Side Impact Regulation Benefits

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Abstract

Analysis of the benefits of new countermeasures are commonly used when setting road safety priorities. This study set out to estimate the likely benefits if Australia was to adopt a new dynamic side impact regulation similar to the current FMVSS 214 regulation in the USA or the proposed ECE Regulation 95 in Europe. These two standards are fundamentally different and likely to result in different countermeasures and benefits. Harm reduction analysis has been used previously for estimating occupant protection benefits from new countermeasures and was used again here. An existing Australia-wide database provided the baseline trauma patterns and a number of assumptions were made based on overseas published figures on the likely injury reduction effects of these two regulations. The total benefit for FMVSS 214 was estimated to be $136 million annually with a unit benefit per car of $147 assuming a 7% discount rate and historical sales and scrapage figures. The equivalent ECE 95 benefit was $147 million annually with a unit Harm figure of $159. These represent occupant trauma reductions of 4.7% and 5.1% respectively. Implementation costs were not available, however, these figures would not seem unreasonable extra costs given the likely injury savings for occupants of Australian vehicles. On this basis, the study recommends that in the short term, the Australian Design Rule system include a revised regulation mandating that all vehicles sold in Australia be required to meet either FMVSS 214 or ECE Regulation 95 with a suitable implementation lead time. The study also recommends additional research into a possible hybrid standard with other possible supplementary regulations to ensure additional long term benefits for occupants involved in side impact collisions.

Keywords

SAFETY, ACCIDENT, VEHICLE OCCUPANT. INJURY, COUNTER-MEASURE, COST-BENEFIT, ECONOMIC, HARM, EVALUATION

Notes

(1) FORS reports are disseminated in the interest of information exchange.
(2) The views expressed are those of the author(s) and do not necessarily represent those of the Commonwealth Government
(3) The Federal Office of Road Safety publishes four series of reports
(a) reports generated as a result of research done within FORS are published in the OR series·
(b) reports of research conducted by other organisations on behalf of FORS are published in the CR series.
(c) reports based on analysis of FORS statistical data bases are published in the SR series;
(d) minor reports of research conducted by other organisations on behalf of FORS are published in the MR series.

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EXECUTIVE SUMMARY

INTRODUCTION

An earlier report by the Monash University Accident Research Centre demonstrated that the current side impact standard in this country (ADR 29) should be reviewed to provide further protection for occupants involved in side impact crashes. Among a number of recommendations of measures likely to improve side impact protection was the need for an improved side impact regulation (Fildes, Lane, Lenard & Vulcan 1994).

With Australia's policy of international harmonisation, there are two regulations in existence overseas that are potential candidates for adopting in this country, namely the current US standard FMVSS 214 or the proposed European ECE Regulation 95

A one-day workshop was initially held in May 1994 in conjunction with the Enhanced Safety Vehicles conference in Munich, Germany involving a number of international experts on side impact requirements to debate the merits of Australia adopting either of these two standards (see Fildes & Vulcan 1995).

Using much of the information collected at this meeting, this study subsequently set out to provide an estimate of the financial benefits if a dynamic side impact standard, similar to these overseas standards, was to apply to Australian vehicles.

THE HARM REDUCTION METHOD

The Harm reduction method has been used previously for estimating the likely benefits of new occupant protection countermeasures (see Monash University Accident Research Centre 1992). Harm is a road trauma metric which contains both frequency and cost components and is therefore able to express the likely reductions in injuries from the introduction of a new measure into financial benefits.

The systematic building block approach used in this study permitted a body region by contact source analysis of benefits which provided an objective estimate of the consequences of Australia adopting either of the two candidate regulations.

DATA SOURCES AVAILABLE

An Australia-wide database was necessary to assess the likely injury reductions for both standards A detailed database was constructed in 1991 of national injury patterns by body regions, restraint conditions and contact sources, along with a series of resultant Harm matrices using BTCE human capital cost estimates (Monash University Accident Research Centre 1992). This comprehensive trauma analysis, based on over 500 real-world crashes examined in the Crash Vehicle File by the Monash University Accident Research Centre, offered a baseline trauma pattern upon which estimates of Harm reductions could be made

While this database was several years old, it nevertheless was still the most up-to-date source of baseline information available. Moreover, while the numbers of crashes (and hence injuries) have reduced over the last 4 years, their costs have risen such that the overall cost of trauma is probably still similar to that estimated for 1991. Thus, this database was judged suitable for use in this study, too.

INJURY REDUCTION ASSUMPTIONS

In making estimates of the likely benefits using the Harm reduction method, it is necessary to assess first the injury savings that will accrue from the new countermeasure. All available published information on the likely body region injury outcome associated with the new standards was sought therefore from available sources overseas.

The sources of test data available on the injury savings for a dynamic side impact standard came primarily from the USA, involving estimates of the effects of FMVSS 214. Other specialised research studies also provided more recent details on the effects of this regulation as well as some comparison test results involving both standard procedures.

It should be noted that the likely benefits of FMVSS 214 outlined in the Notice of Proposed Rulemaking (NHTSA 1990) have not been universally accepted, either outside or within the USA. Figures published by manufacturers and other researchers have suggested that these estimates are an over-statement and that the SID dummy is not the best test dummy to ensure optimal benefits. Some of these concerns were able to be incorporated in the assumptions adopted in this study.

HARM BENEFITS

A detailed system of spreadsheets was assembled for calculating the benefits of both standards. Relevance figures were assigned by body region and seating position (near- or far-side of the vehicle) and the subsequent Harm units removed were computed. The savings by body region and seating position were then summed to arrive at the total estimate of savings for both standards.

Annual Harm saved was converted into Unit Harm benefits using a 7% discount rate and historical vehicle sales and scrapage figures. A 7% discount rate is used in the majority of similar Commonwealth Government feasibility studies and is generally regarded as a rather conservative estimate of unit benefits.

FMVSS 214: For the US standard, FMVSS 214, the total Harm saved annually in Australia, assuming all vehicles were to comply, would amount to A$136 million based on 1991 crash patterns and costs of injuries. This represents a 4.7% reduction in vehicle occupant trauma annually if FMVSS 214 were to apply in Australia. The unit benefit per car would be $147; that is, this amount could be spent on each new vehicle for injury savings to break-even with the additional manufacturing costs imposed by the standard.

ECE REGULATION 95: If the proposed European standard were to apply to Australian vehicles, the Harm benefit is estimated to be A$147 million each year based on A$1991 figures and assuming all vehicles meet the standard. This would amount to a slightly higher 5.1% reduction in occupant trauma annually over the US standard with a unit benefit per car of $159.

LIMITATIONS WITH THESE FIGURES

There was a high degree of confidence in calculating the benefits of FMVSS 214 as there were data available on the likely effectiveness based on US crash patterns and vehicle population which was able to be converted into equivalent Australian figures using the Crashed Vehicle File data and other sources of available information.

Unlike the US standard, the was little or no information available on the likely effects of ECE Regulation 95 in reducing injuries. Hence, these figures can only be viewed as indicative estimates at this stage. It is fair to say, though, that these estimates have some validity, given input from European experts and comparative research performed by Transport Canada The likely consequences of recent amendments to this proposed regulation to reduce the barrier height from 300mm to 260mm has not been thoroughly researched overseas. However, a recent study by the Federal Office of Road Safety suggests that this may not be all that significant in this country

Whether either of these two standards will optimise the benefits available in side impact protection is still an open question. There was a suggestion that some form of a hybrid standard involving the US crash test procedure but with a more sensitive test dummy would lead to even larger benefits. The need for greater attention to head injuries in these standards was also noted.

It was hoped that cost details for having to meet these standards would be provided by the manufacturers through the Federal Chamber of Automobile Industries (FCAI) to enable a full benefit-cost analysis to be undertaken. Unfortunately, this information was not available at the time of publication of this report. Thus, the unit Harm benefits indicate the likely break-even costs for the standards to be cost-effective in this country.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study show that there are likely to be modest benefits to Australians in reduced vehicle trauma of around 5% per annum if all vehicles on the road were to meet either the existing US dynamic side impact standard FMVSS 214 or the proposed European equivalent ECE Regulation 95.

The break-even cost effectiveness figure would be approximately $150 per car with a possible marginal advantage for the European standard.

While implementation costs were not available, these figures would not seem unreasonable, given sufficient lead-time for adoption of a new dynamic side impact regulation.

Three recommendations therefore seem warranted from this study:

1. *That the Australian Design Rule system include a new or revised regulation mandating that all vehicles sold in Australia be required to meet either FMVSS 214 or ECE Regulation 95. A suitable lead time would need to be negotiated with the manufacturers.*

2. *That further research be undertaken to examine whether a hybrid standard would lead to further improvements in occupant protection. In the event that there are sizeable benefits, these results be used to bring about a harmonised side impact standard in the long-term.*

3. *That further research be carried out into the need for additional regulations aimed at reducing head, neck and spinal injuries further in front and side impacts.*

Chapter 1 Introduction

The Monash University Accident Research Centre (MUARC) recently completed a report for the Federal Office of Road Safety (FORS) outlining patterns of injury and contact sources for passenger car occupants involved in side impact collisions (Fildes, Lane, Lenard & Vulcan 1994). The report showed that the existing side impact standard ADR 29 is less than optimal in offering adequate protection for occupants involved in these crashes. A number of recommendations were made of measures likely to improve side impact protection, including an improved side impact regulation. However, the report noted the lack of data generally on the likely benefits of existing or proposed dynamic side impact standards from overseas.

1.1 BACKGROUND

The responsible authorities in the USA and Europe have decided on two fundamentally different test procedures and test dummies for dynamic side impact regulation that cannot be harmonised. The US introduced a revised FMVSS 214 dynamic side impact standard in September 1993 with a phased introduction for full implementation by the end of 1996. The European regulation is due to be introduced for all new vehicles manufactured after October 1995. The Federal Office of Road Safety have indicated a willingness to introduce a new dynamic side impact standard in Australia by 1 January 1998. As current philosophy towards new regulations in this country is for international harmonisation, this raises the question then which of these two standards will optimise side impact crash protection in Australia ?

On behalf of FORS, MUARC organised a one-day workshop in May 1994 in conjunction with the Enhanced Safety Vehicles conference in Munich, Germany involving staff from these two agencies and a number of international experts. The workshop provided an up-to-date account of side impact regulation developments and involved a lengthy discussion of the likely injury benefits if Australia adopted either of these two standards (see Fildes & Vulcan 1994). From the discussions, it was apparent that some data were available on the likely benefits of FMVSS 214 for US vehicles from the Notice of Proposed Rule Making for that standard (NHTSA 1990). However, very little information seemed to be available on an assessment of the benefits likely from the European ECE Regulation 95 (incidental reports by Wall, 1992, and Lowne, 1994 provide some crude estimates of the overall reductions in injury likely for ECE 95 but were by no means, definitive).

