster seat. "The lap seat belt is an incomplete restraint - to be used only when no better system is available. There was significantly greater incidence of belt-induced abdominal injury among lap-belt wearers than lap/sash users". Incidence of head injuries were similar despite that reduced likelihood of head contacts in the centre rear seat. A mechanism of fatal injury was found to be axial tension in the spinal cord due to the deceleration forces when the body was flexed over the seat belt, combined with relatively insignificant head contact. This occurred with one lap-seat belt wearer and the case of the lap seat belt with booster seat - which was considered to be a dangerous combination

M29 *Seat belt and child restraint usage - 1993*

Roads and Traffic Authority of NSW 1992

Research Note 16/94

Regular report on observational surveys of seat belt usage in NSW.
In an unpublished report, Michael Paine conducted further analysis of the data to examine trends with child occupants. Key results were:
Total of 30,842 occupnats in 20411 vehicles. 9.1% of VEHICLES had at least one child on board. 13% had at least one rear seat occupant.
Of the 16802 CARS, 12.5% had at least one rear seat occupant, 0.9% had three occupants in the rear seat and 9.6% had a child onboard.
Of the 1614 CARS WITH CHILREN ONBOARD: 80% had at least one child in
the rear seat, 62% had an infant on board and 2.3% had two infants and one other rear seat occupant [implications for ISOFIX proposal].
For comparison, for the 110 cars in the CAPFA Study: 86% had at least on child in the rear seat, 52% had an infant onboard, 4% had two infants and other occupant in the rear seat.

M30 *CHILD INJURY TOLERANCE THROUGH CASE RECONSTRUCTION*

HAGEDORN A 2001

PROCEEDINGS OF THE 17TH ESV

3 CASE STUDIES.

M31 *INFLUENCE OF REAR (LUGGAGE) LOADING ON CHILD RESTRAINTS*

CLAIRE M 2001

PROCEEDINGS OF THE 17TH ESV

EXCESSIVE EXCURSION A PROBLEM

M32 *CHILD RESTRAINT SYSTEMS - CREST RESULTS*

XAVIER T AND SCHROOTEN M 2001

PROCEEDINGS OF THE 17TH ESV

TNO P SERIES NOT BIOFIDELIC, NOT ABLE TO EVALUATE PROTECTION IN DETAIL

M33 *Crash protection for child passengers: a review of best practice*

Weber, K 2000

UMTRI Research Review, Vol. 31, No. 3,

Comprehensive reivew of child restraint issues. Supportive of Australian practices.

CATEGORY N Pedestrians

N01 *The school bus crossing control arm:an evaluation*

Adams A and Paine M 1997

Research report for the NSW Department of Transport.

Accident statistics involving school buses, objectives of the crossing control arm, application to NSW, on-road observations of children near school buses (without a crossing control arm), closed-road observations of children near a bus with a crossing control arm. It was found that the NSW situation was very different to that in the USA where, in many states, motorists are supposed to stop for a stationery school bus. The crossing control arm may introduce additional dangers in the NSW situation where children are taught to "wait, watch, walk".

N02 *Benefits from changes in vehicle exterior design - in Europe*

Ashton S and Mackay G M 1983

Pedestrian Impact Injury and Assessment

Patterns of injury in real world crashes. Design measures to reduce injury are discussed. "If vehicles were designed such that there were no [severe] vehicle contact head, pelvis and leg injuries at impact speeds below 40km/h then there would be a reduction of about one thrid in the number of pedestrians seriously injured when struck by the front of a car. Arguably, the benefits from [pedestrian friendly] car exterior designs are equal to or greater than the benefits from the provision of passive restraints for occupants". See also Ashton S (1982) 'Vehicle design and pedestrian injuries', Pedestrians Accidents, John Wiley & Sons.

N03 *Vehicle engineering to protect vulnerable road users*

Bly P 1991

The Vulnerable Road User, International Conference on Traffic Safety

"Careful design of the front of cars can greatly reduce injuries caused to pedestrians they may hit. The requirements need not ne very restrictive of styling and need not add significantly to overall cost". "Safer car fronts and truck under-run guards protect other road users: they do not benefit the vehicle owner, who has little incentive to purchase them...the way forward seems to require regulation..."

N04 *Risk and safety on the roads: the older pedestrian*

Clark T, Packham D, Salter D and Silcock D 1995

AA Foundation for Road Safety Research

33% of British road fatalities are pedestrians. 50% of these are people aged 60 or more. Accidents involving older pedestrians are more likely when the pedestrian is on the far side of the road - an indication that faulty judgement of the speed and distance of approaching vehicles is a factor (most of these accidents occurred in daylight during fine weather and women were at higher risk). However, a laboratory study found the relative speed judgement of older people was no worse than a control group.

N05 *The practicalities of engineering cars for pedestrian protection*

Clemo K, Davies R and Keys S 1998

Proceedings of the 16th ESV

MIRA has carried out many tests to the EEVC pedestrian impact procedures. "It appears that cars will need to undergo profound changes in design to meet the required standard" [compare this conclusion with Lawrence below].

N06 *Injury pattern of pedestrians hit by cars of recent design*

Foret-Bruno J, Faverjon G and Le Coz J 1998

Proceedings of the 16th ESV

929 cases of car and pedestrian collisions were evaluated. "At the same impact speed, injury frequencies related to every body area are statistically lower, compared to those found for cars designed in the 70s".

N07 *An analysis of head injuries in real world pedestrian accidents*

Greetham and Guenther D 1983

Pedestrian Impact Injury and Assessment

1042 pedestrian accidents investigated. Elderly pedestrian were found to be at a much higher risk of receiving severe injuries (AIS4+) at impact speeds above 33km/h (persons over 60 had 2.5 times the risk of younger people, including children) or when impacting stiff structures. Severe injuries were more often caused by vehicle contacts than ground contacts (20% of vehicle contacts were AIS4+ compared with only 7% of ground contacts).

N08 *Analysis of circumstances and injuries in 217 pedestrian fatalities*

Harruff R, Avery A and Alter-Pandya A 1998

Accident Analysis and Prevention

Retrospective analysis of fatal pedestrian accidents over a six year period. Proportions of fatal injuries (not cumulative): head 73%, torso 51%, extremities 30%. A related study found that pick-up trucks were over-represented in pedestrian fatality statistics. [Based on limited information such as speed zoning] the authors concluded that vehicle speed alone was a poor predictor of extent of pedestrian injuries. Elderly pedestrians were most vulnerable.

N09 *Update on Pedestrian Crash Data Study*

Isenberg R and Chidester A 1998

Proceedings of the 16th ESV

Results of more than 200 pedestrian collisions are presented. Vehicle/pedestrian interaction, injuries, physical characteristics and avoidance actions are analysed. See also 15th ESV.

N10 *EEVC test methods to evaluate pedestrian protection*

Jansenn E 1996

Proceedings of the 15th ESV

Comprehensive report on the EEVC-developed tests: legform to bumper, upper legform to bonnet leading edge and headform to bonnet top. "Test programs on current cars have shown that it is technical feasible to fulfil the requirements...with new car designs". The requirements should be extended to cover aftermarket bullbars.

N11 *Pedestrian injury - analysis of the PCDS field collision data*

Jarrett K, Reynolds D and Saul R 1998

Proceedings of the 16th ESV

The Pedestrian Crash Data Study (PCDS) is collecting data about pedestrian collisions in the US. Analysis covers age, impact speed, injured body region and vehicle components which caused injury. Changes in injury patterns over the past 20 years are noted. Societal costs of pedestrian injuries are presented.

N12 *Pedestrian safety testing using the EEVC pedestrian impactors*

Lawrence G and Hardy B 1998

Proceedings of the 16th ESV

Report of TRL tested conducted in accordance with EEVC procedures - mainly under Euro-NCAP. "...solutions to the problem of achieving better pedestrian safety are often readily available, low cost and could be applied over a higher proportion of the car surface".

N13 *Accidents to young pedestrians*

Lawson S 1990

Birmingham City Council.

Analysis of 2470 accidents involving young pedestrians (19 and under) in the Birmingham area between 1985 and 1988. 11 of the 30 fatalities to children 9 or under were immediately outside their home. Only 10% were at locations where they were crossing for the first time. One third of all child pedestrian casualties were on a trip to or from school and 25% were going to or from shops. 20% or all casualties were in hospital for more than a month. 1.6% received severe disability and 16.4% had some residual dysfunction. 66% of drivers had regularly driven through the site (50% were returning home from work!). 20% of the pedestrians admitted they did not look for traffic before stepping out and 50% said they did not see the vehicle before the accident. 33% of drivers said they had no time to take avoidance action. 42% of drivers said that a parked vehicle or other obstruction prevented them from seeing the pedestrian.

N14 *Application of ITS to enhance vehicle safety for elderly and disabled*

Ling Suen S and Mitchell C 1998

Proceedings of the 16th ESV

Driver/occupants aids are "mayday" systems, night vision enhancement, obstacle detection and navigation/traffic information systems. Pedestrians could be assisted by people detectors at signal controlled crossings - these detect slow-moving pedestrians and extend the signal phase. "Insufficient effort is being made to ensure that ITS equipment is easy for elderly and disabled people to use".

N15 *Pedestrian safety*

McFadden M 1996

Proceedings of the 15th ESV

Analysis of 350 pedestrian fatalities in Australia during 1992. 66% had serious (severe?) head injuries, 47% had serious chest injuries. 74% were considered primarily responsible for the accident. Alcohol was a factor in 30% of the cases. 10% emerged from behind parked vehicles (on the same side of the side). 85% occurred in built-up areas and 66% were in areas with a speed limit of 60km/h or less. 26% were in "residential" streets. "It is probable that bullbars are involved in 20% of pedestrian fatalities". In 42% of cases there was no braking or swerving prior to impact. A further 12% were unknown, suggesting that no avoidance action is taken by the driver in about half of all pedestrian fatalities. 40% of fatally injured pedestrians were over the age of 60 years.

N16 *Bumper structure for pedestrian protection*

Nagatomi K, Akiyama A and Kobayashi T 1996

Proceedings of the 15th ESV

Honda's research into the use of a readily-crushable bumper to reduce injuries to pedestrians. Dummy tests were used to confirm the simulations.

N17 *Injury causing parts and influence parameters in pedestrian accidents'*

Otte D 1998

Proceedings of the 16th ESV

760 cases of car pedestrian collisions were analysed. 81% were at impact speeds up to 40km/h. Many of the severe head injuries occur at speeds of more than 40km/h. "Current model cars have a lower injury severity risk for head, thorax and lower extremities compared with older models". The EEVC pedestrian impact test procedure is discussed.

N18 *Towards a pedestrian-friendly bonnet*

Otubushin A and Green J 1998

Proceedings of the 16th ESV

Approximately 60% of pedestrian head strikes to vehicle front structures are to the bonnet. Bonnet design has the potential to reduce the severity of the resulting head injuries. A series of headform impacts to the bonnets of 7 European vehicles was conducted.

N19 *Evaluation of school bus signalling systems*

Paine M and Fisher A 1995

Research report for NSW Department of Transport.

Field evaluation of several school bus signalling systems, analysis of signal range requirements (for motorists to be given sufficient warning in order to slow down), visual ergonomics of flashing signal lights, specification of signal requirments, comparison with the systems evaluated in the field. High-intensity fixed-beam "wig-wag" lights at the front and rear were found be the best of the evaluated systems.

N20 *Flashing lights on school buses*

Paine M and Fisher A 1996

Proceedings of 15th ESV

Based on the research report for the NSW Department of Transport (see above). Bright, high-mounted, fixed beam lights have the advantage that the signals are highly visible from 250m away but approaching drivers ride under the beam (move into a lower intensity portion) as they get closer to the bus . Copy on the World Wide Web: http://www1.tpgi.com.au/users/mpaine/buslight.html

N21 *Pedestrian head impact testing at the University of Adelaide*

Streeter L, Anderson R, McLean J and Garrett M 1998

Proceedings of the 16th ESV

A free-flight headform launcher is being used to reconstruct actual pedestrian/vehicle impacts.

N22 *The risk of injuries to pedestrians for different car models*

Tingvell C, Lie A, Kullgren A, Krafft M 1998

Proceedings of the 16th ESV

Real world accidents with pedestrians were studied in relation to car mode

N23 *Dart out accidents involving young pedestrians*

Vaughan R 1997

Proceedings of Accident Invetsigation, Reconstruction, Interpretation

Accident statistics are presented.
The maximum safe travelling speed is shown to be less than 10km/h for four scenarios. "Strategies for avoiding young pedestrian emerging collisions by lowering speed limits are unlikely to succeed, although injury severity will be reduced". This is a rather pessimistic analysis.

N24 *Realization of pedestrian protection measures on cars*

Wollert W, Blodorn J, Appel H and Kuhnel A 1983

Pedestrian Impact Injury and Assessment

A description of the "pedestrian friendly" features of the UNI_CAR experimental safety vehicle: a low, long gently inclined front end with a smooth surface rounded off in all directions; energy absorbing front and bonnet; marked withdrawal (contours?) of the roof edges and sides and steeply raked windscreen [many of these features are now appearing in modern car designs - but mainly for aerodynamic purposes]. Includes a graph of HIC vs head impact velocity for impacts with the bonnet - it was found that the HIC stayed below 1000 up to impact speeds of about 14m/s (50km/h) and then climbed rapidly above 1000. Also at speeds above about 10m/s the head impact speed (to bonnet) was similar to the collision velocity (ie speed of the car).

N25 *Computer simulation system for car-pedestrian accident*

Yoshida S 1998

Proceedings of the 16th ESV

A simulation system was developed by Honda to predict whole body pedestrian dynamic behaviour and the influence of car shape and structure.

N26 *AUSTRALIA'S INVOLVEMENT IN IHRA PEDESTRIAN SAFETY*

ANDERSON R 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

N27 *YOUNG PEDESTRIANS AND REVERSING MOTOR VEHICLES*

PAINE M AND HENDERSON M 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

N28 *PEDESTRIAN INJURY PROJECTION IN AUSTRALIA IF VEHICLES ACHIEVE HIGH STAR RATIN*

COXON C 2001

PROCEEDINGS OF THE 17TH ESV

NO ESTIMATE OF EFFECTIVENESS

N29 *SUMMARY OF IHRA PEDESTRIAN SAFETY WG*

MIZUNO Y 2001

PROCEEDINGS OF THE 17TH ESV

MAKING CARS 'SAFE' AT 40km/h REDUCES FATALS BY 35% AND SERIOUS BY 19%

N30 *EVALUATION OF PEDESTRIAN AIRBAG THROUGH MODELLING AND TESTING*

HOLDING P 2001

PROCEEDINGS OF THE 17TH ESV

CATEGORY O Motorcycles and bicycles

O01 *New developments in retrospective data banks of accidents*

Anselm D and Langwieder K 1998

Proceedings of the 16th ESV

The German Insurance Association (GDV) accident database is described. It includes details on 600 motorcycle/car crashes, including crash characteristics and injury patterns.

O02 *Analysis of the passive safety of motorcycles*

Berg F, Niewohner W, Schmitt B, Eppla J and Bu 1998

Proceedings of the 16th ESV

216 motorcycle accidents were analysed. Collision characteristics, injuries and causes of injuries are described. Pointers are given toward possibilities for improvements.

O03 *Collision dynamics and injury causation in motorcycle accidents*

Careme L 1990

Rider-passenger Protection in Motorcycle Collisions

In depth study of 23 motorcycle crashes involving AIS4+ injuries to neck and chest. The most severe injuries resulted during impacts where the rear wheel of the motorcycle lifted during impact and the rider was pitched forward. The concept of an energy absorbing structure which resisted this pitch motion was proposed.

O04 *Development and testing of a motorcycle airbag restraint system*

Chin B, Okello J, McDonough P and Grose G 1996

Proceedings of the 15th ESV

TRL simulations and tests of a specially designed airbag system for a (large) Norton Commander motorcycle. The system was found to fully restrain the rider during the sled tests and neck loads were significantly less than published tolerance values.

O05 *Motorcycle and bicycle protective helmets*

Corner J, Whitney C, O'Rouke N and Morgan D 1987

FORS CR 55, May 1987.

Post-crash investigation of 329 motorcycle and bicycle accidents. Of the unhelmeted bicyclists who received severe head injuries 40% would definately have had an improved outcome if a substantial helmet had been worn. Laboratory simulations of impacts and sliding motions. It was concluded that the Australian Standards needed to provide improved protection for facial (particularly jaws) and temporal areas, to soften helmet liners (substantial reduction in liner stiffness) and to improve the sliding properties of helmets.

O06 *Motorcycle related injuries to children and adolescents*

Haworth N, Ozanne-Smith, Fox B and Brumen I 1994

MUARC Report 56,

Analyses of hospital admissions. Also a study of 185 injured motorcyclists. "The most effective intervention currently available to reduce motorcyclist injuries is the motorcycle helmet". Uncertainty about the effectiveness of leg protection and airbags. Recessed fuel filler caps reduce injury potential. Protective clothing can significantly reduce soft tissue injury and increase thresholds for some serious injuries. A 1991 benefit/cost study by MUARC indicated that protective clothing would need to be only 2.5% effective to reach break even point. Conspicuity - failure of a motorist to see an approaching motorcycle may have been responsible for between 12% and 21% of crashes. Daytime use of headlights appears effective (about three times less likely to be involved in a crash). Noted that a headlamp which is in use at the time of a crash can increase the risk of fire [this appears doubtful but there may be a need for a fuel system integrity test]. Maintenance of brakes, suspension, clutch and throttle may be an issue.

O07 *Motorcycle crash countermeasures*

Haworth N and Schulze M 1996

MUARC Report 87,

Extensive literature review covering crash avoidance (conspicuity, rider training, car driver training, licensing and enforcement, alcohol, pillion passengers, brakes, rider vision, engine capacity and road environment issues) and injury reduction (helmets, protective clothing, leg protection and airbags). A workshop analysed the achievability and desirability of each countermeasure. Notable results for crash avoidance were: improved road environment, conspicuity of other vehicles and conspicuity of motorcyclists rated high but research was needed on these issues; better maintenance (brakes, suspension, clutch and throttle), daytime headlights/running lights and discouraging use of car phones rated moderate; ABS, bright clothing, pillion restrictions and engine restrictions rated low. Notable results for injury reduction were: protective clothing and footwear, reducing danger from bullbars, improved truck under-run protection, improved education/advice about fastening helmets rated high; expiry dates on helmets, banning sale of second hand helmets and encouraging motorcycle designs which are less hazardous for an ejected rider rated moderate; standards for protective clothing, mandatory full-face helmets and investigation of leg protection devices, while desirable rated low for achievability. It was noted that novices are restricted to low capacity bikes which are unlikely to have advanced features such as ABS (and airbags) but this was not a safety concern. DIY maintenance is a problem because the owners can see the components. Strapless helmets are being developed in France and USA. These use an air bladder to retain the helmet.Window tinting on cars may make it more difficult to detect motorcyclists (also the approaching cyclists cannot see whether the motorists is looking at them).