Thus, there was merit in undertaking further research, aimed at assessing the likely injury reduction benefits of a dynamic side impact crash performance standard in Australia based on either the US standard or the proposed European ECE regulation to provide guidance for future regulation developments in this country.

1.2 THE BENEFIT STUDY

A study was undertaken by the Monash University Accident Research Centre on behalf of the Federal Office of Road Safety to estimate the benefits likely to accrue from adoption of a side impact ADR which will allow demonstration of compliance using either the US or (proposed) ECE regulation. To the degree possible, benefits of one procedure over the other have been highlighted where possible, although this was never intended to be a primary aim.

Given the diversity of ways in which vehicle manufacturers might re-design their cars to meet these standards, a definitive cost-benefit study was not possible at this time. Project outcome, therefore, was to specify what the unit benefits would be if cars met these standards (ie; what the manufacturing costs would need to be to break-even). It is hoped that the Federal Chamber of Automotive Industries will provide more definitive cost information in the near future to enable benefit-cost analysis to be undertaken.

1.3. METHOD OF ASSESSING BENEFITS

The study used the Harm reduction method to compute the potential benefits of the proposed dynamic side impact requirement. Harm refers to the cost of trauma and is the product of the frequency and cost of injury to the community. MUARC were the first agency in Australia to adopt this method developed by Malliaris in the US for use in this country in the previous FORS report CR100 (Monash University Accident Research Centre 1992) which described the potential benefits of frontal crash measures.

In its original form (Malliaris et al 1982; 1985; 1987) Harm was used to specify the total injury savings by the introduction of a particular safety measure. However, in conjunction with Kennerly Digges of University of Washington, MUARC subsequently expanded the method to permit a more detailed and systematic assessment of injury reduction by body region and seating position which could then be summed to total Harm reduction and unit Harm benefits.

This approach enabled test and crash data findings published in the road safety literature to be incorporated in the calculations, thereby reducing the amount of guess-work normally required in calculations such as these. Where no published figures were available, however, the study team were forced to use the consensus view of a panel of experts in arriving at these body region and restraint condition savings. The amount of published data is normally a function of the attention a particular measure has received by the research community as well as its newness. As noted earlier, there has not been much published data on side impact improvements using either standard and so heavy reliance will need to be made on whatever test figures are made available and expert panel assessments for computing the likely benefits of a dynamic side impact standard.

1.4. EXISTING OR PROPOSED REGULATIONS OVERSEAS

As noted previously, there are <u>two</u> fundamentally different test procedures and test dummies implemented or planned for dynamic side impact regulation in the US and Europe that cannot be harmonised. It is worth outlining both these standards as a basis for what is to follow. Those interested in a more full discussion including much of the debate and controversy that surrounds these different standards are referred to Fildes & Vulcan (1994) from which much of this description has been taken.

1.5. U.S. STANDARD FMVSS 214

In September 1993, the US government mandated their revised FMVSS 214 regulation incorporating a dynamic side impact test using their Side Impact Dummy (SID). It allows for phased introduction for all manufacturers with a 10% requirement for the first year (1994 models), a 25% requirement for 1995 models, a 40% requirement for 1996 models and a 100% requirement for 1997 models and beyond. The final form of the proposed European regulation, planned to be introduced later this year, is still under discussion. The major components of the US dynamic test specified in regulation FMVSS 214 comprise:

- a moving deformable barrier of 3010lb (1365kgm),
- a crabbed barrier impact angle of 27deg,
- a barrier impact speed of 33.5mph (54km/h), and
- SID dummies in the front and rear near-side seats.

1.5.1 Crabbed Impact Configuration

FMVSS 214 calls for the impacting sled to be "crabbed" at 27deg and to strike the test vehicle at a travel speed of 33.5mph (about 54km/h). This is illustrated in Figures 1.1. NHTSA argued that the crabbed configuration was important to simulate real world crashes and this was subsequently confirmed by Dalmotas (1994) in comparative crash tests undertaken by Transport Canada using North American vehicles. As these tests involved larger US vehicles, it is unclear whether these findings also apply for a smaller vehicle fleet, typical of Europe.

1.5.2 The US Barrier

The US barrier construction is essentially homogeneous with a protruding bumper layout as shown in Figure 1.2. The main section is constructed from 45psi (±2.5psi) honeycomb material with the bumper section in 245psi (±15psi) aluminium honeycomb material. Because of its size and test arrangement, the US feel that it is less likely to over-emphasise side door strength (Fildes & Vulcan 1994). NHTSA argued that the force and deflection characteristics of the barrier are important when simulating real world crashes. They noted that their barrier is considerably stiffer than the European barrier and that the latter has experienced problems in earlier testing obtaining reproducible results. The bottom edge of the US barrier is 280mm from the ground.

1.5.3 The SID Dummy

The US regulation calls for tests involving the Side Impact Dummy (SID) developed by the NHTSA. SID is a modified Hybrid 2 model developed specifically for side impact testing after extensive cadaver testing in the US and Germany. Its biofidelity requirements led to unequal masses in the dummy, especially its relatively soft arms which was intended to incorporate rib characteristics.

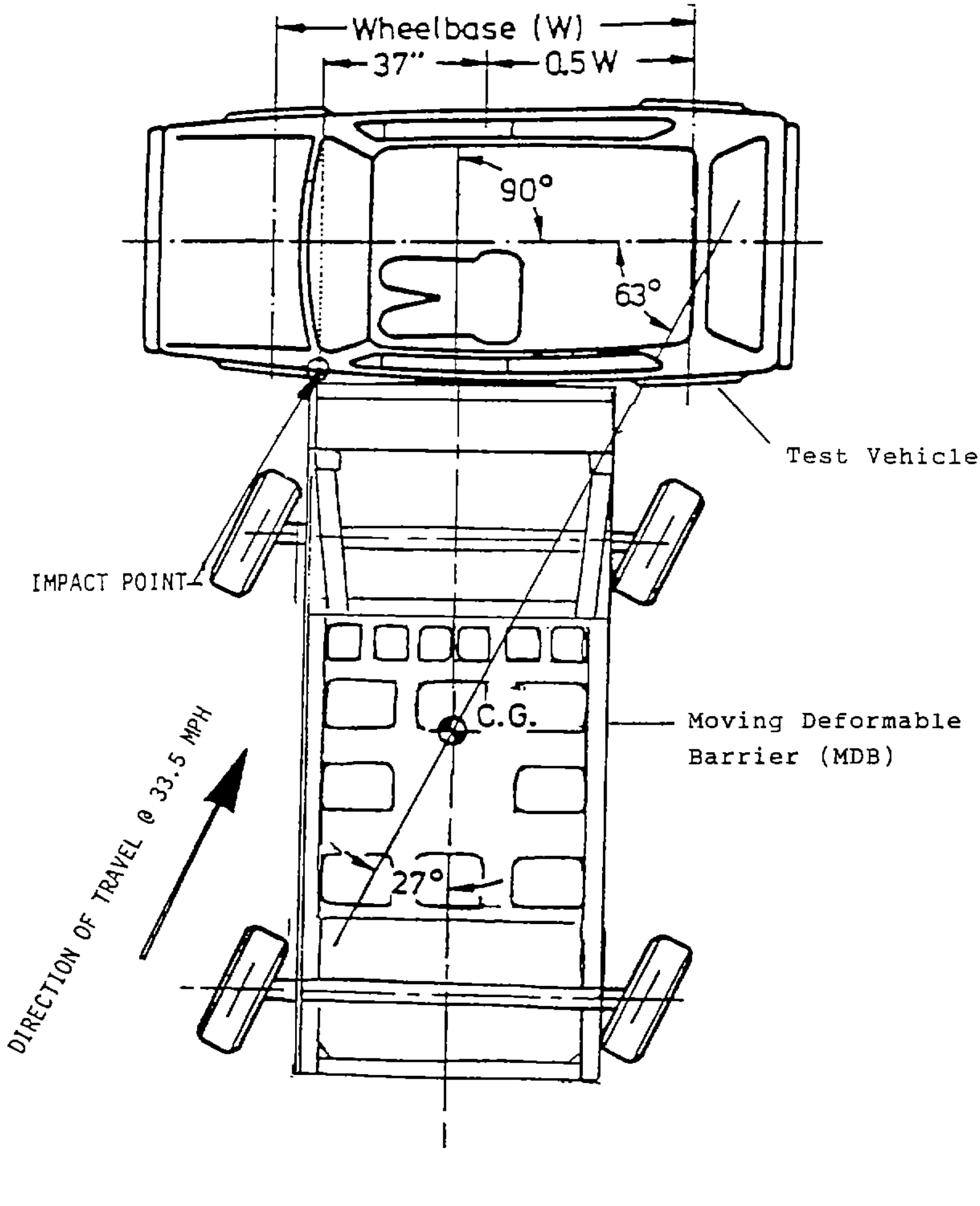

Figure 1.1 *Crabbed test configuration specified for side impact testing in the FMVSS 214 regulation (NHTSA 1990).*