O08 *Feasibilty research on a prototype airbag system for motorcycles*

Iijima S 1998

Proceedings of the 16th ESV

Describes Honda's research program on motorcycle aribags. Some benefits and potential adverse effects were found.

O09 *Braking, stability and handling of motorcycles*

Juniper R & Good M 1983

FORS CR 29

This study involved a literature review and comprehensive analysis of motorcycle dynamics. In regard to accident risk, the study found that "the effect of motorcycle handling characteristics on accident risk has not been studied, due in part to the lack of knowledge of appropriate ways to characterise handling qualities".

O10 *Safety potential of a new motorcycle concept*

Kalliske I and Albus C 1998

Proceedings of the 16th ESV

BMW has developed a new concept in motorcycling. The vehicle incorporates a roll cage, frontal crush element and a rider restraint system. One outcome might be exemption from wearing a helmet (on the basis that it would "as safe as" a normal motorcycle).

O11 *Improvement to motorcycles by protectors fitted to rider's clothing*

Koch H 1996

Proceedings of the 15th ESV

Assessment of protective devices conforming to draft CEN standard 1621-1. Energy-absorbing devices to protect shoulders, elbow, forearms, hip, knees and lower legs. "Leather clothing...does not influence the number or severity of injuries in collisions". Improvements to materials now mean that effective protective devices can be developed.

O12 *The mortality rate in motorcycle accidents - wearing helmets*

Korbori N, Yamaki T and Nakagawa Y 1991

The Vulnerable Road User, International Conference on

These neurosurgeons examined trends in fatal head injuries to motorcyclists before and after mandatory helmet wearing. They found that although helmets reduce the incidence of focal brain injuries, they are less effective at preventing the severe life-threatening brain injuries such diffuse brain injury. A change is rotational velocity of the head at the time of a blow is one of the causes of this type of injury.

O13 *Appropriate and inappropriate strategies for injury reduction*

Ouillet J 1990

Rider-passenger Protection in Motorcycle Collisions

Review of a range of countermeasures. Head injury rates (per 1000 crashes) for non-helmeted riders were three times that of helmeted riders. Rider kinematics in a collision showing the rider being pitched forward. NHTSA-sponsored study of a "crashworthy" motorcycle (roll-cage, anti-pitch front crash bar, airbag, padded knee bolsters) - "it failed to protect the dummy in a collision with a moving car". "tank mounted airbags worked very well in perpendicular impacts with a stationary car ...[but] were nearly useless in impacts with moving cars". "...adding more and more structures to the motorcycle does not work". The assumption that loss of leg space is correlated with severity of leg injuries is disputed: a study of motorcycle crashes found that of 21 cases involving severe leg injuries 57% had little or no loss of leg space. Also out of 16 cases where the leg space was completey collapsed there were 6 severe leg injuries. "... a fundamental flaw in the strategy of putting the protection on the motorcycle: the rider's body moves around too freely during impact to derive much protectionfrom stationary structures". Airbag jackets appeared to show promise in early tests but were dropped from research in favour of tank-mounted airbags. "Perhaps one of the primary benefits of heavy clothing may be the reduction of badly contaminated wounds that delay and prolong medical treatment". Fuel spills were reported in 62% of 900 motorcycle accidents and fire in 14 cases.

O14 *Pedal cycle helmet effectiveness:a field study of accidents*

McIntosh A, Dowdell B and Svensson N 1998

Accident Analysis and Prevention,

42 cases where a pedal cyclist's helmet sustained an impact during a roac accident were studied. Where possible, helmet impact dynamics were reproduced to better understand the nature of the impact and anu failure mechanisms of the model of helmet. In 75% of the cases there was no head injury. There were 4 fatalities but only one was due to head injuries alone. It was found that impacts to the tempero-parietal region produce the greatest risk of injury but parts of this region could be below the test line for the current Australian Standard and therefore might not provide adequate protection. The reduced protection provided by the rim region of the helmet was also noted. Some helmets were found to separate into two or more pieces after the initial impact and this could be dangerous if a second impact occurred.

O15 *Motor cycle safety research literature review 1987-1991.*

Nairn R 1993

FORS CR 117 March 1993.

The review included motorcycle design features such as anti-lock braking systems, crash protection and air bags. In the case of anti-lock and integrated braking systems it was estimated that the cost would be $1,200 per motorcycle and that the measure would be cost-effective if it reduced the cost of motorcycle accidents by at least 5%. An estimate of accident savings was not given.

O16 *Bike racks on the front of buses*

Paine M 1997

Report for ACT Dept Urban Services

Literature review, description of the design of a proprietary bike rack in use in the USA. Comments from users. Mechanisms for pedestrian injury Scarce statistics on pedestrian/bus accidents. Effects of bike rack on injury, road space requirements, driver visibility, visibility of bus lights, cognitive burden on bus driver and overall community health issues resulting from increased bicycle travel.

O18 *An overall evaluation of leg protectors based on ISO 13232*

Rogers N and Zellner J 1998

Proceedings of the 16th ESV

501 cases of motorcycle accidents were analysed by 200 computer simulations, 32 laboratory tests and 14 full-scale tests. Results are presented (see [15th ESV] for negative findings on leg protectors - head and upper body injury risk increased). See also a paper by the same authors in the 15th ESV.

O19 *How can we improve the safety of vulnerable road users?*

Swadling D 1997

ARRB Transport Research WA

Effect of speed on injury severity, WA accident statistics, lack of bicycle parking facilities, road design issues, bicycle lights and reflective clothing (summary of ARRB research report), manual and motorised wheelchairs.

O20 *Positional stability of motorcycle helmets*

Thom D, Hurt H, Ouellet and Liu W 1998

Proceedings of the 16th ESV

Current motorcycle helmet performance standards test the strength of the retention system but the authors claim this does not necessarily ensure that the helmet will be retained on the head, even when securely fastened. Laboratory tests and volunteer tests were conducted. Deficiencies in both the DOT and ISO standards need to be addressed.

CATEGORY P Heavy vehicles

P01 *Improving the safety of commercial vehicles'*

Berg F, Grandel J, Niewohner W and Morschheu 1996

Proceedings of the 15th ESV

DEKRA and Mercedes Benz research into heavy vehicle accidents. Truck occupant protection measures include: reducing the size of the steering wheel and making it collapsible, padding surfaces and removing sharp edges in the cabin and improve cabin strength. It was estimated that about 21% of truck driver injuries could have been prevented with an airbag (14% "possible" plus 7% "likely").

P02 *Pointers towards the improvement of safety in buses - Germany*

Berg F and Niewohner W 1998

Proceedings of the 16th ESV

Crash analysis determined collision parameters such as mass, impact directions, delta-V, and were used to conduct two bus crash trials. Causes of the bus rolling onto its side were examined.

P03 *Improved crashworthy designs for truck underride guards*

Bloch B and Schmutzler L 1998

Proceedings of the 16th ESV

Detailed accident investigations were used to evaluate the effectiveness of typical underride guards. "Clearly improved designs are needed". Innovative practical designs are now available. Existing regulations should be upgraded and manufacturers should be encouraged to "go beyond any minimal requirements...".

P04 *Heavy truck crashworthiness - case studies of truck occupant fatality*

Cheng L, Werner S, Khatua T, Ray R and Lau E 1996

Proceedings of the 15th ESV

Analysis of over 9000 heavy truck fatal accidents (FARS data) and in-depth analysis of 68 cases (NTSB data). 22% of the NTSB crashes were offset head-on crashes between trucks, with substantial intrusion on the driver's side of the cabin, 52% were rear-end collisions between two trucks (often with the trailer tray intruding into the colliding truck's cabin), 12% were collisions with (unyielding) fixed objects. In 60% of the cases the truck rolled onto its side or more (not mutually exclusive from the above perecentages). 16% of the crashes were judged to be "survivable" if seat belts had been used.

P05 *Body engineering considerations to improve the safety in minibuses*

Dickison M and Buckley S 1996

Proceedings of the 15th ESV

Examines the feasibility of fitting lap/sash seat belts in minibuses. MIRA has developed a low cost, low weight solution which is applicable to most vans of unitary construction. Computer modelling is necessary to ensure that the structure is adequate.

P06 *Buses and coaches: evacuation*

Gurley A 1992

Interior Safety of Passenger Transport

A review of European investigations into the evacuation of buses. Several serious bus crashes are evaluated. Difficulties with trial evacuations are discussed. Evacuation times could be reduced by 50% after two practice runs with school chidren.

P07 *School bus seat belts: their fitment, effectiveness and cost*

Henderson M and Paine M 1995

Research report for the NSW Department of Transport.

Literature review, the task of transport of school children in NSW, bus safety standards, occupant protection principles and the effectiveness of seat belts in buses, usage issues, technical issues (most buses are unsuitable for seat belts without major reconstruction), other occupant protection options, cost effectiveness of a range of options. It was recommended that fitment of seat belts in large route service buses not be pursued as a mandatory safety measure, that handrails on seats be replaced or padded, that a code of practice be developed for retrofitting seat belts to small buses (now available), that provisions in the ADRs which exempt some small buses from fitting seat belts be withdrawn and that bus door safety be reviewed (all but one of the fatalities analysed during the study were from door entrapment).

P08 *Safety of buses and coaches - problems and recent solutions*

Kecman D 1995

Automotive Passenger Safety,

Review of Cranfield Impact Centre's recent research on coach safety. Rollover strength, seats and seat belts.

P09 *Seat strength in minibuses*

Kecman D, Lenard J and Thomas P 1998

Proceedings of the 16th ESV

The crashworthiness of seats in minibuses is assessed. A severe minibus accident has the potential to result in multiple casualties.

P10 *Safety measures for the structure of trucks and buses*

Miyazaki T 1998

Proceedings of the 16th ESV

Japan has established 2 expert committees to look at the role of vehicle structure in injuries to heavy vehicle occupants. A range of safety measures is proposed.

P11 *A study of car-truck impacts - energy absorbing guards*

Murray N 1988

Monash University Dept Civil Engineering

Physics of car-truck impacts. Energy-absorbing structures. Designs issue are: the whole system (truck, guard, car, occupant) must be considered; the truck guard would need to absorb at least 100kJ of energy (0.5m stroke and actuation force of 200kN); standardised bumper heights. Preliminary estimates indicated that the benefit cost ratio would, at best, be marginal. Compatible bumper heights would be more effective.

P12 *Australian bus safety standards*

Paine M 1995

Project report for National Road Transport Commission.

Review of construction standards and purchase specifications for buses in each Australian state and territory. Comparison with Australian Design Rule (ADR) requirements. Identification of potential additions to the ADRs based on the bus accident study: Issues included interior padding, seats, seat belts, buses used for school excursions, automatic transmissions, driver's field of view, tachographs, conspicuity and:

Issue	% of all	% of Fat	% Ser.inj.
Fire	3%	4%	3%
Brake failure (mostly older buses)	6%	18%	13%
Evacuation an issue (emergency exits)	27%	67%	52%
Door entrapment (estimate from other work)	-	2 per year	8 per year

P13 *Bus accidents in Australia: 1970-93*

Paine M 1995

Project report for National Road Transport Commission.

Analysis of bus accident statistics from each state and territory. Analysis of press clippings and reports covering 240 bus crashes or incidents

P14 *Belt systems in passenger coaches*

Rasenack W, Appel H, Rau H and Rietz C 1996

Proceedings of 15th ESV

Use of computer simulation to assess the effectiveness of various seat belt systems in coaches. A problem in rollover crashes with occupants "hanging in the air" unable to release the seat belt is pstulated but this disadvantage (if it exists) does not outweigh the advantages of seat belts in preventing injury.

P15 *Development and testing of rear underrun barriers*

Rechnitzer G, Powell C and Seyer K 1996

Proceedings of the 15th ESV

Design and testing of a prototype system. Fibreglass composite tubes are placed within light-weight steel tubes provide very effective energy absorption.

P16 *Research on the evacuation readiness of bus crews and passengers*

Shiosaka Y and Kuboike T 1996

Proceedings of the 15th ESV

Trials of bus emergency evacuation procedures. Regular door and window exits were evaluated. Of concern is that all school children and half of the aged persons failed to exit the bus during the first test. Difficulties were found with reading instructions, operating the opening mechanisms and fear about the height above the ground. An improved display overcame many of the problems.

P17 *Towing caravans and trailers safely*

Staysafe 1992

Staysafe 22

Crash involvement of caravans and trailers in NSW. Issues include tow bar design, brakes, LPG equipment, crashworthiness, roadworthiness, tyres, suspension design (roll steer) and stability.

P18 *Heavy vehicle crash test method in Japan*

Sukegawa Y, Matsukawa F and Oki W 1998

Proceedings of the 16th ESV

Crash tests of a car into a truck fitted with an EEVC "Front Underrun Protection System" are described. The impact speed was 65km/h. Full, 50% and 30% overlap were tested. Effects on injury risk and car deformation are discussed.

P19 *NSW Heavy Vehicle Crash Study - Final Technical Report.*

Sweatman P et al 1990

FORS CR 92 August 1990.

Summarises the findings of a study of 83 heavy vehicle crashes on two NSW highways. In general, vehicles were not available for inspection in this retrospective study therefore the report cautions that the results for vehicle factors must be considered a lower bound. The role played by various vehicle factors is discussed. An estimate is made of the number of crashes in which each countermeasure would have influenced the outcome.

Vehicle Countermeasure	Number of crashes
Reduced truck frontal stiffness	40 (48%)
Improved truck cab crashworthiness	20 (24%)
Truck seat belts fitted/used	19 (23%)
Speed limiters/tachographs	18 (22%)
Driver fatigue detectors	16 (19%)
Improved car crashworthiness	15 (18%)
Truck brake compatibility & ABS	11 (13%)
Fatigue detectors in cars	11 (13%)
Remove truck bullbars	10 (12%)
Lower height of truck & bus front bumpers	9 (11%)
Lower truck centre of gravity (rollover)	9 (11%)
Radar braking on trucks & buses	6 (7%)
Improved truck conspicuity (lights/refl)	5 (6%)
Improved truck load security	5 (6%)
Continued random truck inspections	4 (5%)
Annual truck inspections	2
Improved tyre maintenance	2
Improved truck driver visibility	2
Truck side under-run protection	2
Truck rear under-run protection	2

Note these were confined to highway crashes.

P20 *Heavy vehicle crashes in urban areas*

Sweatman P et al 1995

FORS CR 155.

Literature review, analysis of mass crash data and detailed crash investigation of 88 crashes. 50 to 75% of serious rigid truck crashes and 25 to 50% of serious articulated vehicle crashes occur in urban areas. 25% of articulated vehicle crashes in urban areas were fatal. Heavy vehicles were judged to be wholly or partially responsible in 33% of the crashes. Vehicle factors in these crashes were: drivers field of view (13%); lack of side underrun protection (11%); unguarded wheel areas (11% - mainly for pedestrians and cyclists); length and width (11%); stiffness of rear structure (7%); lack of rear underrun protection (5%); swept path (7%); maintenance (7% - mainly older trucks) ; stiffness of side structure (4%); stiffness of front structure (4%) and front underrun protection (4%). Potential ITS technologies are: pedestrian detectors; on-board red traffic signal indicators and heavy vehicle-sensing traffic signal systems (running red lights was found to be a problem); stability warning systems; route guidance and "Mayday" systems.

P21 *A look at the NHTSA compliant underride guard at speeds above 30mph*

Tomassoni J 1998

Proceedings of the 16th ESV

A series of 8 underride crash tests indicated that underride magnitude was marginally close to passenger compartment intrusion at 30mph. The performance of minimally compliant systems at speeds above 30mph are assessed.

P22 *Design of an energy absorbing truck front bumper bar*

Wasiowych A, Lozzi A and Griffiths M 1996

Proceedings of the 15th ESV

Full scale car to truck crash tests were cinducted to assess potential improvements to front bumpers on trucks (underrun barriers). The device included innovative energy absorbing elements.

P23 *Pedestrian safety: school children around buses*

Staysafe 1992

Staysafe 26

Literature review. Accident data. Regulations. Vehicle engineering issues. Behavioural issues. Traffic and road engineering issues. Technical recommendations included: bright red and amber flashing lights; 40km/h limit when passing buses with the lights flashing; investigate a safety boom; improved bus mirrors; improved demisters; investigate loudspeaker systems; door sensors to reduce risk of entrapment.

P24 *Safety of school children near buses*

Roads and Traffic Authority of NSW 1992

School Bus Task Force Report

Accident data analysis. 107 casualties between 1988 and 1989; 5 were fatal, 38 were serious injuries; 65% were aged 12 or less but appeared to be peaks at the start of primary and high school [inexperience?]; 88% were in the afternoon [child more easily distracted]; 75% of cases the bus obstructed the motorists view; 50% were emerging from the front of the bus and hit by overtaking vehicle (all in 60km/h zones and none were fatal); 25% emerged from the rear of the bus and were hit by an oncoming vehicle (10 serious injuries and 3 fatalities, mostly in 80+ speed zones). Many children were described as "running". The problem of the bus hiding crossing children from oncoming motorists was examined in detail. Recommendations included flashing lights at the front and rear of the bus, a behavioural program (which became "Wait, w walk") and making parents aware of the hazards of waiting on the other side of the road.
Influence of presence of bus. Review of current Australian and overseas practices. Strategies and countermeasures:

P25 *The Travel Safe Report*

Bus and Coach Association 1994

Bus and Coach Association of NSW

Survey of community perception of bus safety. Comparison of risk factors between various types of transport:

Mode	% of passenger km	% of casualties	Relative risk
Bus	36	5	0.17
Car Passenger	39	46	1.19
Bicycle	1	17	39
Pedestrian	6	27	5.2
Other	23	5	-

P26 *EVALUATION OF ISSUES ASSOCIATED WITH SEAT BELTS ON SCHOOL BUSES*

SWADLING 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

P27 *RESEARCH ON BUS PASSENGER SAFETY IN FRONTAL CRASHES*

MITSUISHI H 2001

PROCEEDINGS OF THE 17TH ESV

SLED TESTS OF BUS SEATS WITH 2-PT SEAT BELTS

P28 *POTENTIAL GAIN [FROM] SEAT BELTS AND AIRBAGS IN TRUCKS*

SIMON M 2001

PROCEEDINGS OF THE 17TH ESV

37% OF FATALS, 36% SERIOUS, 22% MINOR

P29 *SEAT BELTS IN BUSES AND RECENT ACCIDENTS IN SPAIN*

FERRER I 2001

PROCEEDINGS OF THE 17TH ESV

HIGHLY EFFECTIVE IN 3 STUDIED CRASHES

P30 *SIMULATIONS OF LARGE SCHOOL BUS SAFETY RESTRAINTS*

MCCRAY L 2001

PROCEEDINGS OF THE 17TH ESV

P31 *LARGE SCHOOL BUS SAFETY RESTRAINT EVALUATION*

ELIAS J 2001

PROCEEDINGS OF THE 17TH ESV

P32 *IMPROVED SAFETY FOR MINIBUSES BY BETTER SEAT AND OCCUPANT RETENTION*

LAWRENCE G 2001

PROCEEDINGS OF THE 17TH ESV

CATEGORY Q Post-crash rescue and medical care

Q01 *Design and implementation of an automobile collision notification system*

Blatt A, Funke D,Donnelly B and Carter A 1996

29th International Symposium on Automotive Technology and Automation,

Comprehensive study and trial funded by NHTSA. "The life saving potential is obvious" but the extent of this potential has not been quantitatively demonstrated. The study is addressing this issue and is looking at the many technical and operational challenges. False alarms need to be kept to a minimum.

Q02 *Emergency Preemption Systems Technical Manual.*

Emergency Preemption Systems 1991

Propriety manual

Technical details about a system which is part of a traffic signals controller and detects the sound of an approaching siren. This avoids the need for special transmitters on emergency vehicles [but the technology is now dated].

Q03 *A searchable transportation fire safety bibliography*

LaDue D and Kononen D 1998

Proceedings of the 16th ESV

Over 1000 articles concerning vehicle fires are included in a searchable database, on CD ROM.

Q04 *Field data improvements for fire safety research*

Lavelle J, Nelander J and Kononen D 1998

Proceedings of the 16th ESV

Various US accident databases were analysed to evaluate the possible causes and effects of vehicle fires and to recommend enhancements to the databases to better understand the causes of vehicle fires.

Q05 *Relationship between crash casualties and crash attributes*

Malleris A, Digges K and DeBlois 1997

Occupant Protection and Injury Assessment in the Crash Environment

Post- crash treatment of automotive crash victims can be improved if the medical personnel have an indication of the crash characteristics. The authors analysed a range of crashes and found that some types of injuries could be predicted from key crash parameters. On-board crash sensors which could be interogated by rescuers (or which automatically transmits crash data to a trauma centre) could assist in this approach.

Q06 *New technology gives motorists an early warning*

NASA 1998

News release by NASA dated 15 June 1998.

As a spin-off of space research NASA has developed an improved system for warning motorists that an emergency vehicle is approaching a controlled intersection. A visual display gives an indication of the direction from which the emergency vehicle is approaching.

Q07 *A case study of 214 fatal crashes involving fire*

Ragland C 1998

Proceedings of the 16th ESV

The FARS database was analysed to determine the intensity, location and timing of fires in fatal crashes. Cases where the fire caused death were identified.

Q08 *ENHANCING POST-CRASH SAFETY THROUGH AUTOMATIC COLLISION NOT.*

KANIANTHRA J 2001

PROCEEDINGS OF THE 17TH ESV

OPTIMISITC 2% OF ALL CRASHES. TRIALS HAD 50% FALSE ALARMS.

Q09 *AUTOMATED CRASH NOTIFICATION: DESIGN AND VALIDATION*

HAMPTON G 2001

PROCEEDINGS OF THE 17TH ESV

CATEGORY R Strategy

R01 *Injury Control - a Global View*

Berger L and Mohan D 1996

Oxford University Press, Delhi.

World statistics on accidental death and injury. In line with Haddon's work, the following strategies are proposed for reducing injuries in road crashes (examples in brackets): 1.Preventing/reducing exposure to injurious "agents" (alternative travel modes, speed reduction); 2.Preventing inappropriate release of the agent (vehicle and road designs to simplify the driver's task); 3.Modifying the release of the agent (use of seat belts); 4.Separating in time or space or with physical barriers (restricting the transport of hazardous materials, median barriers); 5.Modifying surfaces and basic structures (airbags, removing projections); 6. Increasing resistance to injury (therapy for osteoporosis); 7.Emergency response or medical care and rehabilitation (systems that route patients to appropriately trained physicians).

R02 *The potential gains for road safety from existing vehicle technology*

Brown J and Holgate J 1998

Proceedings of the Developments in Safer Motor Vehicles Seminar

Serious injury rate by year of manufacture (decreasing from 5 serious injuries per 100 crashes in pre-1975 vehicles to 2 in 1995). Composition of NSW vehicle fleet. On current trends the % of older vehicles will increase (54% older than 10 years in 1997, predicted 57% in 2015). Strategies to reduce the age of the fleet and increase the uptake of safety options are discussed, including tax incentives, consumer information and targeting fleet buyers.

R03 *Promoting the safe driving policy in NSW fleets of 20 or more vehicles*

Collingwood V 1996

29th International Symposium on Automotive Technology and Automation

Description of the NSW Roads and Traffic Authority's program targeted at fleet operators. "...new vehicles will be chosen and equipped to enhance safe performance. Vehicles will be maintained, presented and operated for maximum safety". Attention is drawn to the results of NCAP tests and Used Car Safety Ratings. Benefits of the program include: community involvement at an organisational level; a means of tackling road safety problems outside the general deterrence approach; a means of targeting heavy vehicles; improved driving at work can carry over into non-work driving; integration of road safety and occupational health and safety and influencing the market for safety features in vehicles.

R04 *Reducing traffic injuries through vehicle safety improvements*

ETSC 1993

European Transport Safety Council, Brussels November 1993.

Background on the road crash situation in Europe and the car safety standards. Priorities in car design for accident avoidance: speed control, vision and conspicuity, ABS, ITS and need for accident research. Occupant protection design issues: improved steering wheel design, airbags, improved seat belts, improved leg protection by limiting footwell intrusion, protection for chest and abdomen in side impacts (structure and padding), improved neck protection (head restraint design) and kinematics in rear impacts (seats and seat belts), padding of upper interior, performance of door latches, fuel system integrity, effects of smaller vehicles, structural incompatibility.

R05 *Comprehensive plan for ITS in Japan.*

Government of Japan 1996

Booklet.

ITS issues relevant to occupant protection are: provision of public transport information (to encourage use of public transport), pedestrian route guidance, vehicle-pedestrian collision avoidance, automatic emergency notification and route guidance for emergency vehicles.

R06 *Vehicle and Equipment Safety Issues*

Griffiths M 1994

Road Safety 2000 Review Conference 1994

Comprehensive review of vehicle safety issues. Concern that advances made under the Australian Design Rule system had stalled during the 1980s (comparison with safety advances in the USA). Benefits of consumer-driven change such as NCAP.

R07 *The crash safety of new car models - a comparative accident study*

Lie A, Tingvell C and Larsson P 1996

Proceedings of the 15th ESV

A car manufactured in 1985 has about twice the risk of a severe or fatal injury than a car manufactured in 1995. The decline in risk only started to show strongly from 1993 onwards. The improvement in crashworthiness has not been at the expense of an increase in aggressivity. Minor injuries are largely unaffected.

R08 *The aging of the Australian car fleet and occupant protection*

McIntosh L and Coxon C 1998

Proceedings of the 16th ESV

Describes factors influencing the safety of occupants in older vehicles. Strategies for reducing the age of the fleet are discussed.

R09 *ESV Government Reports - The Netherlands*

Meekel G 1996

Proceedings of the 15th ESV

Vehicle-related measures were assessed for accessibility, sustainability (emissions) and safety by a group of experts. Chances of implementation were assessed. The most promising measures for the short term were: active vehicle control, improved vehicle conspicuity, front and side underrun protection on heavy vehicles, improved integration of car and public transport. Other promising short term measures were improved tyres, measures to improve vehicle control and driver behaviour, improved interior safety of buses and improved vehicle identification. The most promising long-term measures were: collision avoidance systems, in-car information systems, intelligent speed limiters and automated highway guidance systems. Examples of low-scoring measures were: electric vehicles, improved motorcycle stability, periodic inspections, electronic road pricing, integration of car and bicycles (?), hybride vehicles, fuel cells, forewarning systems, automated car-following systems and automated people movers. These are preliminary results.

R10 *NSW Occupant Protection Strategy 1996-2000 and Action Plan 1996-97*

Roads and Traffic Authority of NSW 1996

CRB 96.146.

R11 *Wilingness to pay for vehicle safety features*

Roy Morgan Research 1992

FORS CR 112, November 1992.

515 new car purchasers were surveyed. On average they were willing to pay $486 for the non-airbag safety package (improved seat belts andseats, improved leg protection, padded steering wheel and seat belt warning device - total estimated retail $270) and $1236 for the airbag safety package (above plus driver's airbag - total estimated retail $700). 68% of low-price car purchasers were willing to pay the $700 estimated retail price of the airbag package. This increased to 80% of fleet managers (also fleet drivers).

R12 *Development of a method of estimating the costs of injuries - NCAP*

Ryan G, Hendrie D and Mullan N 1998

Proceedings of the 16th ESV

The project developed a database of injury costs by body region and injury severity, estimated the cost of injuries from crash test measurements and looked for trends by vehicle age and model grouping. "Head injury was by far the largest component of predicted injury costs".

R13 *Crashworthiness testing and rating and zero deaths in road traffic*

Tingvell C, Lie A and Larsson P 1996

Proceedings of the 15th ESV

Swedish approach to publishing retrospective (real crash) ratings and new car crah test results. The intention is to develop a series of crash tests which simulate a variety of crash situation, including roadside furniture and other vehicles. Certain injury criteria must be met in these crashes. "In a sense, the [vision zero] is also a market driven concept where it is up to the [motor] industry to increase the attractiveness of the roa dtransport system by better protection and not let the road user take the whoile responsibility to stay alive by being more restrictive by lower speed limits etc."

R14 *Vehicle Defects in Crashes - Indepth Vehicles Factor Study*

Duignan P, Williams S and Griffiths M 1996

Proceedings of the 15th ESV

Description of a project by the NSW RTA to investigate vehicle factors in crashes. teams of motor vehicle inspectors were trained in crash investigation techniques. They were notified about crashes by emergency services and attended the scene of the accident. In most cases a thorougl vehicle inspection was conducted.

R15 *Current Road and Vehicle Safety Research*

DETR 1998

UK Dept Environment, Transport and the Regions

Description of road safety projects being undertaken by the UK Dept. Topics include: serious injuries to child occupants, airbags, interior pillar padding, pedestrian protection, NCAP, lower back injuries, compatibility, advanced restraint systems, bus emergency exits, bus seat belts, fire in buses, motorcycle airbags, leg protectors and helmets, whiplash injuries.

R16 *Vision Zero - a Road Safety Concept*

SNRA 1996

Swedish National Road Administration

Description of the vision of "no harm done - no one was hurt"

R17 *Towards Safer Roads*

DETR 1997

UK Dept Environment, Transport and the Regions

Description of UK vision for road safety

R18 *Report to Congress on the NHTSA ITS Program*

NHTSA 1997

NHTSA

Description of US ITS program to date and the plan for future developments. Most are for crash avoidance. An exception is the "Automated Collision Notification Program".

R19 *National Guidelines for Assessment of Defective Vehicles*

Paine M 1995

NRTC/Austroads November 1995

Guidelines for use by enforcement officers for deciding on the appropriate severity of defect notice to be issued. Contributing factors to crashes, effects of defects: impair driver's view, impair visibility of the vehicle to other road users or prevent driver from signalling intentions, impair driver's control of the vehicle, intrude into the roadspace of others or cause a nuisance (noise or emissions), impair the built-in occupant protection afforded by the vehicle in the event of a crash, increase risk of injury after a crash has occurred (rescue). Circumstance were: immediate, imminent, delayed and gradual. A matrix defines the classification of a defect based on its type and the circumstances. Serious injury risk factors for various conditions were provided: high speed limit x2, winding or hilly road x3, wet weather x2, night x2, motorcycle x10, heavy vehicle x2, dangerous goods x2

R20 *Optimising the fleet experience*

Craigen R 1992

Wheels 92

Purchasing trends, resale, maintenance.
52% of new vehicle purchases non-private. Of there 75% business, 13% govt, 5% local govt, 4% federal govt, 3% rental.

R21 *ROAD TRAFFIC ACCIDENTS IN NSW - 1999*

RTA NSW 2001

ROADS AND TRAFFIC AUTHORITY OF NSW

R22 *SPEED CONTROL DEVICES FOR CARS*

PAINE M 1996

RTA RESEARCH REPORT 5/96

BENEFIT COSTS OF SPEED LIMITERS AND OTHER SPEED CONTROL DEVICES:
10% OF RURAL CRASHES INVOLVE SPEEDS OVER 120km/h. TOP SPEED LIMITER 100% EFFECTIVE FOR THESE CRASHES. LIMITED SPEEDO SCALE 50% EFFECTIVE.
AUTOMATIC SPEED LIMITER 50% EFFECTIVE FOR ALL SPEED RELATED CRASHES. SPEED ALARMS 25%.

R23 *OVERCOMING BARRIERS TO FLEET SAFETY IN AUSTRALIA*

MURRAY W 2001

ROAD SAFETY 2001, MUARC, MELBOURNE

R24 *INTELLIGENT SPEED ADAPTION: THE BEST COLLISION AVAOIDANCE SYSTEM*

CARSTEN O 2001

PROCEEDINGS OF THE 17TH ESV

B/C RANGE FROM 7.9 TO 15.4. 37% FATALS, 20% INJURIES.

R25 *RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES*

THOMPSON K 2001

PROCEEDINGS OF THE 17TH ESV

NOT MUCH USEFUL DETAIL

R26 *QUALITY CRITERIA FOR CRASHWORTHINESS ASSESSMENT FROM REAL-WORLD CRASHE*

LANGWIEDER K, FILDES B, ERNVALL T AND 2001

PROCEEDINGS OF THE 17TH ESV

R27 *COMPARATIVE ANALYSIS OF SEVERAL VEHICLE SAFETY RATING SYSTEMS*

CAMERON M 2001

PROCEEDINGS OF THE 17TH ESV

REAL WORLD CRASHES ANALYSED

Appendix B - Summary of Safety Features

VEHICLE SAFETY FEATURES (SORTED BY BENEFIT/COST RATIO)

CODE	DESCRIPTION	INITIAL COST(NET)	ANNUAL MAINT.	NET SAVINGS	BENEFIT/ COST
SL_TOP	TOP SPEED LIMITER (SET AT 120km/h	$1	$0	$10	67.22
HEADL_ON	HEADLIGHTS ON WARNING/AUTO	$50	$20	$55	7.79
DRL	DAYTIME RUNNING LIGHTS	$50	$2	$55	7.67
SB_ILOCK	SEAT BELT INTERLOCK	$50	$0	$23	3.19
SB_LL_F	SEAT BELT LOAD LIMITERS, FRONT	$20	$0	$6	1.95
SL_ALARM	SPEED ALARM	$50	$0	$14	1.92
HI_GLASS	HIGH TRANSMITTANCE GLAZING	$50	$0	$10	1.40
KNEE_PAD	KNEE BOLSTER/PADDING	$100	$0	$19	1.36
GLASS_LAM	LAMINATED OR SHATTER-PROOF GLAZING	$100	$0	$16	1.12
SB_WG_F	SEAT BELT WEBBING GRABBERS, FRONT	$40	$0	$6	1.12
SB_PT_F	SEAT BELT PRETENSIONER, FRONT	$100	$0	$16	1.12
SEAT_SUB	ANTI-SUBMARING SEAT DESIGN	$40	$0	$6	1.12
HAZ_ACT	HAZARD LIGHT ACTIVATE IN SEVERE CRASI	$50	$0	$8	1.11
HELMET	HELMETS/HEAD BANDS FOR OCCUPANTS	$30	$10	$4	0.90
SB_BUCK	SEAT BELT BUCKLE MOUNTED ON SEAT (FI	$50	$0	$6	0.89
PED_IMP	PEDESTRIAN FRIENDLY VEHICLE FRONT	$500	$0	$60	0.85
ABS	ABS BRAKES	$400	$0	$47	0.83
SIDE_ABFT	SIDE AIRBAG - FRONT SEAT, THORAX	$400	$0	$46	0.81
AIRBAG_D	DRIVER AIRBAG	$600	$0	$67	0.79
BDY_COL	CONSPICUOUS BODY COLOUR	$100	$0	$10	0.70
LOAD_REST	LOAD RESTRAINT DEVICES (TETHERS)	$100	$0	$10	0.67
ISA	INTELLIGENT SPEED ADAPTION	$800	$0	$68	0.60
FOOT_PROT	IMPROVED FOOT PROTECTION	$100	$0	$8	0.55
WIPER_SPD	SPEED SENSITIVE INTERMITTENT WIPERS	$100	$0	$7	0.51
WIPER_AUT	WIPERS AUTOMATIC	$100	$0	$7	0.51
HR_ADJ	ADJUSTABLE HEAD RESTRAINT	$100	$0	$7	0.50
HEAD_PAD	HEAD PROTECTION PADDING	$200	$0	$14	0.49
CARGO_BAR	CARGO BARRIER	$300	$0	$20	0.47
MIRROR_AU	EXTERNAL MIRRORS ELECTRICALLY ADJUS	$200	$0	$13	0.47
AB_BONNET	BONNET AIRBAG FOR PEDESTRIAN PROTEC	$500	$0	$32	0.45
AB_SMART	SMART AIRBAG SYSTEM	$500	$0	$28	0.39
CRASH_REC	CRASH RECORDER	$500	$0	$27	0.38
PHONE	MOBILE PHONE AVAILABLE IN EVENT OF A	$200	$0	$11	0.38
SB_LL_R	SEAT BELT LOAD LIMITERS, REAR	$20	$0	$1	0.37
ALC_LOCK	ALCOHOL/DRUG INTERLOCK	$200	$0	$10	0.36
SB_HT_ADJ	SEAT BELT D-RING HEIGHT ADJUSTABLE/AI	$100	$0	$5	0.33
MAYDAY	MAYDAY DISTRESS CALL IN SEVERE CRASH	$500	$0	$21	0.30
CRUISE	CRUISE CONTROL	$150	$0	$6	0.27