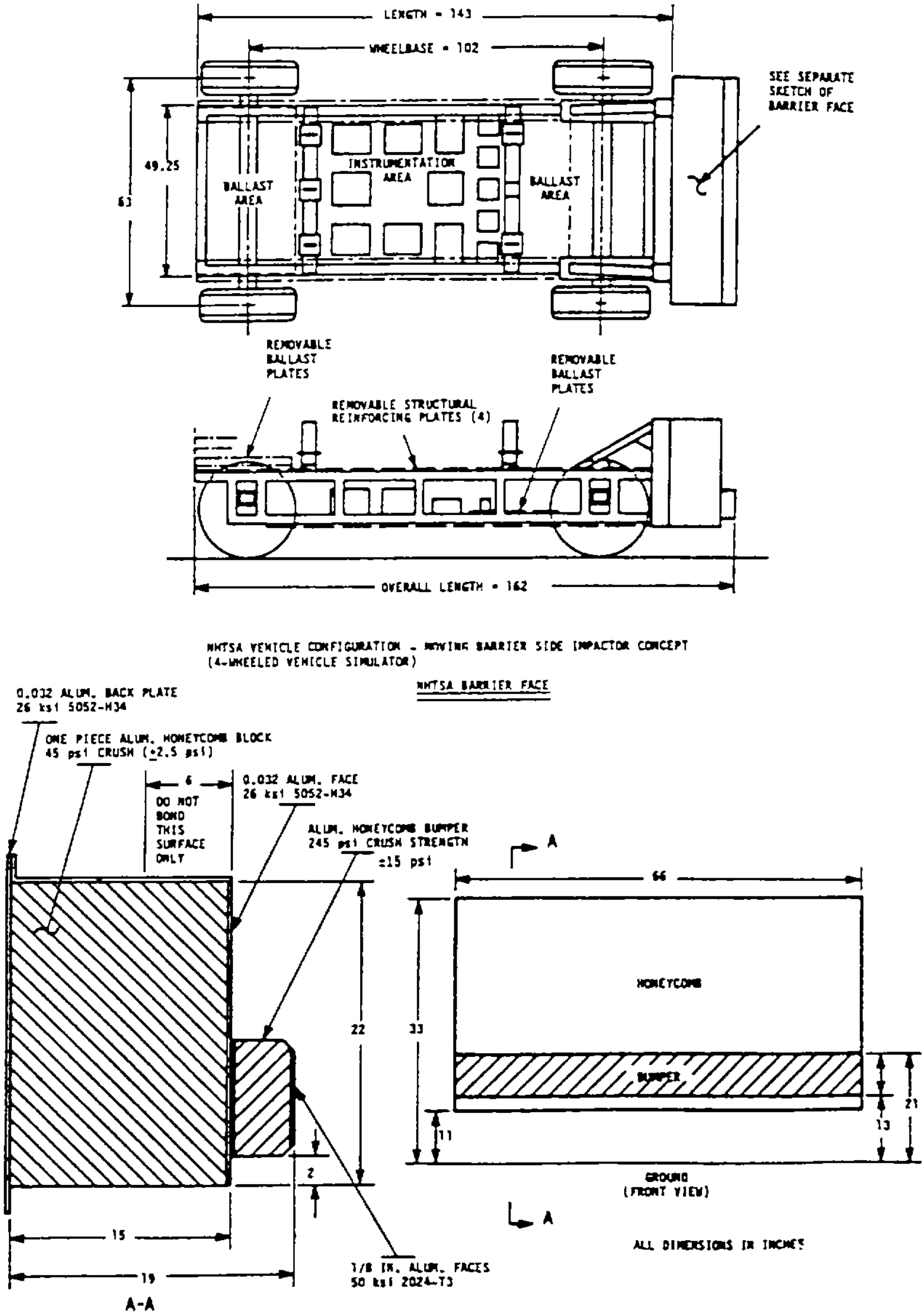

Figure 1.2 NHTSA's moving sled and barrier face used in the test specified for side impact regulation in FMVSS 214 (NHTSA 1990).

SID has been shown to be less sensitive to door padding stiffness than EUROSID or BIOSID, due mainly to its construction and injury criteria. For example, when examining padding selection for a particular structure using the three existing side impact dummies (and their respective injury criteria), both EUROSID and BIOSID showed that 10psi material gives optimal performance. While 10psi would also be optimal for SID, so too would any material from 10 to 40psi (Fildes & Vulcan 1994).

In developing SID, measurement of deflection forces was difficult because of rotation, therefore acceleration of the thorax and the spine became the major injury criteria. This has since become a criticism of SID, both outside and inside the US. Delta-V distributions from NASS showed that the 50th percentile was somewhere between 15 and 20mph which was subsequently adopted as the design speed.

The SID dummy criteria was based on hard thorax injuries including liver and kidney injuries but not soft tissue injury in the abdomen. There is no instrumentation available for measuring these injuries other than those covered by rib acceleration. Cavanaugh et al (1993) proposed an additional injury criteria of Average Spine Acceleration (ACA) which he claimed would overcome some of the insensitivity of SID. So far, this has not been adopted.

SID has no provision for specifying any head injury criteria. US accident data shows that the greatest source of severe injury in side impacts is to the head, not the thorax, although this was less apparent in the Australian study by Fildes et al (1994). Thus, it is argued, FMVSS 214 does not really address the major source of injury from side impacts. The US are currently in the process of issuing an upper interior padding standard for side rails and A- and B-pillars which will address at least part of these head injuries from side impacts.

1.6. PROPOSED EUROPEAN STANDARD

A different dynamic side impact test procedure and injury criteria have been incorporated into a new United Nations ECE regulation which is expected to be introduced for new models manufactured in the European Economic Community after 1st October 1995. Unfortunately, there appears to be little prospect of a harmonised regulation coming out of these two different standards.

1.6.1 European Test Barrier

The European barrier design came from CCMC, a collection of automobile manufacturers in Europe. The barrier comprises six blocks (3 on the top and 3 on the bottom which slightly protrude) which they claimed effectively represent the stiffness values of impacting passenger cars. These values were derived from French testing of representative European passenger car crashes against a rigid barrier wall. Subsequent testing of Japanese cars in Japan showed that these cars also correlated well with these European force characteristics.

The height of the barrier has been somewhat controversial. Originally, it was set at 300mm from the ground surface to the lower edge and practically all development work involved in ECE Regulation 95 has been based on this barrier height. This was slightly above the 280mm adopted for the US barrier. However, recent deliberations by a few European member countries have led to the barrier height being lowered to 260mm. The consequences of this will probably be that the impacting force of the barrier will essentially load the lower sill panel and less likely to simulate the door intrusions normally experienced in a car-to-car collision where no braking has occurred prior to impact (about 45% of crashes).

A barrier mass is 950kg which was about the average mass of European vehicles at the time it was developed. There was very little effect observed in testing different European barriers up to 1100 or 1300kg because most of the peak loads occur between 35 and 50msecs and the barrier mass has little influence at that time. The mass of the barrier certainly influences the amount of intrusion but has less effect on dummy performance compared to peak loading.

1.6.2 Impact Speed & Direction

A perpendicular impact configuration was chosen because some European manufacturers believed this configuration offered best protection to occupants of their vehicles in real world accidents. A perpendicular impact was also the cheapest option and did not appear (at least, not at the early design phase of the regulation) to compromise safe vehicle design.

Early tests by the AAMA compared crabbed with perpendicular impact configurations did not show a lot of difference in performance. This was because of the mass of the dummy and the difference in striking direction did not seem to have much effect during the first 35msecs when the injury effects of side impact collisions are at their maximum. This was also confirmed by Canadians when they crashed vehicles in both crash configurations. It was pointed out, however, that this is somewhat dependent on the type of vehicle, the dummies on-board and the effects on the rear seat passengers. One manufacturer noted the need to take action to improve rear dummy performance when the test configuration was crabbed because the barrier has a tendency to slide along the car towards the rear.

An impact speed of 50km/h was chosen for the standard based on the distribution of impact speeds observed in real world accidents in Europe.

The European barrier was chosen to reflect differences in the vehicle populations, it was claimed, although it is not clear what this means for safety performance. Canadian tests compared both barriers in crashes to North American vehicles and felt that the US barrier was slightly more representative of US vehicle crashes, particularly those involving MPV's. European tests claim that the European barrier reproduced quite well the worst case outcomes for a European vehicle fleet, although this was for a 300mm barrier height.

1.6.3 EUROSID Dummy

The Europeans felt that there was a need for a more sensitive measuring instrument and injury criteria in side impacts than that offered by SID. Early tests from NHTSA suggested that their dummy would present difficulties for Europe, primarily because of the injury criteria adopted. As a result, they set about developing EUROSID, a joint exercise involving several European countries and different test facilities. Head Injury Criteria (HIC) was included in the European test as it was felt that a car should not allow high head values irrespective of what it contacts (this is not required in FMVSS 214). However, it is believed that the Europeans are also considering a subsequent component test similar to the US to help minimise these injuries, rather than simply rely on a single point reading in the full scale performance test.

1.6.4 Dummy Seating Position

The EEVC did recommend dummies in both the front and the rear seating positions on the struck side only. However, it seems that most of the development work has been done with only a front seat dummy on-board (the back seat has tended to be heavily loaded with instrumentation and cameras). ECE has subsequently dropped the requirement for a rear dummy in the proposed regulation. Given that the impact of the barrier is centred on the "R-point" of the vehicle, this seems to be quite sensible as it presents a rather strange crash profile for the rear dummy. It should be remembered that EUROSID was essentially designed for a perpendicular impact (±20degs).

US experience confirms that the benefits of having a rear dummy are really quite small, but politically, it was felt that a rear dummy was necessary to ensure that children, who essentially travel in the rear of US cars, were properly protected. Cost benefit analysis would be hard pressed to justify the need for a rear seat dummy. It should be noted that performance standards will not necessarily guarantee rear seat protection without a rear seat dummy and a separate impact test involving a more rearward impact location.

1.6.5 Dummy Test Criteria

European studies had shown that the most severe injuries in side impacts were to the head, thorax, abdomen and pelvis, so EUROSID was required to detect injuries in these areas.

Head acceleration (HIC) was considered adequate for measuring head injury. For the chest, the Europeans felt that TTI was not appropriate for measuring these injuries and subsequently adopted viscous criteria (V*C). Appropriate values of this parameter were determined for EUROSID (European tests showed that a V*C of 1 = 30% to 40% probability of injury for AIS3 or above). Concern has been expressed by some, though, about the repeatability of the V*C criteria with the EUROSID dummy. While EUROSID has arms, the specification calls for them to be out-of-the-way during impact to minimise their protective role for the chest.

1.6.6 Front Seat Location

The EEVC recommended that the seat be set in the worst position. Manufacturers claimed that they needed to know what the precise seat position would be to enable them to meet the standard so ECE settled on a fixed seat position. However, they do maintain the option for a second test with the seat in another position if it appears that a particular vehicle might not be optimum (eg: if a manufacturer was to simply pad in a strip adjacent to the test dummy position). Seat position has been recently modified to ensure that the dummy H-point is not positioned against the B-pillar.

1.6.7 Implementation Date & Recent Changes

The ECE is still maintaining an implementation date of October 1995 despite some recent changes that have been agreed to with the standard. These changes (against best advice) comprise a drop in the barrier height from 300mm to 260mm and the exclusion of V*C as a primary performance criteria (it will be measured for a period of 2 years after which a decision to include or not will be made).

The EEVC recommended that there should be a design specification for the barrier face and criteria that it should meet. This has not been adopted by the ECE as they wished to adopt a standard for the barrier that was strictly performance based. Consequently, there are at least two polymer barrier faces developed (one in Germany and one in the UK) which did not initially comply with performance criteria but which now seem to. UTAC developed an aluminium honeycomb material with pyramid structures included which perform well against rigid walls but not so in car impacts. Plascore in the US and Cellbond in Huntingdon in the UK are also currently developing composite barrier faces.

The vehicle design solutions necessary to meet the European barrier face are likely to be different to those necessary to meet the US requirement. The design of the European barrier did allow the door to be penetrated in early testing. It was not possible to fend the European barrier off by simply using stiff members over limited areas. However, whether this is still the case now that the barrier has been lowered to 260mm is not clear. Recent research by the Federal Office of Road Safety (Higgins, Hoy, Dowsett & Seyer, 1995) has shown that a selection of the most popular passenger cars sold in Australia have stiff front cross-members below 260mm, even at static ride height. Brake tests on these vehicles revealed nose dive of 75mm or more. This work suggests that lowering the ECE barrier face may not significantly reduce the benefits of ECE Regulation 95 in this country.

Chapter 2 Harm Reduction

This Chapter sets out to describe the method used to calculate the likely benefits that would accrue if either FMVSS 214 or the proposed European standard were to apply to Australian vehicles. It was based on existing Harm patterns in Australia but incorporated best overseas evidence of the likely injury reductions. The Harm reduction method has been used previously with some success in computing these benefits (Monash University Accident Research Centre 1992) and a similar approach was adopted here (see Appendix A for an example of the Harm Reduction method and spreadsheet. The following gives an overview of the method and describes the assumptions used and the resulting benefits.

2.1 OVERVIEW OF METHOD

The concept of "Harm" was first developed in the US and applied to National Accident Sampling System (NASS) database by the National Highway Traffic Safety Administration as a means of determining countermeasure benefits for road safety programs (Malliaris, Hitchcock & Hedlund 1982; Malliaris, Hitchcock & Hansen 1985; Malliaris & Digges 1987). In its original form, it was not suitable for immediate application to these data as it lacked an Australian cost basis. Moreover, it had never quite been used previously for itemising injury reductions by body regions as was envisaged here. Thus, the development and use of Harm in the previous study (Monash University Accident Research Centre 1992) and this study represented a significant international advancement in the ability to assess injury mitigation effects of vehicle countermeasures.

2.1.1 Harm & Injury Mitigation

Harm is a metric for quantifying injury costs from road trauma and involves both a frequency and a unit cost component. The Harm method adopted here comprised the systematic approach outlined in detail in Monash University Accident Research Centre (1992). This approach is more suited for use in computing likely benefits of countermeasures where there are no global estimates of the likely improvements but where there are some data or findings reported on the expected injury reductions (many publications on the effectiveness of side impact regulations show specific test results for particular body region and contact source benefits). The method pieces together a picture of the expected overall benefit from a series of individual body region and seating positions using a building block approach. A computer spreadsheet was developed for making the detailed Harm calculations by body region, similar to that used previously in CR100.

2.2 NATIONAL STATISTICS & HARM ESTIMATES

The first step in the process was to develop National Harm patterns for Australia. These estimates form the basis of the potential savings of injury costs from new occupant protection countermeasures aimed at reducing or preventing injury. This process was described fully in CR 100 (Monash University Accident Research Centre 1992) and will not be repeated here.

However, a summary is provided to outline how this was achieved (those requiring more detail are referred to the original publication). It draws heavily on the excellent work undertaken by Max Cameron and his co-workers at MUARC during the original study.

2.2.1 Occupant casualties and injuries

Unfortunately, no comprehensive Australia-wide database of injuries and their causes was available in this analysis, thus it was necessary to construct one. This involved a complex process of merging several data sources of fatalities, hospitalised occupants and those needing medical treatment, with the necessary checks and balances to ensure that the numbers, use of restraints, seating position, impact direction and speed zone were representative of Australia, generally.

Three data sources were available for constructing the Australia-wide casualty database. First, details of those killed in Australia are collected by the Federal Office of Road Safety in the "*Fatal File*" of which 1988 was most relevant. Second, MUARC's "*Crashed Vehicle File*" contained a random sample of 500 crashes where at least one occupant was either hospitalised or killed in Victoria between 1989 and 1992 which contained comprehensive details on crash characteristics, injuries and cause of injury. Third, the Transport Accident Commission in Victoria maintain a detailed database on all casualties in Victoria which involve injury costs of $317 (July 1987) or more.

Annual Australia-wide estimates were produced by merging these three databases and adjusting the numbers to suit national averages between 1988 and 1990. In total, the database comprised 1,612 killed, 17,134 hospitalised and 58,448 medically treated (not admitted to hospital) occupants or 77,194 total casualties involving an estimated 284,540 injuries at a rate of 3.7 injuries per occupant casualty. This was taken to represent a single year of occupant casualties in Australia.

Source of injury was not available in the Fatal File nor the TAC database but was in the Crashed Vehicle File. To correct for this deficiency, the most severe hospitalised and killed cases in the CVF were taken to represent all fatalities and the minor CVF cases (hospitalised for 3 or less days) were taken to represent non-hospitalised injury sources. Thus, injuries within the Fatal File and TAC database were assumed to have been caused by the same sources as their relevant proxies in the CVF. Following this adjustment, the Australia-wide all injury database was then complete.

Subsequently, these data were broken down by the key factors likely to be relevant for this analysis (eg. seating position, restraint use, and impact direction) and the frequencies of injuries to these occupants, categorised by the body region and Abbreviated Injury Scale (AIS) severity level disaggregated by the same factors as above as well as by the contact source of the injury. These tables formed the basic pattern of injuries and injury sources used in this analysis.

2.2.2 Casualty costs

The next step was to derive comprehensive cost data, categorised and disaggregated by the same factors as for the injury frequency estimates noted above. This was necessary so that individual units of Harm (eg; restrained Head injuries of AIS severity 2) could be established to permit detailed cost savings to be arrived at for incremental changes in trauma patterns.

Estimates of the cost of injury by AIS in Australia were published by the Bureau of Transport Economics for 1985 $A (Steadman & Bryan, 1988). However, these figures did not breakdown costs further by body region injured which was essential for estimating the Harm reductions associated with side impact improvements. To estimate the total cost of injury within each cell of the matrix of injury frequencies (body region by AIS), therefore, it was necessary to arrive at estimates for the average cost of each specific injury. This was based on a matrix of average injury costs in the USA developed by Miller (1991) and explained in detail in Monash University Accident Research Centre (1992).

These figures were then ultimately converted into Australian average injury costs in A$ 1991. The estimated total injury cost to car occupants during 1988-90 was calculated to be $3142.6 million per annum in 1991 prices. The re-scaled average injury costs per level of injury severity are given in Table 2.1.

Table 2.1

Total injury cost ("Harm") to occupants of cars and car derivatives in all types of impact (1991 $A millions, average per annum during 1988-90)

	INJURY SEVERITY							
BODY REGION	Minor (AIS = 1)	Moderate (AIS = 2)	Serious (AIS =3)	Severe (AIS = 4)	Critical (AIS = 5)	Maximum (AIS = 6)	Unknown	**TOTAL**
External	0 0	4 3	0.2	0 0	0.5	6.2	0.0	11.2
Head	12.8	116 6	217.2	290.4	524.9	49.4	0.0	1211 2
Face	99.4	80.3	29.9	2.8	0 0	0 0	0 7	213.1
Neck	20.1	14.1	25.7	0.6	16.3	2 6	0 0	79.5
Chest	33.6	63.7	139.3	99.4	47.5	68 0	0 0	451.4
Abdomen-Pelvis	36.4	64.8	89.7	21.2	23.3	2 0	0 0	237.4
Spine	3.8	23.4	30.9	3.5	42.8	18.3	0.0	122.7
Upper Extremity	64.4	147.4	85 0	0 0	0.0	0.0	0.0	296.7
Lower Extremity	64 4	188 6	265.4	0 6	0 2	0.0	0.0	519.3
TOTAL	334.9	703.2	883.3	418.4	655.6	146.4	0 7	3142 6
No. Occupants Sustaining Injury								77194

2.2.3 Relevance of 1991 Figures

It would have been more preferred if recent injury patterns and costs were available for this analysis, given the sizeable reductions that have occurred in the road toll between 1991 and 1994 and recent inflationary effects. However, it was not possible to re-do these estimates within the time frame and budgetary constraints of the project. It should be noted, though, that these two influences would tend to offset each other (the effects of a reducing road toll would be somewhat ameliorated by the increase in cost of injury through inflation). Thus, it was felt that the total Harm figures were still appropriate for this analysis.

2.2.4 Baseline Harm Matrices

The total harm in Table 2.1 was then broken down by seating position, restraint use and impact direction by using the same procedures for subsets of the injury and occupant casualty data. These figures provided the baseline injury-cost data for establishing the potential cost savings benefits of side impact regulations to reduce occupant injuries in side impacts. Each injury in the Crashed Vehicle Study File was associated with a contact source of the injury. For the hospitalised occupants included in this file it was possible to disaggregate the injury frequencies and total harm by the contact source. However, neither the Fatal File nor the TAC claims records contained injury contact sources to allow similar categorisation of the injuries of the killed and medically treated occupants.

To achieve this, data were selected from the full Crashed Vehicle Study File to act as proxies for the killed (the proxy was those hospitalised for more than 20 days, plus the 23 actual fatalities) and the medically treated but not admitted to hospital (the proxies were those hospitalised for less than 3 days). The injury frequencies from these proxies were adjusted within each AIS severity level by body region category to match the principal estimates. Where the proxy occupants did not sustain any injuries in an injury category for which Harm was estimated by the principal method, the distribution of harm by contact source was estimated from the contact source distribution of the next lowest injury severity level within the same body region.

The total harm within each body region of the front seat occupants involved in side impacts, broken down by contact source of the injury, for both restrained and unrestrained occupants respectively was ultimately produced and used as the baseline Harm figures to calculate the potential savings if a side impact regulation was to be introduced. This process is explained further in the next section.

2.3 INJURY REDUCTION ASSUMPTIONS

A number of assumptions were necessary in determining the likely benefits of a dynamic side impact regulation for Australia and these are detailed below.

2.3.1 Crash Severity

Examination of the damage patterns to local vehicles in the Crashed Vehicle File suggested that catastrophic damage to the vehicle did not occur in car-to-car impacts at delta-Vs below 64km/h, except for impacts with narrow objects. For side impacts with narrow objects, catastrophe seemed to occur among these cases when the narrow object (eg; a pole) impacted the passenger compartment in the region of the occupant. When the impact was in other regions, the occupant would therefore benefit from a standard, providing the crash severity was less than 64km/h.