CODE	DESCRIPTION	INITIAL COST(NET)	ANNUAL MAINT.	NET SAVINGS	BENEFIT/ COST
ENG_IMMOB	ENGINE IMMOBILISER	$300	$0	$11	0.25
STR_ADJ	ADJUSTABLE STEERING COLUMN	$100	$0	$3	0.24
SEAT_ADJ	ADJUSTABLE DRIVERS SEAT (MULTI-FUNCT	$200	$0	$7	0.24
SEAT_LUM	ADJUSTABLE LUMBAR SUPPORT	$50	$0	$2	0.24
AUTO_TRAN	AUTOMATIC TRANSMISSION	$200	$0	$7	0.24
SEAT_COOL	COOLED/HEATED DRIVERS SEAT	$200	$0	$7	0.24
SIDE_AB_FH	SIDE AIRBAG - FRONT, HEAD-PROTECTING (	$400	$0	$12	0.20
HEADWAY	HEADWAY RADAR FOR EXCESSIVE CLOSING	$800	$0	$23	0.20
FUEL_CUT	FUEL AND ENGINE CUT-OFF IN SEVERE CRAS	$100	$0	$3	0.19
AIRBAG_P	FRONT PASSENGER AIRBAG	$400	$0	$11	0.19
SB_CR3	SEAT BELT, CENTRE REAR 3-POINT	$100	$0	$3	0.19
HR_RO	HEAD RESTRAINTS FOR REAR OUTBOARD SI	$80	$0	$2	0.18
POWER_STR	POWER STEERING	$300	$0	$7	0.16
SB_PT_R	SEAT BELT PRETENSIONERS, REAR	$100	$0	$2	0.15
SB_WB_R	SEAT BELT WEBBING GRABBERS, REAR	$40	$0	$1	0.15
HR_RA	HEAD RESTRAINTS FOR ALL REAR SEATS	$120	$0	$2	0.14
SIDE_AB_RT	SIDE AIRBAG, REAR, THORAX	$400	$0	$7	0.12
SB_INFLATE	INFLATABLE SEAT BELT	$200	$0	$3	0.11
IRS	INDEPENDENT REAR SUSPENSION	$300	$0	$4	0.09
MIRR_DIM	AUTO DIMMING REAR VIEW MIRROR	$200	$0	$2	0.06
CR_INT	CHILD SEAT INTEGRATED	$500	$0	$4	0.06
SB_HARNESS	HARNESS SEAT BELT FOR ADULTS (4PT OR (	$400	$0	$2	0.04
SIDE_AB_RH	SIDE AIRBAG, REAR, HEAD-PROTECTING	$400	$0	$2	0.04
NAV_SYS	NAVIGATION SYSTEM (GPS)	$1,500	$0	$7	0.03
TRACTION	TRACTION CONTROL	$700	$0	$2	0.02
TYRE_RF	RUN FLAT TYRES	$400	$0	$1	0.01
MIRR_FOG	ANTI FOGGING (HEATED) EXTERNAL MIRRC	$200	$0	$0	0.01
TYRE_PRES	TYRE PRESSURE MONITORING	$400	$0	$0	0.00

Appendix C - Details of Benefit/Cost Analyses

SAFETY FEATURE ANALYSIS

FEATURE CODE AIR_COND **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION AIR CONDITIONING/CLIMATE CONTROL

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $1,200.00 **MAINTENANCE/YR:** **$40.00**

COST NOTE: GLASS' SGUIDE AND SURVEY OF DEALERS
(Also see references

CRASH INFLUENCE: CASES WHERE DRIVER DISCOMFORT A FACTOR. ASSUMED TO BE ONE THIRD OF FATIGUE CASES: F-17.6%, OTHERS 8.6%.

EFFECTIVENESS: ASSUMED ONE QUARTER EFFECTIVE.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	6%	3%	3%	3%
% EFFECTIVENESS	25%	25%	25%	25%
$ SAVED PER VEHICLE/YEAR	$2.06	$1.76	$0.95	$1.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)
BENEFIT/COST RATIO: 0.00 **HI*:** 0.00

TOTAL SAVINGS/YR **$5.78**
NET SAVINGS/YR -$34.22
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
P19	NSW Heavy Vehicle Crash Study - Final Technical Report.
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

FEATURE CODE ALC_LOCK **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION ALCOHOL/DRUG INTERLOCK

READINESS START-UP **ACCEPTANCE** POOR

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: PROTOTYPES ONLY AT THIS STAGE. BASED ON COST OF SIMILAR GADGETS SUCH AS HEADLIGHT ALERT.
(Also see references

CRASH INFLUENCE: 17% OF FATALS AND 5% OF OTHERS.

EFFECTIVENESS: ASSUMED 20% EFFECTIVE. THIS MAY BE OPTIMISTIC.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	17%	5%	5%	5%
% EFFECTIVENESS	20%	20%	20%	20%
$ SAVED PER VEHICLE/YEAR	$4.83	$2.52	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)
BENEFIT/COST RATIO: 0.36 **HI*:** 0.36

TOTAL SAVINGS/YR **$10.14**
NET SAVINGS/YR $10.14
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R04	Reducing traffic injuries through vehicle safety improvements
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE AUTO_TRANS **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION AUTOMATIC TRANSMISSION

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: GLASS'S GUIDE.
(Also see references

CRASH INFLUENCE: CASES WHERE CHANGING MANUAL GEARS CONTRIBUTED TO ACCIDENT. LIKELY TO BE LESS THAN 1%.

EFFECTIVENESS: SHOULD ELIMINATE ALL CASES. COST ASSUMED TO BE EXTRA ON MANUAL COST.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	1%
% EFFECTIVENESS	100%	100%	100%	100%
$ SAVED PER VEHICLE/YEAR	$1.42	$2.52	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.24 **HI*:** 0.24

TOTAL SAVINGS/YR **$6.73**

NET SAVINGS/YR $6.73
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
P19	NSW Heavy Vehicle Crash Study - Final Technical Report.
R04	Reducing traffic injuries through vehicle safety improvements

FEATURE CODE CRUISE **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION CRUISE CONTROL

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $150.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: SURVEY OF DEALERS AND GLASS'S GUIDE
(Also see references

CRASH INFLUENCE: FATIGUE CRASHES (18% FATALS AND 9% OF OTHERS) AND HIGH SPEED CRASHES (10% OF FATALS AND 5% OF OTHERS)

EFFECTIVENESS: SMALL EFFECT - PERHAPS 5% REDUCTION.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	28%	14%	14%	14%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$1.99	$1.76	$0.95	$1.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.27 **HI*:** 0.27

TOTAL SAVINGS/YR **$5.71**

NET SAVINGS/YR $5.71
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999
R22	SPEED CONTROL DEVICES FOR CARS

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE ISA **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION INTELLIGENT SPEED ADAPTION

READINESS START-UP **ACCEPTANCE** POOR

NET COST (1 OFF) $800.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED MAINLY ON A COMPREHENSIVE REPORT BY UNI OF LEEDS. COST SUBSTANTIALLY LESS IF PIGGY-BACKED ON A NAVIGATION SYSTEM.
(Also see references

CRASH INFLUENCE: SPEED-RELATED CRASHES 40% OF FATALS AND 15% OF OTHERS (R21).

EFFECTIVENESS: POTENTIAL FOR HIGHLY EFFECTIVE ADVANCED SYSTEM. ASSUME BASIC SYSTEM RESULTS IN 50% REDUCTION.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	40%	15%	15%	15%
% EFFECTIVENESS	50%	50%	50%	50%
$ SAVED PER VEHICLE/YEAR	$28.40	$18.90	$10.20	$10.73

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.60 HI*: 0.60

TOTAL SAVINGS/YR **$68.23**

NET SAVINGS/YR $68.23
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
P19	NSW Heavy Vehicle Crash Study - Final Technical Report.
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999
R22	SPEED CONTROL DEVICES FOR CARS
R24	INTELLIGENT SPEED ADAPTION: THE BEST COLLISION AVAOIDANCE SYSTEM

FEATURE CODE NAV_SYS **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION NAVIGATION SYSTEM (GPS)

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $1,500.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: DEALER SURVEY.
(Also see references

CRASH INFLUENCE: ASSUMING A VOICE ACTIVATED SYSTEM IS USED SO THAT RISK OF ACCIDENT DOES NOT INCREASE, THEN BENEFITS ARE FROM GREATER AWARENESS OF ROAD CONDITIONS. FEWER ACCIDENTS DUE TO UNKNOWN ROAD CONDITIONS (WHEN TO TURN ETC). PERHAPS 1% OF ACCIDENTS.

EFFECTIVENESS: GOOD SYSTEM HAS POTENTIAL TO BE 100% EFFECTIVE IN CASE OF ACCIDENTS CAUSED BY UNKNOWN ROAD CONDITIONS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	1%
% EFFECTIVENESS	100%	100%	100%	100%
$ SAVED PER VEHICLE/YEAR	$1.42	$2.52	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.03 HI*: 0.03

TOTAL SAVINGS/YR **$6.73**

NET SAVINGS/YR $6.73
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R09	ESV Government Reports - The Netherlands

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SEAT_ADJ **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION ADJUSTABLE DRIVERS SEAT (MULTI-FUNCTION)

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON 33% TYPICAL COST OF ENTIRE SEAT (~$600) .
(Also see references

CRASH INFLUENCE: ACCIDENTS WHERE DISCOMFORT OR FATIGUE A FACTOR. SAY 5% OF ALL.

EFFECTIVENESS: NO DATA. ASSUME 20% EFFECTIVENESS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	5%	5%	5%	5%
% EFFECTIVENESS	20%	20%	20%	20%
$ SAVED PER VEHICLE/YEAR	$1.42	$2.52	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.24 **HI*:** 0.24

TOTAL SAVINGS/YR **$6.73**

NET SAVINGS/YR $6.73
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE SEAT_COOL **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION COOLED/HEATED DRIVERS SEAT

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: PROTOTYPES ONLY AT THIS STAGE. ASSUMES AIR CONDITIONER ALREADY FITTED.
(Also see references

CRASH INFLUENCE: ACCIDENTS WHERE DISCOMFORT OR FATIGUE A FACTOR. SAY 5% OF ALL.

EFFECTIVENESS: NO DATA. ASSUME 20% EFFECTIVENESS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	5%	5%	5%	5%
% EFFECTIVENESS	20%	20%	20%	20%
$ SAVED PER VEHICLE/YEAR	$1.42	$2.52	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.24 **HI*:** 0.24

TOTAL SAVINGS/YR **$6.73**

NET SAVINGS/YR $6.73
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SEAT_LUM **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION ADJUSTABLE LUMBAR SUPPORT

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST ASSUMES SYSTEM CAN BE READILY INCORPORATED ON THE PRODUCTION LINE.
(Also see references)

CRASH INFLUENCE: ACCIDENTS WHERE DISCOMFORT OR FATIGUE A FACTOR. SAY 5% OF ALL.

EFFECTIVENESS: NO DATA. ASSUME 5% EFFECTIVENESS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	5%	5%	5%	5%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$0.36	$0.63	$0.34	$0.36

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.24 **HI*:** 0.24

TOTAL SAVINGS/YR **$1.68**

NET SAVINGS/YR $1.68
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE SL_ALARM **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION SPEED ALARM

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON RTA SPEED CONTROL REPORT OF 1996. AFTERMARKET COST ABOUT $100. ASSUMED THAT OE COST ABOUT HALF OF THIS.
(Also see references)

CRASH INFLUENCE: SPEED RELATED CRASHES 40% OF FATALS AND 15% OF OTHERS

EFFECTIVENESS: LOW EFFECTIVENESS DUE TO NEED TO MANUALLY SET SPEED. ASSUME 10%.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	40%	15%	15%	15%
% EFFECTIVENESS	10%	10%	10%	10%
$ SAVED PER VEHICLE/YEAR	$5.68	$3.78	$2.04	$2.15

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.92 **HI*:** 1.92

TOTAL SAVINGS/YR **$13.65**

NET SAVINGS/YR $13.65
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999
R22	SPEED CONTROL DEVICES FOR CARS
R24	INTELLIGENT SPEED ADAPTION: THE BEST COLLISION AVAOIDANCE SYSTEM

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* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SL_TOP **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION TOP SPEED LIMITER (SET AT 120km/h

READINESS TAKE-OFF **ACCEPTANCE** POOR

NET COST (1 OFF) $1.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: ASSUMES THAT ENGINE MANAGEMENT CHIP IS RECODED TO LOWER THE MAXIMUM SPEED (MOST ARE SET AT 250km/h+). IN THE LONG TERM THIS WILL BE NIL COST
(Also see references

CRASH INFLUENCE: PROPORTION OF CRASHES ESTIMATED TO INVOLVE SPEEDS IN EXCESS OF 120km/h. ESTIMATED 3% OF ALL FATALS AND 1% OF OTHERS.

EFFECTIVENESS: HIGHLY EFFECTIVE FOR THESE CRASHES. ASSUME 100%. JOYRIDING DETERRENT (HIGH RISK GROUP)

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	3%	1%	1%	1%
% EFFECTIVENESS	100%	100%	100%	100%
$ SAVED PER VEHICLE/YEAR	$4.26	$2.52	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 67.22 HI*: 67.22

TOTAL SAVINGS/YR **$9.57**

NET SAVINGS/YR $9.57
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R22	SPEED CONTROL DEVICES FOR CARS

FEATURE CODE STR_ADJ **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION ADJUSTABLE STEERING COLUMN

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON PRODUCTION LINE CHANGE. NEGLIGIBLE IN LONG TERM.
(Also see references

CRASH INFLUENCE: LOSS OF CONTROL CRASHES. SMALL NUMBER OF FATIGURE CRASHES. ASSUMED 5% OF ALL.

EFFECTIVENESS: MODERATE. ASSUME 10%

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	5%	5%	5%	5%
% EFFECTIVENESS	10%	10%	10%	10%
$ SAVED PER VEHICLE/YEAR	$0.71	$1.26	$0.68	$0.72

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.24 HI*: 0.24

TOTAL SAVINGS/YR **$3.37**

NET SAVINGS/YR $3.37
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L90	STEERING COLUMN MOVEMENT IN SEVERE FRONTAL CRASHES - EFFECT ON AI

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* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE WIPER_AUTO **CATEGORY** *DRIVERS CONTROL OF VEHICLE*

DESCRIPTION WIPERS AUTOMATIC

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON AFTERMARKET KITS SUCH AS HEADLIGHT ALERTS.
(Also see references

CRASH INFLUENCE: WET WEATHER ACCIDENTS. 18% OF FATALS, 21% OF INJURY, 26% OF PROPERY

EFFECTIVENESS: ONLY WHERE DRIVER'S FAIL TO OPERATE WIPERS. PERHAPS 5%.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	18%	21%	21%	26%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$1.28	$2.65	$1.43	$1.86

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.51 HI*: 0.51

TOTAL SAVINGS/YR **$7.21**

NET SAVINGS/YR $7.21
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE ABS **CATEGORY** *HANDLING AND BRAKING*

DESCRIPTION ABS BRAKES

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: GLASS'S GUIDE TYPICAL VALUE.
(Also see references

CRASH INFLUENCE: ASSUME 70% OF ALL ACCIDENTS INVOLVE EMERGENCY BRAKING. FORS STUDIES OF PEDESTRIAN ACCIDENTS FOUND THAT IN HALF THE CASES THERE WAS NO PRE-CRASH AVOIDANCE. LESS WITH OTHER TYPES OF ACCIDENTS.

EFFECTIVENESS: ABS ONLY EFFECTIVE FOR A SMALL PROPORTION WHERE LOSS OF CONTROL OCCURRED OR DRIVER WAS RELUCTANT TO BRAKE HEAVILY FOR FEAR OF SKIDDING. ASSUMED 10% OF ALL EMERGENCY BRAKING CASES.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	70%	70%	70%	70%
% EFFECTIVENESS	10%	10%	10%	10%
$ SAVED PER VEHICLE/YEAR	$9.94	$17.64	$9.52	$10.01

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.83 HI*: 0.83

TOTAL SAVINGS/YR **$47.11**

NET SAVINGS/YR $47.11
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
N15	Pedestrian safety
R04	Reducing traffic injuries through vehicle safety improvements

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE HEADWAY **CATEGORY** *HANDLING AND BRAKING*

DESCRIPTION HEADWAY RADAR FOR EXCESSIVE CLOSING SPEEDS

READINESS START-UP **ACCEPTANCE** POOR

NET COST (1 OFF) $800.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: PROTOTYPES ONLY AT THIS STAGE. BASED ON SIMILAR ELECTRONIC SYSTEMS SUCH AS CD PLAYER.
(Also see references

CRASH INFLUENCE: MOSTLY VEHICLES RUNNING INTO THE REAR OF VEHICLE IN FRONT ABOUT 20% OF ALL CRASHES

EFFECTIVENESS: US DATA SUGGESTS 25% OF ALL ACCIDENTS INVOLVE DISTRACTION. ASSUME HEADWAY ALERT WOULD INFLUENCE ABOUT ONE THIRD OF THESE - SAY 10% OVERALL.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$214.00	$341.00	$194.00	$376.00
% OF CRASHES INFLUENCED	20%	20%	20%	20%
% EFFECTIVENESS	10%	10%	10%	10%
$ SAVED PER VEHICLE/YEAR	$4.28	$6.82	$3.88	$7.52

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.20 **HI*:** 0.20

TOTAL SAVINGS/YR **$22.50**

NET SAVINGS/YR $22.50
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K67	HOW SON TO BRAKE AND HOW HARD TO BRAKE
K68	DISTANCE BEHAVIOUR ON MOTORWAYS WITH REGARD TO ACTIVE SAFTEY
K69	NHTSA DRIVER DISTRACTION RESEARCH
L64	Neck and spinal injuries: injury outcome and crash characteristics in Aust.
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

FEATURE CODE IRS **CATEGORY** *HANDLING AND BRAKING*

DESCRIPTION INDEPENDENT REAR SUSPENSION

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $300.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: GLASS'S GUIDE
(Also see references

CRASH INFLUENCE: ASSUME 30% OF ALL ACCIDENTS INVOLVE SWERVING OR OTHER DIRECTIONAL CONTROL.