Observations of cases in the MUARC Crashed Vehicle File indicated that in severe crashes with narrow objects, the head, rather than chest, was the primary cause of most life threatening injuries to these occupants. No benefit was assumed for these life threatening head injuries from severe impacts with narrow objects (see the next assumption on fatal head injuries). Tests published in the Notification of Proposed Rulemaking for FMVSS 214 (NHTSA 1990) indicated a relatively constant benefit for delta-Vs between 13 and 21mph

(20 and 34km/h) although no data were available for higher or lower speeds. Based on this limited linearity, however, the application was assumed to apply to non-catastrophic severities up to 64km/h.

> ***Assumption 1:*** *The standard which requires a test at a crash severity of around 27km/h delta-V will provide benefits at crash speeds up to 64km/h. No benefits are assumed above this speed.*

2.3.2 Fatal Head Injuries

Severe intrusion at the occupant location from narrow object impacts frequently results in AIS 5 and 6 head injuries at speeds less than 64km/h. These cases are considered to be beyond benefit of the proposed side impact regulations; the standards do not guarantee countermeasures sufficient to address the broad range of head injuries in catastrophic side impact crashes. Consequently, it is not expected to reduce head injuries significantly . However, survivors with head injuries would benefit to some degree if their chest injuries were also reduced.

> ***Assumption 2:*** *Near-side occupants who sustain AIS 5 or 6 fatal head injuries are excluded from any benefit from the standards. Reductions in chest injuries to occupants who sustain a non-fatal head injury are included.*

2.3.3 Cars and Fixed Objects

NHTSA (1990) conducted a set of crash tests that indicated similar injury reduction benefits from regulation countermeasures for both car-to-car and pole impacts (FRIA IVA-2).

> ***Assumption 3:*** *The benefits will apply to both car-to-car and car-to-fixed-object in side impact collisions*

2.3.4 Compartment & Non-Compartment Strikes

Only 10% of side impacts in Fildes et al (1994) were non-compartment strikes. These cases would certainly benefit from improvements in door hardware and armrest design. Padding the door would also be a benefit in non-compartment strikes (FRIA IVA-2 in NHTSA 1990). In addition, non-side impact cases could benefit from reduced injuries in rebound or those involving vehicle rotation. These additional benefits, not currently considered, compensate for any over-estimation in considering non-compartment strikes.

> ***Assumption 4:*** *The benefits will apply to occupants involved in both non-compartment and compartment side impacts.*

2.3.5 Body Region Benefits

The SID dummy and Thoracic Trauma Index (TTI) measures include liver, spleen and kidney injuries in the measurement of chest injuries (FRIA IIIB-18 in NHTSA 1990). EUROSID also measures head and abdominal injuries which need to be treated separately in the analysis. SID uses pelvic G's as a measure of pelvic injuries (FRIA IV-22 in NHTSA 1990) which has been subject to some criticism of its general usefulness (Fildes & Vulcan 1994).

> ***Assumption 5:*** *The benefits will apply to hard thorax (chest including liver, kidney and the spleen), pelvic, femur, shoulder, upper extremity, head and face injuries caused by contact with the door panel, hardware or armrest.*

2.3.6 Hard Thorax Benefits

The TTI curve shown in Figure 2.1 was derived from data based on 84 cadaver tests, ranging in impact speeds from 10 to 40mph (16 to 64km/h). The National Highway Traffic Safety Administration note that "the agency is confident that the relationship between TTI and injury risk is valid for the entire range of vehicles and impacts for which countermeasures must be designed" (FRIA IIIB-26 in NHTSA 1990). For the V*C curve shown in Figure 2.2, Viano (1987) suggests it is applicable for the range from 1m/s to 18m/s (4 to 65km/h).

> ***Assumption 6:*** *The injury risk curves for TTI and V*C apply to the range of impact speeds for side crashes at severities less than 64km/h for injuries of AIS 3 or greater.*

Injury Reduction & Crash Severity

In calculating effectiveness, it is necessary to apply data from a single speed test condition to a range of crash severities. The effect of varying crash severities was studied in developing the side impact injury criteria. Testing included side impacts of cadavers into rigid and padded walls at speeds of 17, 20 and 23mph (27, 32 and 37km/h). It was observed that by applying padding to the wall at the higher speeds, the injuries were similar in severity to those at the lower speed into a rigid wall. Consequently, the effect of the countermeasure was to limit the injuries at a higher crash severity to those observed at a lower one without the countermeasure.

This observation of actual injuries provides the basis for applying single speed crash tests to a spectrum of crash severities. Presumably, the countermeasure will reduce the severity of the crash environment on the occupant. The most commonly used measure of crash environment severity is delta-V. In the FRIA, the delta-V distribution is given for 2645 side impact occupants taken from the National Crash Severity Survey crash file in the United States. The distributions for this population and those with AIS 3+ injuries is shown in Figure 2.3. This figure also shows the probability of AIS 3+ injury for the population exposed. By matching the probability of AIS 3+ injury functions for the TTI (d) and delta-V, it is possible to obtain relationships between these two variables, as shown in Figure 2.4.

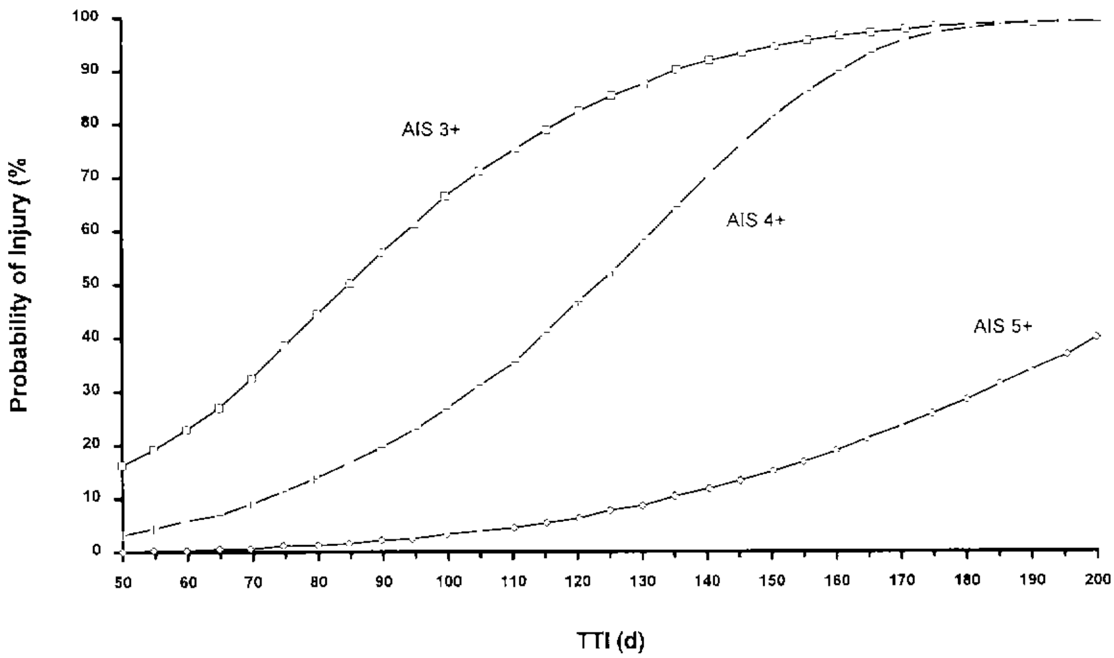

Figure 2.1 *The probability of injury versus TTI(d) measurements (from NHTSA 1990).*

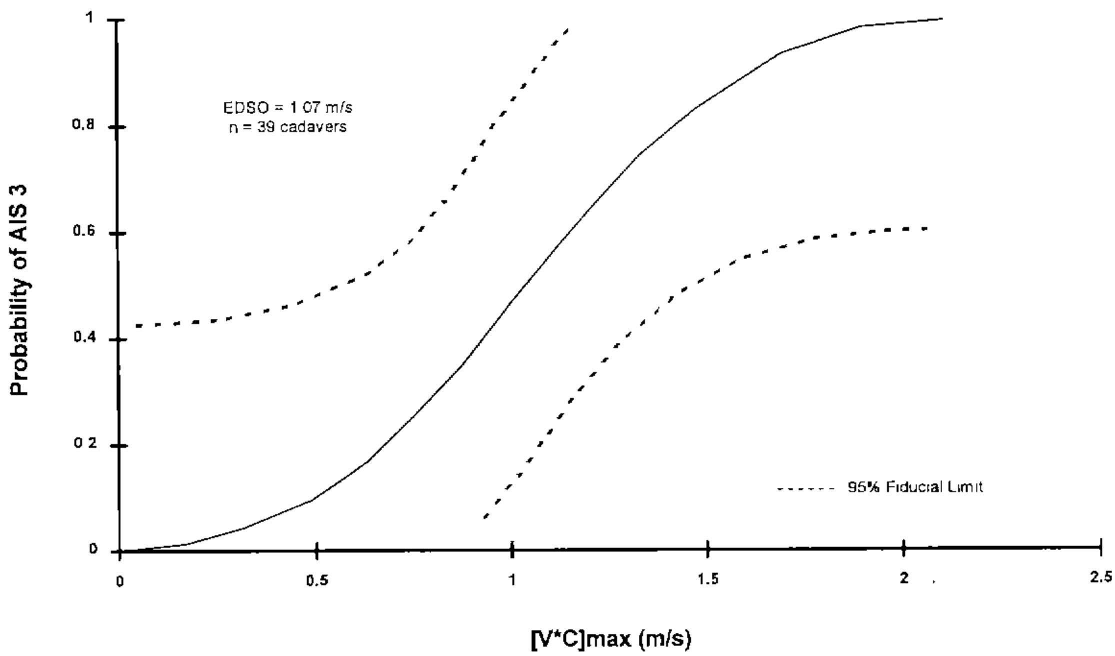

Figure 2.2 *Chest injury risk function relating to the probability of AIS 3+ injury as a function of the peak viscous response (from Viano, 1987).*

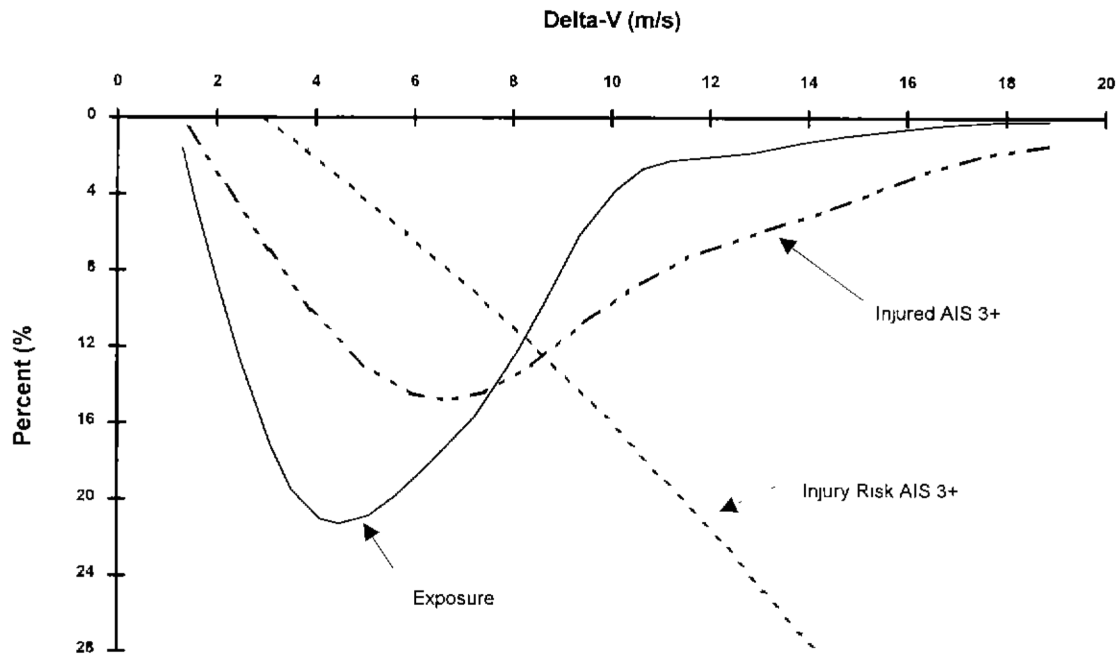

Figure 2.3 *Injury data from crash investigation studies and exposure information as a function of delta-V or change in velocity of the struck vehicle (from Viano 1987).*

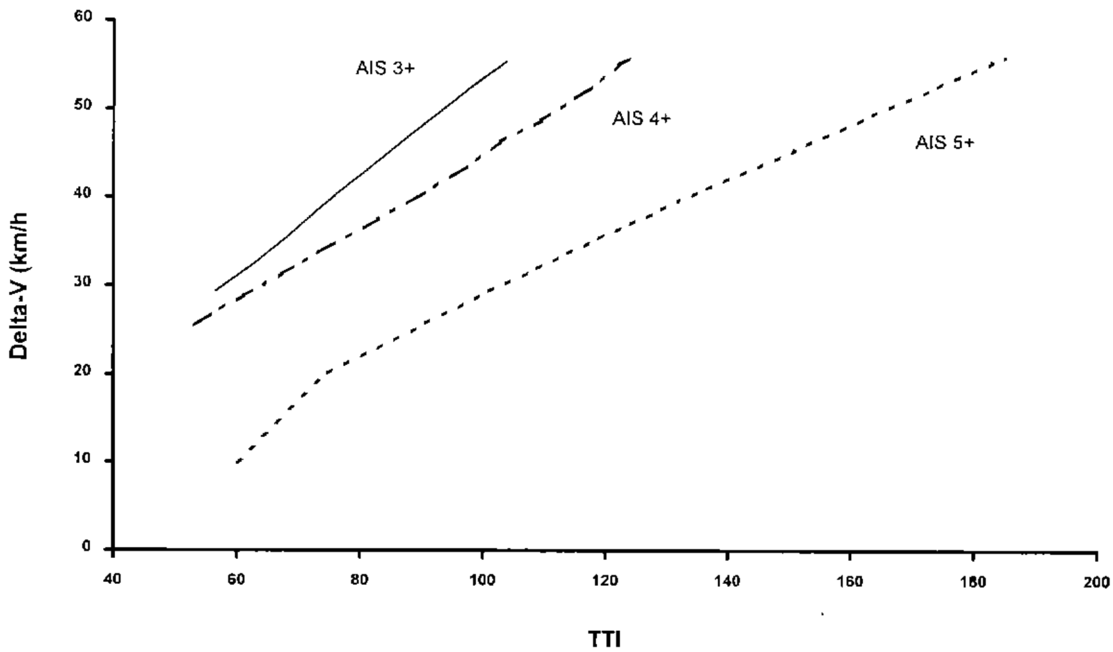

Figure 2.4 *Relationship between delta-V and TTI for injuries of AIS 3+ and AIS 5+ severity, calculated by combining Figures 2.2 and 2.4.*

Table 2.2:
Percent reduction in injuries, given a reduction in lateral Delta-V and the subsequent change in TTI.

Change in Delta-V	AIS 3+	AIS 5+	Change in TTI
1 mph	13.17%	12.86%	2.93
2 mph	24.94%	23.07%	5 85
3 mph	35.74%	33.30%	8.78
4 mph	45 60%	43.56%	11.71
5 mph	54.03%	51.16%	14 64
6 mph	61.52%	58.78%	17 56
7 mph	68.06%	63 78%	20.49
8 mph	73.18%	68 77%	23.42
9 mph	77.83%	73.82%	26.35

In the FRIA, NHTSA (1990) calculated the reduction in chest injuries to near-side occupants, given a reduction in lateral delta-V. This is done by shifting the injury risk in Figure 2.4 to the right by an incremental delta-V and calculating a new injury population from the exposed population and the injury risk curve. The result in 1mph increments for two injury levels is shown in Table 2.2 from which, subsequently, it is possible to show a direct relationship of reduction in TTI(d) vs injury reduction. These relationships come directly from the assumptions and analysis in the FRIA, pages IV-26;32 in NHTSA (1990) and provides the basis for estimating the benefit of each incremental reduction in TTI(d) when applied to a fleet of vehicles involved in side impact crashes. These are used as the effectiveness factors when calculating Harm reductions at each AIS level.

> ***Assumption 7:*** *The effectiveness of an incremental reduction in TTI on chest injuries from interior door contacts to near-side occupants is as outlined above. The AIS 3+ curve is used for calculating injury reductions involving AIS 1 to 4 injuries while the AIS 5+ curve is used for calculating AIS 5 and 6 injury reductions.*

TTI for Australian Vehicles

Figures of TTI reductions discussed so far are based on tests involving US vehicles which are likely to be quite different to Australian equivalents. As no similar tests have been carried out using Australian vehicles, it was necessary to use crash data as the basis for adjusting for these differences. Figure 2.5 shows the hard thorax injury risk curves by crash severity for the US NCSS file against the MUARC Crashed Vehicle File. These NCSS data uses a "*tow-away*" entry criteria, compared to a more severe "*hospitalisation*" requirement in the CVF. Thus, the NCSS file is likely to contain a much larger number of lower severity cases in which there were less serious injuries (AIS 1 and 2 predominantly).

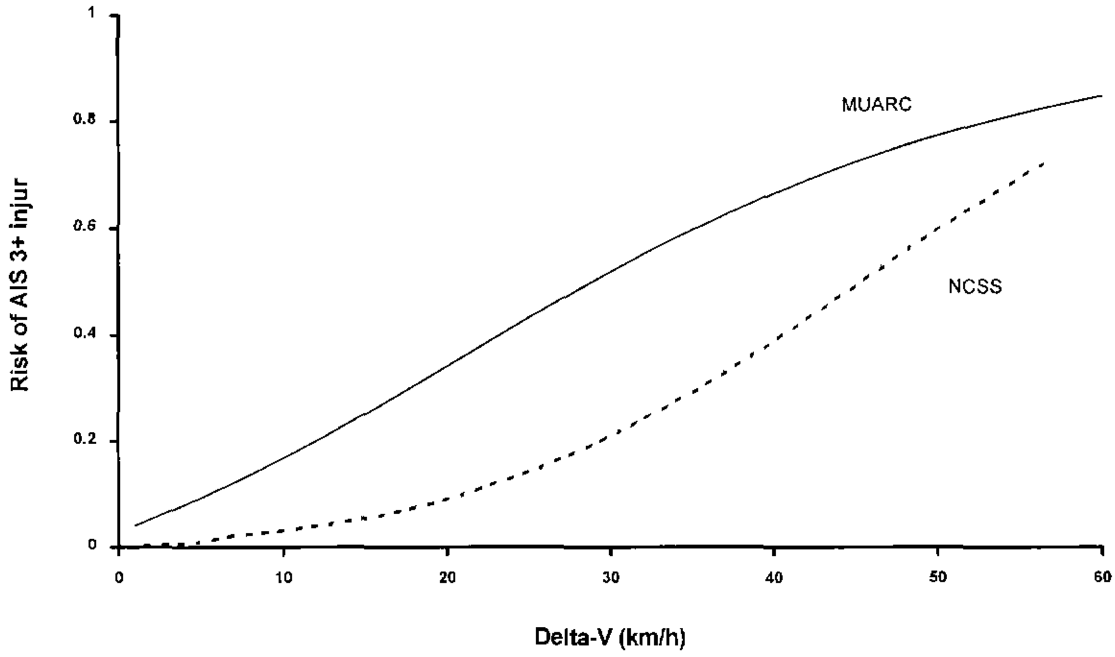

Figure 2.5 *Plot of the risk of a hard thorax AIS 3+ injury by delta-V for near-side occupants from data collected by the National Crash Sampling System (NCSS) & MUARC's Crashed Vehicle File.*

It was assumed that the MUARC file was representative of higher severity crashes in Australia. However, it was necessary to adjust the MUARC data to account for the missing low severity crashes and lower severity injuries. This was done using the NCSS file for crashes less than 32km/h. The first part of Table 2.3 shows the original distributions of NCSS and MUARC data. The ratio of NCSS to MUARC cases was highest below 16km/h and more modest above that figure, confirming the lack of lower severity local cases. To adjust for this, an adjusted NCSS/CVF ratio was established where the data for delta-V 33km/h and above was assumed to be representative. The ratio of NCSS to MUARC for the 33-40 and 41-48 cells decreased from a ratio of 2.78 to 1.82, that is, an average ratio of 1.53). In the lower cells, therefore, it was assumed that the 1.53 ratio was maintained, producing the figures listed in NCSS/CVF ratio column of Tablė 2.3. The final step, then, was to compute the adjusted MUARC sample numbers using these ratios and readjust the percentage differences. The resulting MUARC adjusted distribution, while not exactly the same as the NCSS distribution (it resembles NCSS at the lower severities and the original CVF at the higher severities), is nevertheless a more representative distribution for use in this analysis. Sensitive analyses were also undertaken assuming two other transition scenarios, one involving a more rapid shift of MUARC to NCSS and the other a more gradual shift. The results of these showed little variation in the ultimate relevance figure (43.9% to 45%) and the original estimate was deemed to provide a sound basis for injury reductions in Australian vehicles.