EFFECTIVENESS: LOW EFFECTIVENESS (ASSUME 2%) UNLESS COMBINED WITH BETTER TYRES.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	30%	30%	30%	30%
% EFFECTIVENESS	2%	2%	2%	2%
$ SAVED PER VEHICLE/YEAR	$0.85	$1.51	$0.82	$0.86

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.09 **HI*:** 0.09

TOTAL SAVINGS/YR **$4.04**

NET SAVINGS/YR $4.04
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE POWER_STR **CATEGORY** *HANDLING AND BRAKING*

DESCRIPTION POWER STEERING

READINESS SATURATION **ACCEPTANCE** GOOD

NET COST (1 OFF) $300.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: GLASS'S GUIDE

(Also see references

CRASH INFLUENCE: SOME ACCIDENTS INVOLVING LOSS OF CONTROL AND A SMALL PROPORTION OF FATIGUE ACCIDENTS. ASSUME AROUND 20% OF ALL ACCIDENTS

EFFECTIVENESS: LOW EFFECTIVENESS. ASSUME 5%.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	20%	20%	20%	20%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$1.42	$2.52	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.16 **HI*:** 0.16

TOTAL SAVINGS/YR **$6.73**

NET SAVINGS/YR $6.73

(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE TRACTION **CATEGORY** *HANDLING AND BRAKING*

DESCRIPTION TRACTION CONTROL

READINESS TAKE-OFF **ACCEPTANCE** GOOD

NET COST (1 OFF) $700.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: SURVEY OF DEALERS

(Also see references

CRASH INFLUENCE: LOSS OF CONTROL ACCIDENTS INVOLVING EXCESSIVE ACCELERATION. 5% OF ALL

EFFECTIVENESS: LOW DUE TO EXTRA RISK TAKING. SAY 5%.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	5%	5%	5%	5%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$0.36	$0.63	$0.34	$0.36

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.02 **HI*:** 0.02

TOTAL SAVINGS/YR **$1.68**

NET SAVINGS/YR $1.68

(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE TYRE_PRES **CATEGORY** *HANDLING AND BRAKING*

DESCRIPTION TYRE PRESSURE MONITORING

READINESS START-UP **ACCEPTANCE** MODERATE

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: PROTOTYPE TECHNOLOGY (FOR CARS). BASED ON SIMILAR ELECTRONIC SYSTEMS.
(Also see references

CRASH INFLUENCE: ACCIDENTS INVOLVING TYRE FAILURE. 0.5%

EFFECTIVENESS: LOW. PERHAPS 5%

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	1%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$0.04	$0.06	$0.03	$0.04

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.00 HI*: 0.00

TOTAL SAVINGS/YR **$0.17**

NET SAVINGS/YR $0.17
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE TYRE_RF **CATEGORY** *HANDLING AND BRAKING*

DESCRIPTION RUN FLAT TYRES

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: ASSUMES A NOMINAL $100 EXTRA PER TYRE (IE ABOUT DOUBLE THE COST OF A NORMAL TYRE)
(Also see references

CRASH INFLUENCE: ACCIDENTS DUE TO TYRE FAILURE 0.5%

EFFECTIVENESS: MODERATE. PERHAPS 20%

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	1%
% EFFECTIVENESS	20%	20%	20%	20%
$ SAVED PER VEHICLE/YEAR	$0.14	$0.25	$0.14	$0.14

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.01 HI*: 0.01

TOTAL SAVINGS/YR **$0.67**

NET SAVINGS/YR $0.67
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

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* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE DRV_LIGHTS **CATEGORY** *HAZARD RECOGNITION BY DRIVER*

DESCRIPTION DRIVING LIGHTS

READINESS HARVEST **ACCEPTANCE** POOR

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$5.00**

COST NOTE: RETAIL PRICE OF BASIC SYSTEMS. MAINTENANCE COST ASSUMES GLOBE FAILURE EVERY 3 YEARS.
(Also see references

CRASH INFLUENCE: NIGHTTIME (36% OF FATALS. 21% OF OTHERS) WHERE NORMAL HEADLIGHTS DID NOT PROVIDE SUFFICIENT LIGHTING (PERHAPS 10%): 3.6% FATALS, 2.1% OF OTHERS

EFFECTIVENESS: PERHAPS ONE QUARTER COULD HAVE BEEN PREVENTED BY BETTER LIGHTING.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	4%	2%	2%	2%
% EFFECTIVENESS	25%	25%	25%	25%
$ SAVED PER VEHICLE/YEAR	$1.28	$1.32	$0.71	$0.75

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.00 HI*: 0.00

TOTAL SAVINGS/YR **$4.07**

NET SAVINGS/YR -$0.93
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

FEATURE CODE FOG_LAMPS **CATEGORY** *HAZARD RECOGNITION BY DRIVER*

DESCRIPTION FOG LAMPS

READINESS HARVEST **ACCEPTANCE** POOR

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$5.00**

COST NOTE: RETAIL PRICE OF BASIC SYSTEMS. MAINTENANCE COST ASSUMES GLOBE FAILURE EVERY 3 YEARS.
(Also see references

CRASH INFLUENCE: ACCIDENTS OCCURRING IN FOG. PROBABLY LESS THAN 1% OF ALL IN AUSTRALIA (CF 20% ON WET ROADS).

EFFECTIVENESS: PERHAPS ONE QUARTER COULD BE PREVENTED.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	1%
% EFFECTIVENESS	25%	25%	25%	25%
$ SAVED PER VEHICLE/YEAR	$0.36	$0.63	$0.34	$0.36

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.00 HI*: 0.00

TOTAL SAVINGS/YR **$1.68**

NET SAVINGS/YR -$3.32
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE HI_GLASS **CATEGORY** *HAZARD RECOGNITION BY DRIVER*

DESCRIPTION HIGH TRANSMITTANCE GLAZING

READINESS START-UP **ACCEPTANCE** MODERATE

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: COULD BE NIL COST IN THE LONG TERMN BUTR ASSUME THE IMPROVED GALZING TECHNOLOGY IS NEEDED TO CUT HEAT TRANSMISSION WHILE LETTING VISIBLE
(Also see references

CRASH INFLUENCE: NIGHT, DUSK AND DAWN 58% OF FATALS AND 47% OF OTHERS

EFFECTIVENESS: PERHAPS 3%, BASED ON US FIELD OF VIEW RESEARCH. RAMIFICATIONS FOR TINTED WINDOWS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	58%	47%	47%	47%
% EFFECTIVENESS	3%	3%	3%	3%
$ SAVED PER VEHICLE/YEAR	$2.47	$3.55	$1.92	$2.02

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.40 **HI*:** 1.40

TOTAL SAVINGS/YR **$9.96**

NET SAVINGS/YR $9.96
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

FEATURE CODE MIRR_DIM **CATEGORY** *HAZARD RECOGNITION BY DRIVER*

DESCRIPTION AUTO DIMMING REAR VIEW MIRROR

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON SIMILAR ELECTRONIC DEVICES.
(Also see references

CRASH INFLUENCE: NIGHTTIME (36% FATALS, 21% OF OTHERS)

EFFECTIVENESS: WHERE GLARE FROM FOLLOWING VEHICLE'S HEADSLIGHTS CONTRIBUTED TO ACCIDENT. NO DATA BUT ASSUME 1%.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	36%	21%	21%	21%
% EFFECTIVENESS	1%	1%	1%	1%
$ SAVED PER VEHICLE/YEAR	$0.51	$0.53	$0.29	$0.30

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.06 **HI*:** 0.06

TOTAL SAVINGS/YR **$1.63**

NET SAVINGS/YR $1.63
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE MIRR_FOG **CATEGORY** *HAZARD RECOGNITION BY DRIVER*

DESCRIPTION ANTI FOGGING (HEATED) EXTERNAL MIRRORS

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON SIMILAR ELECTRONIC EQUIP.
(Also see references

CRASH INFLUENCE: COLD, HUMID CONDITIONS - MOSTLY AT NIGHT. VERY DEPENDENT ON GEOGRAPHIC LOCATION. PERHAPS 1% OF ACCIDENTS ON AVERAGE

EFFECTIVENESS: CASES WHERE POOR VIEW IN EXTERNAL MIRRORS CONTRIBUTED. PERHAPS 5% EFFECTIVE.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	1%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$0.07	$0.13	$0.07	$0.07

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.01 **HI*:** 0.01

TOTAL SAVINGS/YR **$0.34**

NET SAVINGS/YR $0.34
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE MIRROR_AUTO **CATEGORY** *HAZARD RECOGNITION BY DRIVER*

DESCRIPTION EXTERNAL MIRRORS ELECTRICALLY ADJUSTABLE

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON ETSC REPORT.
(Also see references

CRASH INFLUENCE: ACCIDENTS WHERE DRIVER DID NOT RECOGNISE HAZARD TO REAR. PERHAPS 20% OF ALL ACCIDENTS.

EFFECTIVENESS: CASES WHERE MIRROR WAS NOT CORRECTLY ADJUSTED FOR DRIVER (20%?) TIMES CHANCES THAT DRIVER WOULD USE THE ELECTRIC ADJUSTMENT CORRECTLY (50%?) = 10%

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	20%	20%	20%	20%
% EFFECTIVENESS	10%	10%	10%	10%
$ SAVED PER VEHICLE/YEAR	$2.84	$5.04	$2.72	$2.86

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.47 **HI*:** 0.47

TOTAL SAVINGS/YR **$13.46**

NET SAVINGS/YR $13.46
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R04	Reducing traffic injuries through vehicle safety improvements

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE WIPER_SPD **CATEGORY** *HAZARD RECOGNITION BY DRIVER*

DESCRIPTION SPEED SENSITIVE INTERMITTENT WIPERS

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON COST OF OTHER ELECTRONIC GADGETS. MANY LUXURY VEHICLES NOW HAVE THIS FEATURE AS STANDARD.
(Also see references

CRASH INFLUENCE: WET WEATHER ACCIDENTS. 18% OF FATALS, 21% OF INJURY, 26% OF PROPERY

EFFECTIVENESS: LIGHT RAIN/SPRAY WHERE FIXED PERIOD NOT ADEQUATE. PERHAPS 5% OF CASES.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	18%	21%	21%	26%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$1.28	$2.65	$1.43	$1.86

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.51 **HI*:** 0.51

TOTAL SAVINGS/YR **$7.21**

NET SAVINGS/YR $7.21
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE BDY_COL **CATEGORY** *HAZARD RECOGNITION BY OTHERS*

DESCRIPTION CONSPICUOUS BODY COLOUR

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST. COULD BE NIL COST FOR SOME COLOURS. FOR COMPARISON "METALLIC" PAINT TYPICALLY COSTS ABOUT $200-$300.
(Also see references

CRASH INFLUENCE: ACCIDENTS WHERE OTHER DRIVER DID NOT SEE SUBJECT VEHICLE. ASSUMED DAWN AND DUSK (20% OF ALL ACCIDENTS) . TWO VEHICLE ACCIDENTS (70% OF FATALS, 75% OF OTHERS) = 14% FATALS AND 15% OF OTHERS.

EFFECTIVENESS: BODY COLOUR WILL ONLY CHANGE OUTCOME WHERE AMBIENT LIGHT AND BACKGROUND ARE MORE FAVORABLE TO THE CHOSEN COLOUR. PERHAPS 10% OF ALL CASES. TOKEN COST OF ALTERNATIVE BODY COLOUR MAKES B/C CALC DUBIOUS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	14%	15%	15%	15%
% EFFECTIVENESS	10%	10%	10%	10%
$ SAVED PER VEHICLE/YEAR	$1.99	$3.78	$2.04	$2.15

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.70 **HI*:** 0.70

TOTAL SAVINGS/YR **$9.95**

NET SAVINGS/YR $9.95
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R09	ESV Government Reports - The Netherlands
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE DRL **CATEGORY** *HAZARD RECOGNITION BY OTHERS*

DESCRIPTION DAYTIME RUNNING LIGHTS

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$2.00**

COST NOTE: OE COSTS AND ANNUAL MAINTENANCE BASED ON DUTCH AND CANADIAN
(Also see references ESTIMATES. AFTERMARKET COST ABOUT $200 BASED ON DISCUSSIONS WITH AUTO-

CRASH INFLUENCE: NON-NIGHTTIME (64% OF FATALS. 79% OF OTHERS) TWO VEHICLE ACCIDENTS (70% OF FATALS, 75% OF OTHERS) = 45% FATALS AND 59% OF OTHERS.

EFFECTIVENESS: MORE EFFECTIVE AT DAWN AND DUSK (AROUND ONE QUARTER OF NON-NIGHT ACCIDENTS. RESEARCH ESTIMATES AVERAGE 15% EFFECTIVE.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	45%	59%	59%	59%
% EFFECTIVENESS	15%	15%	15%	15%
$ SAVED PER VEHICLE/YEAR	$9.59	$22.30	$12.04	$12.66

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 7.67 HI*: 7.67

TOTAL SAVINGS/YR **$56.58**

NET SAVINGS/YR $54.58
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K58	DAYTIME RUNNING LIGHTS - A NORTH AMERICAN SUCCESS STORY
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

FEATURE CODE HEADL_ON **CATEGORY** *HAZARD RECOGNITION BY OTHERS*

DESCRIPTION HEADLIGHTS ON WARNING/AUTO

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$20.00**

COST NOTE: OE COSTS AND ANNUAL MAINTENANCE BASED ON DUTCH AND CANADIAN
(Also see references ESTIMATES. AFTERMARKET COST ABOUT $150 BASED ON DISCUSSIONS WITH AUTO-

CRASH INFLUENCE: NON-NIGHTTIME (64% OF FATALS. 79% OF OTHERS) TWO VEHICLE ACCIDENTS (70% OF FATALS, 75% OF OTHERS) = 45% FATALS AND 59% OF OTHERS.

EFFECTIVENESS: MORE EFFECTIVE AT DAWN AND DUSK (AROUND ONE QUARTER OF NON-NIGHT ACCIDENTS). DAYTIME RUNNING LIGHTS AROUND 15% AND HEADLIGHTS SHOULD BE MORE EFFECTIVE - PERHAPS 20% (ALARM LESS EFFECTIVE). HEADLIGHT REPLACEMENT COULD BE COSTLY.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	45%	59%	59%	59%
% EFFECTIVENESS	20%	20%	20%	20%
$ SAVED PER VEHICLE/YEAR	$12.78	$29.74	$16.05	$16.87

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 7.79 HI*: 7.79

TOTAL SAVINGS/YR **$75.44**

NET SAVINGS/YR $55.44
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K58	DAYTIME RUNNING LIGHTS - A NORTH AMERICAN SUCCESS STORY
R04	Reducing traffic injuries through vehicle safety improvements
R09	ESV Government Reports - The Netherlands
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE CARGO_BAR **CATEGORY** *HAZARD TO OCCUPANTS*

DESCRIPTION CARGO BARRIER

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $300.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: SURVEY OF DEALERS FOR COST AS OPTIONAL EQUIPMENT.
(Also see references

CRASH INFLUENCE: STATION WAGGONS AND VANS = 25% OF ALL LIGHT VEH. BUT COSTED PER VEHICLE THEREFORE 100%. MOSTLY FRONTAL COLLISIONS - 60%.

EFFECTIVENESS: ONLY EFFECTIVE WHERE HAZARDOUS CARGO IS PRESENT. PERHAPS 5% OF CASES. NO EFFECT ON PROPERTY LOSS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	60%
% EFFECTIVENESS	5%	5%	5%	5%
$ SAVED PER VEHICLE/YEAR	$4.26	$7.56	$4.08	$4.29

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.47 **HI*:** 1.89

TOTAL SAVINGS/YR **$20.19**

NET SAVINGS/YR $20.19
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K15	Automotive load protection
L78	VEHICLE OCCUPANT SURVEY 1994
M31	INFLUENCE OF REAR (LUGGAGE) LOADING ON CHILD RESTRAINTS

FEATURE CODE FOOT_PROT **CATEGORY** *HAZARD TO OCCUPANTS*

DESCRIPTION IMPROVED FOOT PROTECTION

READINESS START-UP **ACCEPTANCE** GOOD

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST. IMPROVED DESIGNS SHOULD NOT COST MORE IN LONG TERM.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL COLLISIONS (60%) INVOLVING FOOT INJURY (6%) GIVES 4% FOR INJURY BUT NIL FOR FATALS AND PROPERTY.

EFFECTIVENESS: SCOPE FOR MAJOR IMPROVEMENT. 50% REDUCTION ASSUMED.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	0%	4%	4%	0%
% EFFECTIVENESS	0%	50%	50%	0%
$ SAVED PER VEHICLE/YEAR	$0.00	$5.04	$2.72	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.55 **HI*:** 0.55

TOTAL SAVINGS/YR **$7.76**

NET SAVINGS/YR $7.76
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L15	Lower limb injuries to passenger car occupants
L16	Foot and leg injuries in frontal car collisions
L21	Seat belt limitations in collisions with no compromise of passenger compartment
L59	The reduction of the risk of lower leg injuries in offset crash tests
L62	Lower extremity loads in offset frontal crashes
L80	SAFETY BENEFITS RESULTING FROM VEHICLE DESIGN CHANGES SINCE THE IN
L85	FACTORS INFLUENCING LOWER EXTREMITY INJURIES

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* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE GLASS_LAM **CATEGORY** *HAZARD TO OCCUPANTS*

DESCRIPTION LAMINATED OR SHATTER-PROOF GLAZING FOR ALL WINDOWS

READINESS START-UP **ACCEPTANCE** MODERATE

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: ASSUMES THAT WINDSCREENS ARE ALREADY LAMINATED. COST BASED ON
(Also see references ESTIMATED COST DIFFERENCE BETWEEN LAMINATED AND TEMPERED WINDSCREEN,

CRASH INFLUENCE: MOSTLY SIDE IMPACT AND ROLLOVER CRASHES - 30% OF CRASHES.

EFFECTIVENESS: ONLY EFFECTIVE WHERE IT HELPS TO RESTRAIN OCCUPANT WITHIN VEHICLE AND PREVENT CONTACT WITH EXTERNAL OBJECTS OR PREVENTS LACERATIONS. L58 ESTIMATES 3% OF ALL CASUALTIES SUGGESTING 10% EFFECTIVENESS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	30%	30%	30%	0%
% EFFECTIVENESS	10%	10%	10%	0%
$ SAVED PER VEHICLE/YEAR	$4.26	$7.56	$4.08	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.12 **HI*:** 1.12

TOTAL SAVINGS/YR **$15.90**

NET SAVINGS/YR $15.90
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L58	Glazing effects of door or frame deformations in crashes, Part 2
L64	Neck and spinal injuries: injury outcome and crash characteristics in Aust.

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE HEAD_PAD **CATEGORY** *HAZARD TO OCCUPANTS*

DESCRIPTION HEAD PROTECTION PADDING

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON PAPERS FROM 16TH ESV.
(Also see references

CRASH INFLUENCE: MOSTLY SIDE IMPACTS AND ROLLOVERS (30% OF CRASHES).

EFFECTIVENESS: NHTSA ESTIMATE 6% OF ALL FATALITIES DUE TO HEAD CONTACTS, SUGGESTING 20% OF INFLUENCED CRASHES (6/0.3). ASSUME 50% EFFECTIVE IN THESE CASES = 10% OF FATAL AND SERIOUS. PERHAPS 5% OF MINOR.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	30%	30%	30%	30%
% EFFECTIVENESS	10%	10%	5%	0%
$ SAVED PER VEHICLE/YEAR	$4.26	$7.56	$2.04	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.49 **HI*:** 0.49

TOTAL SAVINGS/YR **$13.86**

NET SAVINGS/YR $13.86
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L17	Upper interior head, face and neck injury experiments
L26	Upper interior head impact protection of occupants in real world crashes
L36	The role of the upper car interior in car occupant brain injury
L38	Protective headgear for car occupants
L39	New requirements and solutions on head impact protection
L51	Head and neck injury in side impacts
L53	The risk of skull/brain injuries in modern cars
L61	Head injury risk assessment and prevention in automobile accidents
L81	NARROW OBJECT CRASHES AND INJURY OUTCOMES
L82	TIMBER POLE CRASHES

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE HELMET **CATEGORY** *HAZARD TO OCCUPANTS*

DESCRIPTION HELMETS/HEAD BANDS FOR OCCUPANTS

READINESS START-UP **ACCEPTANCE** POOR

NET COST (1 OFF) $30.00 **MAINTENANCE/YR:** **$10.00**

COST NOTE: BASED ON A LOW COST BICYCLE HELMET (RETAIL VALUE)
(Also see references

CRASH INFLUENCE: MOSTLY SIDE IMPACTS AND ROLLOVERS (30% OF CRASHES).

EFFECTIVENESS: NHTSA ESTIMATE 6% OF ALL FATALITIES DUE TO HEAD CONTACTS, SUGGESTING 20% OF INFLUENCED CRASHES (6/0.3). ASSUME 50% EFFECTIVE IN THESE CASES = 10% OF FATAL AND SERIOUS. PERHAPS 5% OF MINOR. REPLACED EVERY THREE YEARS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	30%	30%	30%	30%
% EFFECTIVENESS	10%	10%	5%	0%
$ SAVED PER VEHICLE/YEAR	$4.26	$7.56	$2.04	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.90 **HI*:** 0.90

TOTAL SAVINGS/YR **$13.86**

NET SAVINGS/YR $3.86
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K01	Crashworthness research at the NHMRC Road Accident Research Unit
L26	Upper interior head impact protection of occupants in real world crashes
L36	The role of the upper car interior in car occupant brain injury
L38	Protective headgear for car occupants
L39	New requirements and solutions on head impact protection
L53	The risk of skull/brain injuries in modern cars
L61	Head injury risk assessment and prevention in automobile accidents
L81	NARROW OBJECT CRASHES AND INJURY OUTCOMES

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE KNEE_PAD **CATEGORY** *HAZARD TO OCCUPANTS*

DESCRIPTION KNEE BOLSTER/PADDING

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON MUARC REPORT CR100.
(Also see references

CRASH INFLUENCE: Frontal crashes involving upper leg injury.

EFFECTIVENESS: Properly designed bolsters should be effective. MUARC estimates 5.3% HARM reduction

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	0%	10%	10%	0%
% EFFECTIVENESS	0%	50%	50%	0%
$ SAVED PER VEHICLE/YEAR	$0.00	$12.60	$6.80	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.36 **HI*:** 1.36

TOTAL SAVINGS/YR **$19.40**

NET SAVINGS/YR $19.40
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L43	Feasibility of Occupant Protection Countermeasures
L85	FACTORS INFLUENCING LOWER EXTREMITY INJURIES
L89	COMPARISON OF EURONCAP ASSESSMENTS WITH INJURY CAUSATION IN ACCI

FEATURE CODE LOAD_RESTR **CATEGORY** *HAZARD TO OCCUPANTS*

DESCRIPTION LOAD RESTRAINT DEVICES (TETHERS)

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: AUTHOR'S EXPERIENCE PURCHASING THESE ITEMS (RETAIL).
(Also see references

CRASH INFLUENCE: FRONTAL CRASHES INVOLVES WAGONS, VANS AND HATCHES. ~ 40% OF LIGHT VEHICLE FLEET BUT 100% OF THESE VEHICLES.

EFFECTIVENESS: NO DATA. ASSUME HALF EFFECTIVENESS OF CARGO BARRIER DUE TO MISUSE AND LACK OF USE.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	60%
% EFFECTIVENESS	3%	3%	3%	0%
$ SAVED PER VEHICLE/YEAR	$2.56	$4.54	$2.45	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.67 **HI*:** 2.68

TOTAL SAVINGS/YR **$9.54**

NET SAVINGS/YR $9.54
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K15	Automotive load protection
M31	INFLUENCE OF REAR (LUGGAGE) LOADING ON CHILD RESTRAINTS

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE AB_BONNET **CATEGORY** *HAZARD TO OTHER ROAD USERS*

DESCRIPTION BONNET AIRBAG FOR PEDESTRIAN PROTECTION

READINESS START-UP **ACCEPTANCE** POOR

NET COST (1 OFF) $500.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOT IN PRODUCTION. COST BASED ON PASSENGER AIRBAG, ASSUMING VOLUME PRODUCTION IN LONG TERM.
(Also see references

CRASH INFLUENCE: PEDESTRIAN FATALITIES EQUIVALENT TO 31% OF CAR OCCUPANT FATALITIES. 16% OF INJURIES.

EFFECTIVENESS: ABOUT 60% ARE SERIOUS HEAD INJURIES. ASSUME AIRBAGS WILL REDUCE THESE BY HALF.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	31%	16%	16%	0%
% EFFECTIVENESS	30%	30%	30%	0%
$ SAVED PER VEHICLE/YEAR	$13.21	$12.10	$6.53	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.45 HI*: 0.45

TOTAL SAVINGS/YR **$31.83**

NET SAVINGS/YR $31.83
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L77	Ford focuses on safety
N21	Pedestrian head impact testing at the University of Adelaide
N25	Computer simulation system for car-pedestrian accident
N29	SUMMARY OF IHRA PEDESTRIAN SAFETY WG
N30	EVALUATION OF PEDESTRIAN AIRBAG THROUGH MODELLING AND TESTING
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE PED_IMP **CATEGORY** *HAZARD TO OTHER ROAD USERS*

DESCRIPTION PEDESTRIAN FRIENDLY VEHICLE FRONT

READINESS START-UP **ACCEPTANCE** POOR

NET COST (1 OFF) $500.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: COST ESTIMATE BASED ON 2 PAPERS AT 16TH ESV (LAWRENCE AND OTUBUSHIN).
(Also see references MID-RANGE USE TO BALANCE GOVERNMENT AND INDUSTRY ESTIMATES.

CRASH INFLUENCE: NEARLY ALL PEDESTRIAN ACCIDENTS (27% OF FATALS INVOLVING LIGHT VEHICLES, 25% OF SERIOUS, 14% OF MINOR)

EFFECTIVENESS: EUROPEAN RESEARCH SUGGESTS MEASURES WOULD BE HIGHLY EFFECTIVE BUT ASSUME 50% TO COVER UNCERTAINTY.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	27%	25%	14%	0%
% EFFECTIVENESS	50%	50%	50%	0%
$ SAVED PER VEHICLE/YEAR	$19.17	$31.50	$9.52	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.85 **HI*:** 0.85

TOTAL SAVINGS/YR **$60.19**

NET SAVINGS/YR $60.19
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K54	Road safety strategy: current problems and future options
N02	Benefits from changes in vehicle exterior design - in Europe
N12	Pedestrian safety testing using the EEVC pedestrian impactors
N15	Pedestrian safety
N26	AUSTRALIA'S INVOLVEMENT IN IHRA PEDESTRIAN SAFETY
N28	PEDESTRIAN INJURY PROJECTION IN AUSTRALIA IF VEHICLES ACHIEVE HIGH S
N29	SUMMARY OF IHRA PEDESTRIAN SAFETY WG
N30	EVALUATION OF PEDESTRIAN AIRBAG THROUGH MODELLING AND TESTING

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE AB_SMART **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SMART AIRBAG SYSTEM

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $500.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON AUTOLIV PAPER.
(Also see references

CRASH INFLUENCE: ASSUME FRONTAL CRASHES ONLY - 60% OF ALL

EFFECTIVENESS: AIRBAGS + SEAT BELTS ALREADY HIGHLY EFFECTIVE. SMART AIRBAGS WILL BENEFIT AGED AND SMALL OCCUPANTS - SAY 20% OF ALL OCCUPANTS AND 50% EFFECTIVE = 10% OF ALL OCCUPANTS
K54 ESTIMATES 4 TO 8% OF ALL CASUALTIES

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	60%
% EFFECTIVENESS	10%	10%	5%	0%
$ SAVED PER VEHICLE/YEAR	$8.52	$15.12	$4.08	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.39 **HI*:** 0.39

TOTAL SAVINGS/YR **$27.72**

NET SAVINGS/YR $27.72
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K54	Road safety strategy: current problems and future options
L34	Smart seat belts - some population considerations
L44	New restraint technologies for vehicle safety
L57	Optimisation of an intelligent total restraint system
L83	EFFECT OF OCCUPANT CHARACTERISTICS IN INJURY RISK - ACTIVE RESTRAIN

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE AIRBAG_D **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION DRIVER AIRBAG

READINESS HARVEST **ACCEPTANCE** EXCELLENT

NET COST (1 OFF) $600.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: GLASS'S GUIDE AND DATA GATHERED FOR ANCAP.
(Also see references

CRASH INFLUENCE: ASSUME FRONTAL CRASHES - 60% OF ALL

EFFECTIVENESS: L30 INDICATES FATALS AND SERIOUS INJURIES REDUCE BY 40%. BUT L43 INDICATES OVERALL SAVING OF 15%, SUGGESTING 25% EFFECTIVENESS. LATTER USED.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	60%
% EFFECTIVENESS	25%	25%	10%	0%
$ SAVED PER VEHICLE/YEAR	$21.30	$37.80	$8.16	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.79 HI*: 0.79

TOTAL SAVINGS/YR **$67.26**

NET SAVINGS/YR $67.26
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K07	The effectiveness of ADRs aimed at occupant protection.
L30	The effect of airbags to injuries and accident costs
L43	Feasibility of Occupant Protection Countermeasures
L45	Effectiveness of Occupant Protection Systems and Their Use
L79	EFFECTIVENESS OF AIRBAGS IN AUSTRALIA
L80	SAFETY BENEFITS RESULTING FROM VEHICLE DESIGN CHANGES SINCE THE IN
L86	EFFECTIVENESS OF (DRIVER) AIRBAGS IN AUSTRALIA
L90	STEERING COLUMN MOVEMENT IN SEVERE FRONTAL CRASHES - EFFECT ON AI
R09	ESV Government Reports - The Netherlands
R11	Wilingness to pay for vehicle safety features

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE AIRBAG_P **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION FRONT PASSENGER AIRBAG

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: GLASS'S GUIDE AND SURVEY OF DEALERS.
(Also see references

CRASH INFLUENCE: FRONTAL CRASHES. INJURIES TO FRONT PASSENGER ONLY. 60% OF CRASHES x 20% OF INJURED OCCUPANTS (L78)

EFFECTIVENESS: L43 SUGGESTS PASSENGER AIRBAG ABOUT 20% EFFECTIVE (LESS THAN DRIVER). COST OF UNNECESSARY DEPLOYMENTS?

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	12%	12%	12%	12%
% EFFECTIVENESS	20%	20%	10%	0%
$ SAVED PER VEHICLE/YEAR	$3.41	$6.05	$1.63	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.19 HI*: 0.97

TOTAL SAVINGS/YR **$11.09**

NET SAVINGS/YR $11.09
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
L43	Feasibility of Occupant Protection Countermeasures
L78	VEHICLE OCCUPANT SURVEY 1994
L80	SAFETY BENEFITS RESULTING FROM VEHICLE DESIGN CHANGES SINCE THE IN
L84	PRELIMINARY EVALUATION OF PASSENGER AIRBAG EFFECTIVENESS IN AUSTR
R04	Reducing traffic injuries through vehicle safety improvements

FEATURE CODE CR_INT **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION CHILD SEAT INTEGRATED

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $500.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON SEAT COSTS AND UPMARKET CHILD RESTRAINTS.
(Also see references

CRASH INFLUENCE: YOUNG CHILDREN INJURED IN CAR ACCIDENTS: 2% OF CAR OCCUPANTS INJURED OR KILLED.

EFFECTIVENESS: ONLY EFFECTIVE WHERE A CHILD RESTRAINT IS NOT USED OR MISUSED. PERHAPS 50% OF SERIOUS INJURIES BASED ON M08.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	2%	2%	2%	0%
% EFFECTIVENESS	50%	50%	0%	0%
$ SAVED PER VEHICLE/YEAR	$1.42	$2.52	$0.00	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.06 HI*: 0.28

TOTAL SAVINGS/YR **$3.94**

NET SAVINGS/YR $3.94
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
M08	Children in car crashes
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE HR_ADJ **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION ADJUSTABLE HEAD RESTRAINT

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST FOR ALL SEATS.
(Also see references

CRASH INFLUENCE: MOSTLY REAR IMPACTS AND LOWER SEVERITY CRASHES - 23% OF MINOR INJURY AND PERHAPS 10% OF SERIOUS/FATAL CRASHES.

EFFECTIVENESS: MARGINAL BECAUSE USER NEEDS TO ADJUST HEAD RESTRAINT TO OPTIMUM POSITION. PERHAPS 10% OF CASES.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	10%	10%	23%	23%
% EFFECTIVENESS	10%	10%	10%	0%
$ SAVED PER VEHICLE/YEAR	$1.42	$2.52	$3.13	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.50 **HI*:** 0.50

TOTAL SAVINGS/YR **$7.07**

NET SAVINGS/YR $7.07
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K17	Effects of car and seat on the loading of occupant's neck in rear impacts
L64	Neck and spinal injuries: injury outcome and crash characteristics in Aust.
L65	What happens to the cervical spinal cord during neck injury?
L66	An overview of ergonomic issues in neck injury amelioration
L67	The measurement of neck injury risk
L68	Neck injury severity and vehicle design

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE HR_RA **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION HEAD RESTRAINTS FOR ALL REAR SEATS

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $120.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON 15% OF SEAT COST
(Also see references

CRASH INFLUENCE: MOSTLY LOWER SEVERITY REAR IMPACTS (23% OF MINOR, 10% OF SERIOUS/FATAL) WHERE THERE ARE REAR SEAT OCCUPANTS (12% OF CARS) = 3% OF MINOR, 1% OF SERIOUS/FATAL

EFFECTIVENESS: PERHAPS 30% EFFECTIVE IN THESE CRASHES, ASSUMING CORRECT GEOMETRY.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	3%	23%
% EFFECTIVENESS	30%	30%	30%	0%
$ SAVED PER VEHICLE/YEAR	$0.43	$0.76	$1.22	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.14 HI*: 0.70

TOTAL SAVINGS/YR **$2.41**

NET SAVINGS/YR $2.41
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K17	Effects of car and seat on the loading of occupant's neck in rear impacts
L64	Neck and spinal injuries: injury outcome and crash characteristics in Aust.
L68	Neck injury severity and vehicle design
L78	VEHICLE OCCUPANT SURVEY 1994

FEATURE CODE HR_RO **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION HEAD RESTRAINTS FOR REAR OUTBOARD SEATS

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $80.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON 15% OF SEAT COST
(Also see references

CRASH INFLUENCE: MOSTLY LOWER SEVERITY REAR IMPACTS (23% OF MINOR, 10% OF SERIOUS/FATAL) WHERE THERE ARE OUTBOARD REAR SEAT OCCUPANTS (10% OF CARS) = 2% OF MINOR, 1% OF SERIOUS/FATAL

EFFECTIVENESS: PERHAPS 30% EFFECTIVE IN THESE CRASHES, ASSUMING CORRECT GEOMETRY.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	2%	2%
% EFFECTIVENESS	30%	30%	30%	0%
$ SAVED PER VEHICLE/YEAR	$0.43	$0.76	$0.82	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.18 HI*: 0.70

TOTAL SAVINGS/YR **$2.00**

NET SAVINGS/YR $2.00
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K17	Effects of car and seat on the loading of occupant's neck in rear impacts
L64	Neck and spinal injuries: injury outcome and crash characteristics in Aust.
L68	Neck injury severity and vehicle design
L78	VEHICLE OCCUPANT SURVEY 1994

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SB_BUCK **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT BUCKLE MOUNTED ON SEAT (FRONT)

READINESS SATURATION **ACCEPTANCE** GOOD

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: MAINLY THE ESTIMATED OF COST OF STRENGTHENING SEAT. MOST VEHICLE NOW HAVE THIS FEATURE.
(Also see references

CRASH INFLUENCE: FRONTAL CRASHES. 60% OF ALL.

EFFECTIVENESS: LOW - ONLY EFFECTIVE WHERE A POORLY FITTING SEAT BELT RESULTED IN INJURY. MOST VEHICLES NOW HAVE THIS FEATURE. SAY 10% OF ALL CASUALTIES AND 20% REDUCTION = 2%

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	2%	2%	2%	0%
$ SAVED PER VEHICLE/YEAR	$1.70	$3.02	$1.63	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.89 **HI*:** 0.89

TOTAL SAVINGS/YR **$6.36**

NET SAVINGS/YR $6.36
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE SB_CR3 **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT, CENTRE REAR 3-POINT

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON PAPER FROM LAP BELT CONFERENCE, 1994.
(Also see references

CRASH INFLUENCE: MAINLY FRONTAL CRASHES (60% OF ALL) BUT ONLY WHERE CENTRE REAR SEAT IS OCCUPIED AND NO CHILD RESTRAINT USED. OBSERVATIONAL SURVEYS SUGGEST LESS THAN 1% OF VEHICLES. ASSUME 1% OVERALL.

EFFECTIVENESS: 3 POINT BELT HALVES INJURY RISK COMPARED TO 2 POINT BELT. ASSUME 50% EFFECTIVE.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	0%
% EFFECTIVENESS	50%	50%	50%	0%
$ SAVED PER VEHICLE/YEAR	$0.71	$1.26	$0.68	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.19 **HI*:** 1.86

TOTAL SAVINGS/YR **$2.65**

NET SAVINGS/YR $2.65
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L70	An overview of manual lap belts in the centre rear
L72	A study of seat belt syndrome in the centre rear seating position
L73	Retrofitting of lap sah seat belts in centre rear seating positions
M28	Lap-only seat belts: findings from the CAPFA study
M29	Seat belt and child restraint usage - 1993

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SB_HARNESS **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION HARNESS SEAT BELT FOR ADULTS (4PT OR 6PT)

READINESS TAKE-OFF **ACCEPTANCE** POOR

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON COST OF NORMAL SEAT BELTS AND ALLOWING FOR EXTRA ANCHORAGE POINTS.
(Also see references

CRASH INFLUENCE: FRONTAL CRASHES (60% OF ALL)

EFFECTIVENESS: LIMITED SCOPE FOR REDUCING INJURY BEYOND EXISTING 3 POINT BELTS. ASSUME 10% OF FATAL AND SERIOUS INJURY INVOLVE SEAT BELT LIMITATIONS AND HARNESS WOULD BE 10% EFFECTIVE = 1% OVERALL..