> ***Assumption 8:*** *The average TTI for Australian cars can be estimated by comparing the hard thorax injury distribution for near-side occupants in Australian crashes with those in the NCSS and adjusting MUARC values to include more low severity crashes.*

Table 2.3
Sample distributions for the NCSS and the MUARC-CVF databases both before and after adjustment to account for lower severity abnormalities

Delta-V km/h	NCSS n	Sample %	CVF n	Original %	NCSS/CVF ratio	CVF n	Adjusted %
0-8	540	20.4%	1	1 0%	9 91	55	15.1%
9-16	1205	45.6%	1	1.0%	9 91	122	33.7%
17-23	555	21.0%	23	22.1%	6.48	86	23.7%
24-32	240	9.1%	36	34.6%	4.24	57	15.7%
33-40	75	2.8%	27	26.0%	2.78	27	7.5%
41-48	20	0.8%	11	10 6%	1 82	11	3.0%
49-56	10	0.4%	5	4 8%	2 00	5	1.4%

Using these adjusted delta-V case figures, it is possible to adjust the number of injuries and injury risks accordingly. The additional injuries were computed for each data cell by multiplying the NCSS injury risk for that cell by the increase in the sample size. A new injury risk factor was computed by dividing the number of AIS 3+ injured people by the total number of people in each cell. The resulting reduction in injury risk by delta-V plot for near-side occupants sustaining an AIS 3+ hard thorax injury is shown in Figure 2.6.

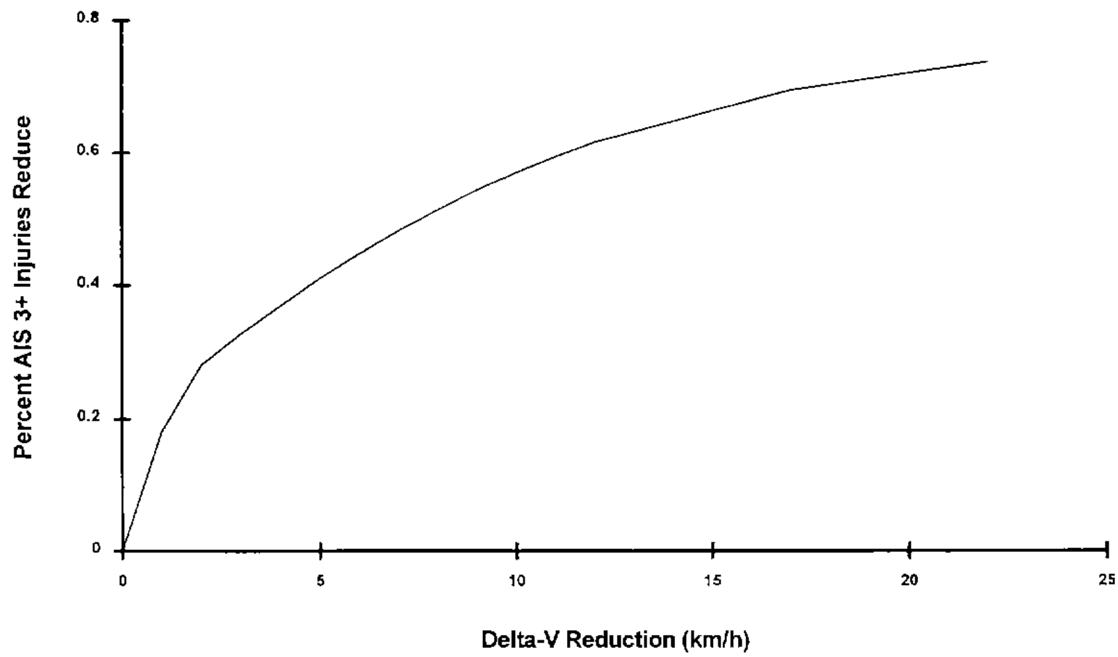

Figure 2.6 *Corrected injury reduction plot by delta-V for near-side occupants sustaining an AIS 3+ hard thorax injury in a side impact crash in Australia*

Table 2.4
Percent of Hard Thorax Injury Reductions for Various Delta-V Reductions

Delta-V Reduction	AIS 3+ Injury Reduction
1 km/h	18.0%
2 km/h	28.1%
3 km/h	32.7%
4 km/h	36.9%
5 km/h	41.0%
6 km/h	44 7%
7 km/h	48.2%
8 km/h	51.4%
9 km/h	54 4%
10km/h	57.0%
11 km/h	59.4%
12 km/h	61.6%

The figure shows the percentage of AIS 3+ injuries prevented by reducing the crash severity. By applying these percentages to the number of injuries at each crash speed in the original crash vehicle file, an estimate of baseline injuries for the adjusted CVF is first established. Then, to determine the injuries saved for say a 2km/h reduction in severity, the number of people exposed at each increment of crash severity is then multiplied by the injury risk associated with a 2km/h reduction in crash severity. If such a reduction was achieved for the total vehicle fleet, this would result in a reduction of hard thorax injuries to occupants in near-side crashes each year from 75 to 54 (a reduction of 28% in the number of these injuries). Table 2.4 shows the percent reductions in AIS 3+ injuries to the hard thorax for incremental reductions in delta-V, based on the adjusted CVF data and the method illustrated above.

> ***Assumption 9:*** *The hard thorax injury reductions to occupants in side impact crashes in Australia are as listed in Table 2.4 and detailed above.*

Range of Crash Severity Benefits

As discussed earlier, the side impact standard is expected to provide protection across the crash severity range of 0 to 64 km/h. Improved protection can equate to reducing the crash severity by an incremental amount across the entire range. Systematic tests of cars in side impacts have been reported by NHTSA in the United States. One purpose of these tests was to determine the baseline performance of the vehicle fleet on the road. Table 2.5 summarises the test results for 4-door cars conducted before the side impact standard was announced. The test results provided a wide range of TTI values (from 72.5 to 119.4) with reductions expected to meet a TTI of 85 ranging from 0 at 72.5 to 34.4 at 119.4. The resultant reduction in delta-V to meet an 85 TTI based on these test results were estimated to range from 0 to 19 km/h. Assuming these values are also applicable in this country, it is expected that hard thorax injury reduction for the entire Australian fleet would be 45.1%.

Table 2.5
AIS 3+ Injury Reduction Estimates for 4-door cars from NHTSA Tests

Car	TTI	TTI Reduction	Delta-V	% Reduction
Ford	119.4	34.4	19	71.7%
Chrysler	111.5	26.5	15	66.8%
Mazda	105.5	20.5	11	59.4%
Honda	95	10	6	44.7%
GM	89.5	4.5	2	28.1%
Eagle	72.5	0	0	0.0%
Average AIS 3+ Injury Reduction is 45 1%				

As noted previously, the MUARC file is representative of severe crashes but understates minor ones which frequently involve AIS 1 and 2 level injuries. While these data were adjusted for AIS 3+ injuries in previous discussion, they were not adjusted for AIS 1 and 2 injuries. Based on data from other countries, it seemed that low level injuries were twice as frequent as reported in the MUARC database. Thus, to compensate for these missing data, a higher relevance factor of 0.9 was assumed for AIS 1 and 2 injuries.

> ***Assumption 10:*** *Based on the above analysis, a relevance factor of 0.45 is expected for AIS 3 to 6 hard thorax injuries over the crash severity range of 0 to 64 km/h. For the more minor AIS 1 and 2 injuries, a relevance factor of 0.90 would be expected, based on the conservative evidence of NHTSA which suggests these low level injuries are at least twice as frequent as the more severe ones.*

SID & EUROSID Differences

The Regulatory Impact Statement by NHTSA (1990) dealt with reductions in AIS 3+, 4+ and 5+ injuries. The assumption was that all these injuries would be reduced to AIS 2 and below in their analysis and this has been subject to criticisms. A more reasonable expectation for a dynamic impact standard would be a uniform reduction across the range of differing injury severities. Improvements in injury reduction may be offered by a more precise measurement device, such as EUROSID over SID.

> ***Assumption 11:*** *The reduction in hard thorax injuries by the use of SID and TTI measures are 2 - AIS over the crash severity range listed above. The hard thorax injury reductions possible using EUROSID and V*C measures would be 3-AIS across the same delta-V range.*

2.3.7 Pelvic Injuries

Haffner (1985) published a curve of pelvic fracture criteria for lateral impact loading which is shown in Figure 2.7 below. These values were used in the Regulatory Impact Statement issued by NHTSA (1990) as a basis for estimating the benefits of reduced pelvic accelerations in side impacts.

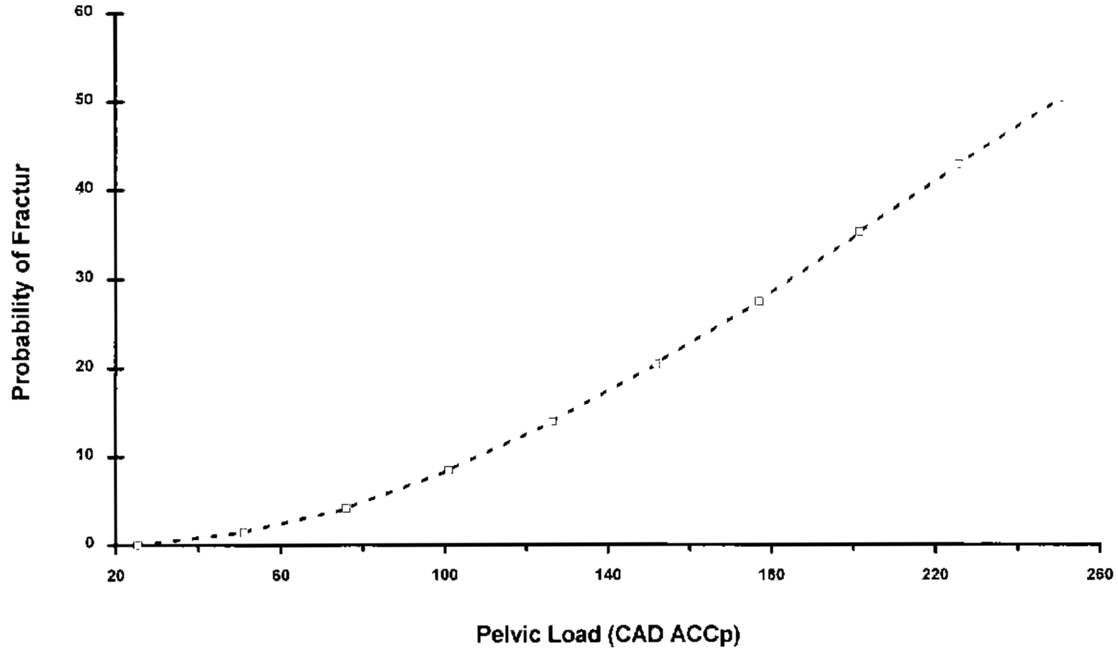

Figure 2.7 *Fracture probability by pelvic loading (from Haffner 1985).*

The relation is based on estimated injury risk to the entire population, although it is known that older people have a much higher risk of pelvic fracture that the average shown in this curve. Based on US vehicle crashes and Haffner's curve, a value of 130gs was established for FMVSS 214 which would be expected to yield a front seat reduction of 17.6% and a rear seat reduction of 9.3% in AIS 2+ pelvic injuries. It is assumed that all pelvic injury benefits would be fracture reductions, including AIS 2 fractures, and thus all relevant injuries are reduced to the AIS 1 level.