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	1%	1%	0%	0%
$ SAVED PER VEHICLE/YEAR	$0.85	$1.51	$0.00	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.04 **HI*:** 0.04

TOTAL SAVINGS/YR **$2.36**

NET SAVINGS/YR $2.36
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE SB_HT_ADJ **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT D-RING HEIGHT ADJUSTABLE/AUTOMATIC

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST. NEGLIGIBLE COST IN LONG TERM.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60% OF ALL)

EFFECTIVENESS: CASES WHERE INCORRECT FIT OF SEAT BELT CONTRIBUTED TO INJURY. ASSUME 10% OF FATAL/SERIOUS INJURIES AND 20% EFFECTIVE = 2% OVERALL.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	2%	2%	0%	0%
$ SAVED PER VEHICLE/YEAR	$1.70	$3.02	$0.00	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.33 **HI*:** 0.33

TOTAL SAVINGS/YR **$4.73**

NET SAVINGS/YR $4.73
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L83	EFFECT OF OCCUPANT CHARACTERISTICS IN INJURY RISK - ACTIVE RESTRAIN
M29	Seat belt and child restraint usage - 1993

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SB_ILOCK **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT INTERLOCK

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: (Also see references) OE COST BASED ON MUARC REPORT CR100 AND ESV15 - TURBELL. THESE ARE RELATIVELY SIMPLE SYSTEMS.

CRASH INFLUENCE: ACCIDENTS (MOSTLY FRONTAL) INVOLVING UNRESTRAINED OCCUPANTS WHERE A SEAT BELT WAS AVAILABLE. 22% OF FATALS AND SERIOUS INJURIES, 3% OF MINOR INJURIES.

EFFECTIVENESS: SEAT BELTS 50% EFFECTIVE, COMPARED WITH UNRESTRAINED OCCUPANTS. INTERLOCK PERHAPS 50% EFFECTIVE = 25% OVERALL

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	22%	22%	3%	0%
% EFFECTIVENESS	25%	25%	25%	0%
$ SAVED PER VEHICLE/YEAR	$7.81	$13.86	$1.02	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 3.19 **HI*:** 3.19

TOTAL SAVINGS/YR **$22.69**

NET SAVINGS/YR $22.69
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K54	Road safety strategy: current problems and future options
L41	Fitting and wearing of seat belts in Australia.
L43	Feasibility of Occupant Protection Countermeasures
L54	Optimizing seat belt usage by interlock systems

FEATURE CODE SB_INFLATE **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION INFLATABLE SEAT BELT

READINESS START-UP **ACCEPTANCE** GOOD

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: (Also see references) PROTOTYPE TECHNOLOGY. NOMINAL COST BASED ON PASSENGER AIRBAG (40%)

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60% OF ALL)

EFFECTIVENESS: CASES WHERE SEAT BELTS CONTRIBUTED TO INJURY. ASSUME 10% OF ALL CASES AND INFALTABLE BELT 10% EFFECTIVE = 1% OVERALL.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	1%	1%	1%	0%
$ SAVED PER VEHICLE/YEAR	$0.85	$1.51	$0.82	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.11 **HI*:** 0.11

TOTAL SAVINGS/YR **$3.18**

NET SAVINGS/YR $3.18
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

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* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SB_LL_F **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT LOAD LIMITERS, FRONT

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $20.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: ASSUMED SIMILAR TO WEBBING CLAMPS.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60% OF ALL)

EFFECTIVENESS: CASES WHERE SEAT BELT CONTRIBUTED TO INJURY. ASSUME 10% OF ALL CASES AND THAT LOAD LIMITERS WOULD BE 20% EFFECTIVE = 2% OVERALL FOR FATAL AND SERIOUS. LESS FOR MINOR INJURY.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	2%	2%	1%	0%
$ SAVED PER VEHICLE/YEAR	$1.70	$3.02	$0.82	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.95 **HI*:** 1.95

TOTAL SAVINGS/YR **$5.54**

NET SAVINGS/YR $5.54
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE SB_LL_R **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT LOAD LIMITERS, REAR

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $20.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON MUARC REPORT CR100
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES WITH REAR SEAT OCCUPANTS. 60% OF ALL CRASHES X 13% REAR SEAT OCCUPANCY = 8% OVERALL.

EFFECTIVENESS: CASES WHERE SEAT BELTS CONTRIBUTED TO INJURY - HIGHER THAN FRONT SEATS - SAY 15% OF ALL. ASSUME LOAD LIMITERS 20% EFFECTIVE = 3% OVERALL

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	8%	8%	8%	0%
% EFFECTIVENESS	3%	3%	1%	0%
$ SAVED PER VEHICLE/YEAR	$0.34	$0.60	$0.11	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.37 **HI*:** 1.85

TOTAL SAVINGS/YR **$1.05**

NET SAVINGS/YR $1.05
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
L60	Optimized restraint systems for rear seat passengers
M29	Seat belt and child restraint usage - 1993

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SB_PT_F **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT PRETENSIONER, FRONT

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON MUARC REPORTR CR100.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60% OF ALL)

EFFECTIVENESS: CASES WHERE SEAT BELTS ALLOWED TOO MUCH OCCUPANT EXCURSION. SAY 20% OF ALL CASES. ASSUME 25% EFFECTIVENESS FOR PRETENSIONERS = 5% OVERALL.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	5%	5%	5%	0%
$ SAVED PER VEHICLE/YEAR	$4.26	$7.56	$4.08	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.12 HI*: 1.12

TOTAL SAVINGS/YR **$15.90**

NET SAVINGS/YR $15.90
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L43	Feasibility of Occupant Protection Countermeasures

FEATURE CODE SB_PT_R **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT PRETENSIONERS, REAR

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON MUARC REPORT CR100.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60%) WITH REAR SEAT OCCUPANTS (13%) = 8% OVERALL

EFFECTIVENESS: CASES WHERE SEAT BELTS ALLOWED TOO MUCH OCCUPANT EXCURSION. SAY 20% OF ALL CASES. ASSUME 25% EFFECTIVENESS FOR PRETENSIONERS = 5% OVERALL

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	8%	8%	8%	0%
% EFFECTIVENESS	5%	5%	5%	0%
$ SAVED PER VEHICLE/YEAR	$0.57	$1.01	$0.54	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.15 HI*: 0.74

TOTAL SAVINGS/YR **$2.12**

NET SAVINGS/YR $2.12
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L43	Feasibility of Occupant Protection Countermeasures
L60	Optimized restraint systems for rear seat passengers
M29	Seat belt and child restraint usage - 1993

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SB_WB_R **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT WEBBING GRABBERS, REAR

READINESS TAKE-OFF **ACCEPTANCE** MODERATE

NET COST (1 OFF) $40.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON MUARC REPORT CR100.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60%) WITH REAR SEAT OCCUPANTS (13%) = 8% OVERALL

EFFECTIVENESS: CASES WHERE SEAT BELTS ALLOWED TOO MUCH OCCUPANT EXCURSION. SAY 20% OF ALL CASES. ASSUME 10% EFFECTIVENESS FOR WEBBING GRABBERS = 2% OVERALL

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	8%	8%	8%	0%
% EFFECTIVENESS	2%	2%	2%	0%
$ SAVED PER VEHICLE/YEAR	$0.23	$0.40	$0.22	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.15 **HI*:** 0.74

TOTAL SAVINGS/YR **$0.85**

NET SAVINGS/YR $0.85
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L60	Optimized restraint systems for rear seat passengers
M29	Seat belt and child restraint usage - 1993

FEATURE CODE SB_WG_F **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SEAT BELT WEBBING GRABBERS, FRONT

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $40.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON MUARC REPORT CR100.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60% OF ALL)

EFFECTIVENESS: CASES WHERE SEAT BELTS ALLOWED TOO MUCH OCCUPANT EXCURSION. SAY 20% OF ALL CASES. ASSUME 10% EFFECTIVENESS FOR WEBBING GRABBERS = 2% OVERALL.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	2%	2%	2%	0%
$ SAVED PER VEHICLE/YEAR	$1.70	$3.02	$1.63	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.12 **HI*:** 1.12

TOTAL SAVINGS/YR **$6.36**

NET SAVINGS/YR $6.36
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L43	Feasibility of Occupant Protection Countermeasures

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SEAT_SUB **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION ANTI-SUBMARING SEAT DESIGN

READINESS HARVEST **ACCEPTANCE** MODERATE

NET COST (1 OFF) $40.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON MUARC REPORT CR100.
(Also see references

CRASH INFLUENCE: MOSTLY FRONTAL CRASHES (60% OF ALL)

EFFECTIVENESS: CASES WHERE SUBMARINING A FACTOR. PERHAPS 10% OF ALL. IMPROVED SEAT DESIGN MIGHT BE 20% EFFECTIVE = 2% OVERALL.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	60%	60%	60%	0%
% EFFECTIVENESS	2%	2%	2%	0%
$ SAVED PER VEHICLE/YEAR	$1.70	$3.02	$1.63	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.12 HI*: 1.12

TOTAL SAVINGS/YR **$6.36**

NET SAVINGS/YR $6.36
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L43	Feasibility of Occupant Protection Countermeasures

FEATURE CODE SIDE_AB_FH **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SIDE AIRBAG - FRONT, HEAD-PROTECTING (CURTAIN)

READINESS TAKE-OFF **ACCEPTANCE** GOOD

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: USUALLY PART OF SAFETY PACKAGE. NOMINAL COST BASED ON PASSENGER AIRBAG.
(Also see references

CRASH INFLUENCE: See reference L75. 4.6% of US crashes potentially influenced by head-protecting tubular struc

EFFECTIVENESS: See reference L75. Effectivenes better for severe injuries.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	5%	5%	5%	0%
% EFFECTIVENESS	50%	50%	25%	0%
$ SAVED PER VEHICLE/YEAR	$3.55	$6.30	$1.70	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.20 HI*: 0.20

TOTAL SAVINGS/YR **$11.55**

NET SAVINGS/YR $11.55
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
L75	Benefits of the inflatable tubular structure
L81	NARROW OBJECT CRASHES AND INJURY OUTCOMES
L82	TIMBER POLE CRASHES
L88	CRASH AND FIELD PERFORMANCE OF SIDE AIRBAGS

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SIDE_AB_RH **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SIDE AIRBAG, REAR, HEAD-PROTECTING

READINESS TAKE-OFF **ACCEPTANCE** GOOD

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON PASSENGER AIRBAG.
(Also see references

CRASH INFLUENCE: US RESEARCH SUGGESTS 5% OF CRASHES INFLUENCED BY HEAD PROTECTING SIDE AIRBAGS. 13% OF VEHCLES HAVE REAR SEAT OCCUPANTS = 1% OVERALL

EFFECTIVENESS: ASSUME 50% EFFECTIVE FOR FATALS AND SERIOUS INJURIES. LESS FOR MINOR.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	1%	1%	1%	0%
% EFFECTIVENESS	50%	50%	25%	0%
$ SAVED PER VEHICLE/YEAR	$0.71	$1.26	$0.34	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.04 **HI*:** 0.20

TOTAL SAVINGS/YR **$2.31**

NET SAVINGS/YR $2.31
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
K02	Advanced designs for side impact and rollover protection
K14	Side impact protection opportunities
L03	Reduction of head rotational motions in side impacts - inflatable curtains
L22	Development of side impact airbag system for head and thorax protection
L55	Evaluation of advanced side airbags for head protection
L75	Benefits of the inflatable tubular structure
L81	NARROW OBJECT CRASHES AND INJURY OUTCOMES
L82	TIMBER POLE CRASHES
L88	CRASH AND FIELD PERFORMANCE OF SIDE AIRBAGS
M29	Seat belt and child restraint usage - 1993

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SIDE_AB_RT **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SIDE AIRBAG, REAR, THORAX

READINESS TAKE-OFF **ACCEPTANCE** GOOD

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON PASSENGER AIRBAG (70%)
(Also see references

CRASH INFLUENCE: SIDE IMPACTS (20%) WITH REAR SEAT OCCUPANTS (13%) = 3% OVERALL.

EFFECTIVENESS: ASSUME 50% EFFECTIVENESS FOR FATAL AND SERIOUS.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	3%	3%	3%	0%
% EFFECTIVENESS	50%	50%	25%	0%
$ SAVED PER VEHICLE/YEAR	$2.13	$3.78	$1.02	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.12 **HI*:** 0.61

TOTAL SAVINGS/YR **$6.93**

NET SAVINGS/YR $6.93
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
K02	Advanced designs for side impact and rollover protection
K14	Side impact protection opportunities
K25	Side impact regulation benefits for Australia
L22	Development of side impact airbag system for head and thorax protection
L25	Strategies for passenger car designs to improve side impact protection
L27	Field study on the potential benefit of different side airbag systems
L88	CRASH AND FIELD PERFORMANCE OF SIDE AIRBAGS

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE SIDE_ABFT **CATEGORY** *OCCUPANT RESTRAINT*

DESCRIPTION SIDE AIRBAG - FRONT SEAT, THORAX

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $400.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON PROPORTIONAL COST OF A TYPICAL "SAFETY PACK" THAT INCLUDES SIDE AIRBAGS AND DATA GATHERING FOR ANCAP.
(Also see references

CRASH INFLUENCE: SIDE IMPACT CRASHES (20%)

EFFECTIVENESS: ASSUME 50% EFFECTIVENESS FOR FATAL AND SERIOUS.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	20%	20%	20%	0%
% EFFECTIVENESS	50%	50%	25%	0%
$ SAVED PER VEHICLE/YEAR	$14.20	$25.20	$6.80	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.81 **HI*:** 0.81

TOTAL SAVINGS/YR **$46.20**

NET SAVINGS/YR $46.20
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K02	Advanced designs for side impact and rollover protection
K14	Side impact protection opportunities
K25	Side impact regulation benefits for Australia
L22	Development of side impact airbag system for head and thorax protection
L25	Strategies for passenger car designs to improve side impact protection
L27	Field study on the potential benefit of different side airbag systems
L88	CRASH AND FIELD PERFORMANCE OF SIDE AIRBAGS

FEATURE CODE CRASH_REC **CATEGORY** *OTHER AVOIDANCE FACTORS*

DESCRIPTION CRASH RECORDER

READINESS START-UP **ACCEPTANCE** POOR

NET COST (1 OFF) $500.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: BASED ON RTA SPEED CONTROL STUDY.
(Also see references

CRASH INFLUENCE: SPEED-RELATED CRASHES 40% OF FATALS AND 15% OF OTHERS (R21).

EFFECTIVENESS: KNOWLEDGE THAT SPEEDING BEHAVIOUR IS BEING RECORDED MAY INFLUENCE SOME DRIVERS TO SLOW DOWN. PERHAPS 20% REDUCTION.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	40%	15%	15%	15%
% EFFECTIVENESS	20%	20%	20%	20%
$ SAVED PER VEHICLE/YEAR	$11.36	$7.56	$4.08	$4.29

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.38 **HI*:** 0.38

TOTAL SAVINGS/YR **$27.29**

NET SAVINGS/YR $27.29
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
P19	NSW Heavy Vehicle Crash Study - Final Technical Report.
R21	ROAD TRAFFIC ACCIDENTS IN NSW - 1999

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE ENG_IMMOB **CATEGORY** *OTHER AVOIDANCE FACTORS*

DESCRIPTION ENGINE IMMOBILISER

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $300.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: GLASS'S GUIDE.

(Also see references

CRASH INFLUENCE: JOY RIDING DETERRENT.

EFFECTIVENESS: REDUCED RISK OF THEFT

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	10%	10%	5%	5%
% EFFECTIVENESS	20%	20%	20%	20%
$ SAVED PER VEHICLE/YEAR	$2.84	$5.04	$1.36	$1.43

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.25 HI*: 0.25

TOTAL SAVINGS/YR **$10.67**

NET SAVINGS/YR $10.67

(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
R25	RISK-BENEFIT ANALYSIS METHODS FOR VEHICLE SAFETY DEVICES

FEATURE CODE FUEL_CUT **CATEGORY** *POST-CRASH FACTORS (RESCUE)*

DESCRIPTION FUEL AND ENGINE CUT-OFF IN SEVERE CRASH

READINESS TAKE-OFF **ACCEPTANCE** GOOD

NET COST (1 OFF) $100.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: NOMINAL COST BASED ON SIMILAR KITS SUCH AS HEADLIGHT ALERT.

(Also see references

CRASH INFLUENCE: ALL SEVERE CRASHES (FATAL OR INJURY) INVOLVING FIRE. ABOUT 3%

EFFECTIVENESS: MOST FIRES PROBABLY DUE TO RUPTURE OF FUEL TANK OR LINES. PERHAPS 20% REDUCTION FOR FATAL AND SERIOS, 10% FOR MINOR. NIL FOR PROPERTY.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	3%	3%	3%	3%
% EFFECTIVENESS	20%	20%	10%	0%
$ SAVED PER VEHICLE/YEAR	$0.85	$1.51	$0.41	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.19 HI*: 0.19

TOTAL SAVINGS/YR **$2.77**

NET SAVINGS/YR $2.77

(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
P12	Australian bus safety standards
Q03	A searchable transportation fire safety bibliography
Q04	Field data improvements for fire safety research
Q07	A case study of 214 fatal crashes involving fire

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE HAZ_ACT **CATEGORY** *POST-CRASH FACTORS (RESCUE)*

DESCRIPTION HAZARD LIGHT ACTIVATE IN SEVERE CRASH

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $50.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: RELATIVELY SIMPLE SWITCHING MECHANISM IF TRIGGERED BY AIRBAG SYSTEM.
(Also see references ESTIMATED COST OF RELAY AND WIRING HARNESS.

CRASH INFLUENCE: SEVERE CRASHES (SERIOUS OR FATAL)

EFFECTIVENESS: REDUCES DANGER FROM OTHER VEHICLES. PROBABLY VERY SMALL REDUCTION - PERHAPS 2%.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	100%	100%	0%	0%
% EFFECTIVENESS	2%	2%	0%	0%
$ SAVED PER VEHICLE/YEAR	$2.84	$5.04	$0.00	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 1.11 **HI*:** 1.11

TOTAL SAVINGS/YR **$7.88**

NET SAVINGS/YR $7.88
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
K54	Road safety strategy: current problems and future options
Q05	Relationship between crash casualties and crash attributes

FEATURE CODE MAYDAY **CATEGORY** *POST-CRASH FACTORS (RESCUE)*

DESCRIPTION MAYDAY DISTRESS CALL IN SEVERE CRASH

READINESS START-UP **ACCEPTANCE** MODERATE

NET COST (1 OFF) $500.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: PROTOTYPES ONLY AT THIS STAGE. NOMINAL COST BASED ON SIMILAR ELECTRONIC
(Also see references EQUIP SUCH AS GPS.

CRASH INFLUENCE: ALL SEVERE AND SERIOUS CRASHES.

EFFECTIVENESS: UK DETR ESTIMATES 17% OF FATALS PREVENTABLE BY MORE TIMELY TREATMENT. ASSUME MAYDAY HALF AS EFFECTIVE AND HALF AGAIN FOR SERIOUS INJURIES.

CRASH SAVING ANALYSIS	**FATALS**	**SERIOUS**	**MINOR**	**PROPERTY**
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	100%	100%	0%	0%
% EFFECTIVENESS	8%	4%	0%	0%
$ SAVED PER VEHICLE/YEAR	$11.36	$10.08	$0.00	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.30 **HI*:** 0.30

TOTAL SAVINGS/YR **$21.44**

NET SAVINGS/YR $21.44
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	**TITLE**
K54	Road safety strategy: current problems and future options
Q01	Design and implementation of an automobile collision notification system
Q05	Relationship between crash casualties and crash attributes
Q08	ENHANCING POST-CRASH SAFETY THROUGH AUTOMATIC COLLISION NOT.
Q09	AUTOMATED CRASH NOTIFICATION: DESIGN AND VALIDATION

* "HI" benefit cost value assumes above average exposure, where applicable

SAFETY FEATURE ANALYSIS

FEATURE CODE PHONE **CATEGORY** *POST-CRASH FACTORS (RESCUE)*

DESCRIPTION MOBILE PHONE AVAILABLE IN EVENT OF ACCIDENT

READINESS HARVEST **ACCEPTANCE** GOOD

NET COST (1 OFF) $200.00 **MAINTENANCE/YR:** **$0.00**

COST NOTE: COST OF HANDS-FREE KIT ONLY.
(Also see references

CRASH INFLUENCE: ALL SERIOUS ACCIDENTS WHERE A NORMAL PHONE IS NOT READILY AVAILABLE. ASSUME 100%.
IGNORE SAFETY HAZARDS DUE TO HAVING PHONE IN VEHICLE.

EFFECTIVENESS: UK DETR ESTIMATES 17% OF FATALITIES COULD BE PREVENTED BY MORE TIMELY TREATMENT. ASSUME MOBILE PHONE ONE QUARTER OF THESE AND SERIOUS INJURIES HALF AGAIN.

CRASH SAVING ANALYSIS	FATALS	SERIOUS	MINOR	PROPERTY
CRASH COST/VEHICLE/YEAR	$142.00	$252.00	$136.00	$143.00
% OF CRASHES INFLUENCED	100%	100%	0%	0%
% EFFECTIVENESS	4%	2%	0%	0%
$ SAVED PER VEHICLE/YEAR	$5.68	$5.04	$0.00	$0.00

DISCOUNT RATE 7.00% (OVER 10 YEARS)

BENEFIT/COST RATIO: 0.38 HI*: 0.38

TOTAL SAVINGS/YR **$10.72**

NET SAVINGS/YR $10.72
(Total savings - Maintenance)

MAIN REFERENCES FOR THIS SAFETY FEATURE

CODE	TITLE
K54	Road safety strategy: current problems and future options
Q08	ENHANCING POST-CRASH SAFETY THROUGH AUTOMATIC COLLISION NOT.
Q09	AUTOMATED CRASH NOTIFICATION: DESIGN AND VALIDATION

* "HI" benefit cost value assumes above average exposure, where applicable

Appendix D - Derivation of cost estimates

ESTIMATED COST OF SAFETY FEATURES

AB_BONNET BONNET AIRBAG FOR PEDESTRIAN PROTECTION

OE COST: $500.00 ***ANNUAL MAINT.:*** $0.00

NOT IN PRODUCTION. COST BASED ON PASSENGER AIRBAG, ASSUMING VOLUME PRODUCTION IN LONG TERM.

AB_SMART SMART AIRBAG SYSTEM

OE COST: $500.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON AUTOLIV PAPER.

ABS ABS BRAKES

OE COST: $1,000.00 ***ANNUAL MAINT.:*** $0.00

GLASS'S GUIDE TYPICAL VALUE.

AIR_COND AIR CONDITIONING/CLIMATE CONTROL

OE COST: $2,000.00 ***ANNUAL MAINT.:*** $40.00

GLASS' SGUIDE AND SURVEY OF DEALERS

AIRBAG_D DRIVER AIRBAG

OE COST: $1,000.00 ***ANNUAL MAINT.:*** $0.00

GLASS'S GUIDE AND DATA GATHERED FOR ANCAP.

AIRBAG_P FRONT PASSENGER AIRBAG

OE COST: $550.00 ***ANNUAL MAINT.:*** $0.00

GLASS'S GUIDE AND SURVEY OF DEALERS.

ALC_LOCK ALCOHOL/DRUG INTERLOCK

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

PROTOTYPES ONLY AT THIS STAGE. BASED ON COST OF SIMILAR GADGETS SUCH AS HEADLIGHT ALERT.

AUTO_TRANS AUTOMATIC TRANSMISSION

OE COST: $1,100.00 ***ANNUAL MAINT.:*** $0.00

GLASS'S GUIDE.

BDY_COL CONSPICUOUS BODY COLOUR

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST. COULD BE NIL COST FOR SOME COLOURS. FOR COMPARISON "METALLIC" PAINT TYPICALLY COSTS ABOUT $200-$300.

CARGO_BAR CARGO BARRIER

OE COST: $300.00 ***ANNUAL MAINT.:*** $0.00

SURVEY OF DEALERS FOR COST AS OPTIONAL EQUIPMENT.

CR_INT CHILD SEAT INTEGRATED

OE COST: $500.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON SEAT COSTS AND UPMARKET CHILD RESTRAINTS.

CRASH_REC CRASH RECORDER

OE COST: $500.00 **ANNUAL MAINT.:** $0.00

BASED ON RTA SPEED CONTROL STUDY.

CRUISE CRUISE CONTROL

OE COST: $450.00 **ANNUAL MAINT.:** $0.00

SURVEY OF DEALERS AND GLASS'S GUIDE

DRL DAYTIME RUNNING LIGHTS

OE COST: $50.00 **ANNUAL MAINT.:** $2.00

OE COSTS AND ANNUAL MAINTENANCE BASED ON DUTCH AND CANADIAN ESTIMATES. AFTERMARKET COST ABOUT $200 BASED ON DISCUSSIONS WITH AUTO-ELECTRICIANS.

DRV_LIGHTS DRIVING LIGHTS

OE COST: $100.00 **ANNUAL MAINT.:** $5.00

RETAIL PRICE OF BASIC SYSTEMS. MAINTENANCE COST ASSUMES GLOBE FAILURE EVERY 3 YEARS.

ENG_IMMOB ENGINE IMMOBILISER

OE COST: $300.00 **ANNUAL MAINT.:** $0.00

GLASS'S GUIDE.

FOG_LAMPS FOG LAMPS

OE COST: $100.00 **ANNUAL MAINT.:** $5.00

RETAIL PRICE OF BASIC SYSTEMS. MAINTENANCE COST ASSUMES GLOBE FAILURE EVERY 3 YEARS.

FOOT_PROT IMPROVED FOOT PROTECTION

OE COST: $100.00 **ANNUAL MAINT.:** $0.00

NOMINAL COST. IMPROVED DESIGNS SHOULD NOT COST MORE IN LONG TERM.

FUEL_CUT FUEL AND ENGINE CUT-OFF IN SEVERE CRASH

OE COST: $100.00 **ANNUAL MAINT.:** $0.00

NOMINAL COST BASED ON SIMILAR KITS SUCH AS HEADLIGHT ALERT.

GLASS_LAM LAMINATED OR SHATTER-PROOF GLAZING FOR ALL WINDOWS

OE COST: $100.00 **ANNUAL MAINT.:** $0.00

ASSUMES THAT WINDSCREENS ARE ALREADY LAMINATED. COST BASED ON ESTIMATED COST DIFFERENCE BETWEEN LAMINATED AND TEMPERED WINDSCREEN, EXTRAPOLATED TO REMAINING GLAZING.

HAZ_ACT HAZARD LIGHT ACTIVATE IN SEVERE CRASH

OE COST: $50.00 **ANNUAL MAINT.:** $0.00

RELATIVELY SIMPLE SWITCHING MECHANISM IF TRIGGERED BY AIRBAG SYSTEM. ESTIMATED COST OF RELAY AND WIRING HARNESS.

HEAD_PAD HEAD PROTECTION PADDING

OE COST: $200.00 **ANNUAL MAINT.:** $0.00

NOMINAL COST BASED ON PAPERS FROM 16TH ESV.

HEADL_ON HEADLIGHTS ON WARNING/AUTO

OE COST: $50.00 ***ANNUAL MAINT.:*** $20.00

OE COSTS AND ANNUAL MAINTENANCE BASED ON DUTCH AND CANADIAN ESTIMATES. AFTERMARKET COST ABOUT $150 BASED ON DISCUSSIONS WITH AUTO-ELECTRICIANS.

HEADWAY HEADWAY RADAR FOR EXCESSIVE CLOSING SPEEDS

OE COST: $800.00 ***ANNUAL MAINT.:*** $0.00

PROTOTYPES ONLY AT THIS STAGE. BASED ON SIMILAR ELECTRONIC SYSTEMS SUCH AS CD PLAYER.

HELMET HELMETS/HEAD BANDS FOR OCCUPANTS

OE COST: $30.00 ***ANNUAL MAINT.:*** $10.00

BASED ON A LOW COST BICYCLE HELMET (RETAIL VALUE)

HI_GLASS HIGH TRANSMITTANCE GLAZING

OE COST: $50.00 ***ANNUAL MAINT.:*** $0.00

COULD BE NIL COST IN THE LONG TERMN BUTR ASSUME THE IMPROVED GALZING TECHNOLOGY IS NEEDED TO CUT HEAT TRANSMISSION WHILE LETTING VISIBLE LIGHT THROUGH. NOMINAL COST OF $50.

HR_ADJ ADJUSTABLE HEAD RESTRAINT

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST FOR ALL SEATS.

HR_RA HEAD RESTRAINTS FOR ALL REAR SEATS

OE COST: $120.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON 15% OF SEAT COST

HR_RO HEAD RESTRAINTS FOR REAR OUTBOARD SEATS

OE COST: $80.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON 15% OF SEAT COST

IRS INDEPENDENT REAR SUSPENSION

OE COST: $300.00 ***ANNUAL MAINT.:*** $0.00

GLASS'S GUIDE

ISA INTELLIGENT SPEED ADAPTION

OE COST: $800.00 ***ANNUAL MAINT.:*** $0.00

BASED MAINLY ON A COMPREHENSIVE REPORT BY UNI OF LEEDS. COST SUBSTANTIALLY LESS IF PIGGY-BACKED ON A NAVIGATION SYSTEM.

KNEE_PAD KNEE BOLSTER/PADDING

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

BASED ON MUARC REPORT CR100.

LOAD_RESTR LOAD RESTRAINT DEVICES (TETHERS)

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

AUTHOR'S EXPERIENCE PURCHASING THESE ITEMS (RETAIL).

MAYDAY MAYDAY DISTRESS CALL IN SEVERE CRASH

OE COST: $500.00 ***ANNUAL MAINT.:*** $0.00

PROTOTYPES ONLY AT THIS STAGE. NOMINAL COST BASED ON SIMILAR ELECTRONIC EQUIP SUCH AS GPS.

MIRR_DIM AUTO DIMMING REAR VIEW MIRROR

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON SIMILAR ELECTRONIC DEVICES.

MIRR_FOG ANTI FOGGING (HEATED) EXTERNAL MIRRORS

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON SIMILAR ELECTRONIC EQUIP.

MIRROR_AUTO EXTERNAL MIRRORS ELECTRICALLY ADJUSTABLE

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON ETSC REPORT.

NAV_SYS NAVIGATION SYSTEM (GPS)

OE COST: $2,000.00 ***ANNUAL MAINT.:*** $0.00

DEALER SURVEY.

PED_IMP PEDESTRIAN FRIENDLY VEHICLE FRONT

OE COST: $500.00 ***ANNUAL MAINT.:*** $0.00

COST ESTIMATE BASED ON 2 PAPERS AT 16TH ESV (LAWRENCE AND OTUBUSHIN). MID-RANGE USE TO BALANCE GOVERNMENT AND INDUSTRY ESTIMATES.

PHONE MOBILE PHONE AVAILABLE IN EVENT OF ACCIDENT

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

COST OF HANDS-FREE KIT ONLY.

POWER_STR POWER STEERING

OE COST: $700.00 ***ANNUAL MAINT.:*** $0.00

GLASS'S GUIDE

SB_BUCK SEAT BELT BUCKLE MOUNTED ON SEAT (FRONT)

OE COST: $50.00 ***ANNUAL MAINT.:*** $0.00

MAINLY THE ESTIMATED OF COST OF STRENGTHENING SEAT. MOST VEHICLE NOW HAVE THIS FEATURE.

SB_CR3 SEAT BELT, CENTRE REAR 3-POINT

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

BASED ON PAPER FROM LAP BELT CONFERENCE, 1994.

SB_HARNESS HARNESS SEAT BELT FOR ADULTS (4PT OR 6PT)

OE COST: $400.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON COST OF NORMAL SEAT BELTS AND ALLOWING FOR EXTRA ANCHORAGE POINTS.

SB_HT_ADJ SEAT BELT D-RING HEIGHT ADJUSTABLE/AUTOMATIC

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST. NEGLIGIBLE COST IN LONG TERM.

SB_ILOCK SEAT BELT INTERLOCK

OE COST: $50.00 ***ANNUAL MAINT.:*** $0.00

OE COST BASED ON MUARC REPORT CR100 AND ESV15 - TURBELL. THESE ARE RELATIVELY SIMPLE SYSTEMS.

SB_INFLATE INFLATABLE SEAT BELT

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

PROTOTYPE TECHNOLOGY. NOMINAL COST BASED ON PASSENGER AIRBAG (40%)

SB_LL_F SEAT BELT LOAD LIMITERS, FRONT

OE COST: $20.00 ***ANNUAL MAINT.:*** $0.00

ASSUMED SIMILAR TO WEBBING CLAMPS.

SB_LL_R SEAT BELT LOAD LIMITERS, REAR

OE COST: $20.00 ***ANNUAL MAINT.:*** $0.00

BASED ON MUARC REPORT CR100

SB_PT_F SEAT BELT PRETENSIONER, FRONT

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

BASED ON MUARC REPORTR CR100.

SB_PT_R SEAT BELT PRETENSIONERS, REAR

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

BASED ON MUARC REPORT CR100.

SB_WB_R SEAT BELT WEBBING GRABBERS, REAR

OE COST: $40.00 ***ANNUAL MAINT.:*** $0.00

BASED ON MUARC REPORT CR100.

SB_WG_F SEAT BELT WEBBING GRABBERS, FRONT

OE COST: $40.00 ***ANNUAL MAINT.:*** $0.00

BASED ON MUARC REPORT CR100.

SEAT_ADJ ADJUSTABLE DRIVERS SEAT (MULTI-FUNCTION)

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON 33% TYPICAL COST OF ENTIRE SEAT (~$600) .

SEAT_COOL COOLED/HEATED DRIVERS SEAT

OE COST: $200.00 ***ANNUAL MAINT.:*** $0.00

PROTOTYPES ONLY AT THIS STAGE. ASSUMES AIR CONDITIONER ALREADY FITTED.

SEAT_LUM ADJUSTABLE LUMBAR SUPPORT

OE COST: $50.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST ASSUMES SYSTEM CAN BE READILY INCORPORATED ON THE PRODUCTION LINE.

SEAT_SUB ANTI-SUBMARING SEAT DESIGN

OE COST: $40.00 ***ANNUAL MAINT.:*** $0.00

BASED ON MUARC REPORT CR100.

SIDE_AB_FH SIDE AIRBAG - FRONT, HEAD-PROTECTING (CURTAIN)

OE COST: $550.00 ***ANNUAL MAINT.:*** $0.00

USUALLY PART OF SAFETY PACKAGE. NOMINAL COST BASED ON PASSENGER AIRBAG.

SIDE_AB_RH SIDE AIRBAG, REAR, HEAD-PROTECTING

OE COST: $550.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON PASSENGER AIRBAG.

SIDE_AB_RT SIDE AIRBAG, REAR, THORAX

OE COST: $400.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON PASSENGER AIRBAG (70%)

SIDE_ABFT SIDE AIRBAG - FRONT SEAT, THORAX

OE COST: $550.00 ***ANNUAL MAINT.:*** $0.00

BASED ON PROPORTIONAL COST OF A TYPICAL "SAFETY PACK" THAT INCLUDES SIDE AIRBAGS AND DATA GATHERING FOR ANCAP.

SL_ALARM SPEED ALARM

OE COST: $50.00 ***ANNUAL MAINT.:*** $0.00

BASED ON RTA SPEED CONTROL REPORT OF 1996. AFTERMARKET COST ABOUT $100. ASSUMED THAT OE COST ABOUT HALF OF THIS.

SL_TOP TOP SPEED LIMITER (SET AT 120km/h

OE COST: $1.00 ***ANNUAL MAINT.:*** $0.00

ASSUMES THAT ENGINE MANAGEMENT CHIP IS RECODED TO LOWER THE MAXIMUM SPEED (MOST ARE SET AT 250km/h+). IN THE LONG TERM THIS WILL BE NIL COST SINCE IT IS SIMPLY AN ALTERNATIVE CHIP OF THE SAME VALUE. A NOTIONAL VALUE OF $1 PER VEHICLE WAS ASSIGNED TO ENABLE A B/C CALCULATION. NIL MAINTENANCE.

STR_ADJ ADJUSTABLE STEERING COLUMN

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON PRODUCTION LINE CHANGE. NEGLIGIBLE IN LONG TERM.

TRACTION TRACTION CONTROL

OE COST: $1,000.00 ***ANNUAL MAINT.:*** $0.00

SURVEY OF DEALERS

TYRE_PRES TYRE PRESSURE MONITORING

OE COST: $400.00 ***ANNUAL MAINT.:*** $0.00

PROTOTYPE TECHNOLOGY (FOR CARS). BASED ON SIMILAR ELECTRONIC SYSTEMS.

TYRE_RF RUN FLAT TYRES

OE COST: $400.00 ***ANNUAL MAINT.:*** $0.00

ASSUMES A NOMINAL $100 EXTRA PER TYRE (IE ABOUT DOUBLE THE COST OF A NORMAL TYRE)

WIPER_AUTO WIPERS AUTOMATIC

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

BASED ON AFTERMARKET KITS SUCH AS HEADLIGHT ALERTS.

WIPER_SPD SPEED SENSITIVE INTERMITTENT WIPERS

OE COST: $100.00 ***ANNUAL MAINT.:*** $0.00

NOMINAL COST BASED ON COST OF OTHER ELECTRONIC GADGETS. MANY LUXURY VEHICLES NOW HAVE THIS FEATURE AS STANDARD.