> ***Assumption 12**: The pelvic fracture relationship published by Haffner is valid and the crash performance in terms of the risk of pelvic injury of US and Australian vehicles is similar. Injury reductions to AIS 1 are expected for a relevant percentage of side impact crashes.*

2.3.8 Abdominal Injuries

SID does not measure abdominal injury directly, although it is expected that some abdominal injury will be saved by the introduction of a dynamic side impact standard from reductions in TTI(d) for the hard thorax and pelvic Gs. As EUROSID includes a measure of abdominal injury, it is expected to provide greater abdominal benefits over those of SID.

Assumption 13: The relevance factors for abdominal injuries are the same as those expected for the hard thorax. However, an overall injury reduction of AIS 1 is expected for SID and AIS 3 for EUROSID, assuming abdominal injury criteria is applied when using this test dummy.

2.3.9 Head & Face Injuries Among Survivors

Previous Harm analysis in frontal crashes has shown that softening the vehicle structure greatly reduces the Head Injury Criteria (HIC) but was less effective in reducing face injuries. Softening structural members with one inch of padding was estimated to reduce head injuries by 2 AIS. In the absence of any test data, this level of benefit is assumed for head contacts with the door panel as the standard is expected to result in improved door padding. For facial injuries, padded steering assemblies are expected to provide a 1 AIS benefit and the same is assumed for the side impact standard. Since EUROSID measures head injury (and SID does not), some additional benefit should accrue from reducing contacts with the side rails using this test dummy.

Assumption 14: All head injuries in side impacts from contact with the door panel are reduced by 2 AIS and face injuries by 1 AIS over the range 0 to 64km/h. For EUROSID, an additional benefit of 2 AIS applies to head contacts with the side rails.

2.3.10 Upper Extremities

Introduction of a dynamic side impact standard is likely to lead to more crash friendly door panels (less injurious door hardware and more forgiving arm rests) which is expected to reduce upper extremity and shoulder injuries in side impacts. There are no data available on the benefits of these improvements. In the absence of test data, it would seem reasonable to expect a likely benefit of 1 AIS reduction in upper extremity and shoulder injuries from these improvements.

Assumption 15: All upper extremity, shoulder and lower extremity injuries in side impacts from contact with the door panel and fittings will be reduced by 1 AIS over the impact range from 0 to 64km/h.

2.3.11 Far-Side Occupants & Ejection

The standard calls for the prevention of far-side door openings during the crash test. Tests of US cars manufactured in the early eighties showed that the far-side door opened in 4 out of 12 vehicles tested (33% of cases). Improvements at the test impact speed are expected to provide benefits at even higher delta-Vs, but probably not as high as the 64km/h assumed for near-side occupant chest injuries with the door interior.

Assumption 16: A dynamic side impact standard will result in the elimination of all injuries with exterior contacts for far-side occupants ejected through the far-side door over the severity range 0 to 40 km/h.

2.3.12 Relevance & Crash Severity

Because of the minimal number of cases of side impacts in the Crashed Vehicle File, it is desirable to use all data available, including those cases for which delta-V is unknown. It is reasonable to assume that they are similar to those for which delta-V is known as the main reason delta-V could not be calculated in this study was the failure to locate the second vehicle at the time of inspection (likely to be a random event). The Harm for these cases, then, will be included at the same proportion as the file for those cases for which delta-V could be computed.

> ***Assumption 17:*** *The crash severity relevance figure at each AIS level for hard thorax to door panel contacts is the ratio of those injured at each AIS level at delta-Vs below 64 km/h to all injuries at each AIS for which delta-V is known. Similar relevance figures can be for other body regions where sufficient data exists.*

2.4 CALCULATION OF HARM REDUCTIONS

These 17 assumptions can now enable the Harm reductions associated with the introduction of a dynamic side impact standard in Australia to be calculated, using the method outlined earlier. Summaries of the benefits by body region and seating position are described in the next Chapter, along with the annual savings expected in Harm and trauma reduction.

Chapter 3 Harm Benefits

The previous chapter described the Harm reduction method used for calculating the benefits of a dynamic side impact regulation for Australia and the various data sources and assumptions necessary for making these computations. This chapter shows the resultant benefits summed from individual body regions and seating positions, assuming that either the existing United States FMVSS 214 regulation or the European Proposed ECE Regulation 95 were to apply to vehicles sold in this country.

Benefits have been expressed two ways. First, as an annual savings in Harm assuming that all vehicles in the total vehicle fleet were to meet these standards (this can be expressed as both a savings in A$ for the population each year as well as a proportional reduction in Harm). Second, as a unit Harm figure for each vehicle, based on a 7 percent discount factor, assuming similar vehicle life and scrappage rates to those of the immediate past.

3.1 DETAILED HARM CALCULATIONS

Spreadsheets were developed around a series of body regions and contact sources for both front and rear seat occupants and near- and far-side seating positions. The body regions of interest comprised:

- the head,
- the face,
- the hard thorax (chest + spleen, liver and kidneys)
- the abdomen (minus spleen, liver and kidneys),
- the pelvis
- upper limbs and the shoulder, and
- lower limbs (thigh, knee, leg and feet).

Relevant contacts for each body region and seating position were determined from the previous side impact benefit study report CR 137 (Fildes et al 1994) based on a systematic investigation of current model vehicles involved in side impact collisions. These included:

- the near-and far-side door panels,
- side glazing (including window frame),
- roof, side rails and A-, B- and C-pillars,
- floor and toepan,
- exterior objects (road surface and impacting objects),

- other occupants,
- front of the vehicle (windscreen, steering assy, instrument panel, etc), and
- rear of the vehicle (screen, seats, etc).

Injury and contact source relevance was judged on the basis of the likelihood of a particular countermeasure (eg: door padding, improved structural integrity, etc) resulting from the introduction of the regulation. This was in part assessed from manufacturers' response to FMVSS 214 as well as the discussion that emanated from the earlier one day meeting of international research specialists in Munich (see Fildes & Vulcan 1994). Dr. Kennerly Digges prior involvement at NHTSA leading up to the introduction of FMVSS 214 was extremely valuable for this task.

One-page summaries of these spreadsheets are shown in Tables 3.1 to 3.8 which detail the benefits by body region and seating position if either FMVSS 214 and ECE Reg 95 were to be introduced in Australia. These body region benefits are then summed in Table 3.9 to show the total amount of side impact Harm saved each year (in A$ millions) as well as the discounted unit value over its life of each car. The discounting procedure was described fully in CR 100 and is repeated here for completeness.

3.1.1 Discount Present Value Method

The discount present value method sums the average Harm attributed to the measure for one car over its life and then discounts the benefits in future years back to the present. For the purpose of this calculation, it is assumed that percentage of total Harm reduction for all cars of a certain age group is equal to the percentage of total relevant casualty crashes involving that age group. This is detailed further below:

$$\frac{H_1}{H} = \frac{F_1}{F} \quad \text{or} \quad H_1 = \frac{F_1}{F} \times H$$

where H_1 = Harm reduction for all cars in their first year

H = total Harm reduction for all cars in one year

F_1 = number of cars involved in casualty crashes in first year

F = total number of cars involved in casualty crashes in one year

Note: Both F_1 and F have been derived from frequency distributions of crashed cars involving fatal, hospitalised, and medically treated occupants, weighted according to their average cost at each severity level. First year means in the calendar year in which the vehicle was manufactured. For instance, a car showing 12/89 on its compliance plate as its date of manufacture would be in its first year for less than one month.

$$\frac{H_1}{V_1} \quad \text{where } V_1 = \text{number of new cars registered that year}$$

The total benefit B attributed to the measure for one car is then obtained by adding up the Harm reduction in each year of its life, discounted back to the first year [No discount is applied back to the first year because both the costs and benefits accrue progressively during the year]

$$B = \frac{H_1}{V_1} + \frac{H_2}{V_2[1+d]} + \frac{H_3}{V_3[1+d]^2} + \cdots \frac{H_n}{V_n[1+d]^{n-1}}$$

where H_n = reduction in Harm by the measure for cars in their nth year

V_n = number of new cars registered n years ago

d = discount rate (07 equals 7%)

It should be noted that this calculation assumes that the involvement rate in three years time of cars which were new this year can be estimated by the involvement rate of three year old cars this year [where involvement rate is measured as crashes per thousand new cars originally registered three years ago] This allows for scrapping some cars each year and for the fact that as new vehicles become older, their crash involvement rate may be different to that when new.

3.1.2 Discount Rate

The selection of an appropriate discount rate is really a matter of opinion (there is no magic number). Traditionally, the Commonwealth Government has used 7% as an appropriate rate, while other state governments, however, have used a range of different values (the Victorian Government, for instance, uses 4%). A smaller discount rate gives greater weight to benefits received in the distance future and is thus less conservative.

Department of Finance (1991) recommend that where possible, sensitivity analysis be undertaken involving a range of different discount rates to represent the 'best rate', 'most likely' and 'worst case' scenarios. They maintain that values of 6, 8 and 10 percent are useful values for sensitivity analysis. It was not possible to perform sensitivity analysis here within the constraints of the project. It is acknowledged that the choice of the discount rate has a marked effect on the calculation Not only does it influence the BCR, but also the cost of injury [Steadman and Bryan 1988 used a 7% discount rate in determining the cost of injury for each injury severity level and noted that a 4% rate would increase the cost of injury overall by 17%]. Thus, a 7% discount rate would seem to be the 'most likely' outcome here

Table 3.1 *Estimated Harm reduction benefits to the head from the introduction of a side impact regulation based on FMVSS 214 or ECE Regulation 95.*

FMVSS 214 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	1.31	0 6%		7 88	3.4%	
SIDE RAILS	1.27	0.6%	0.6%	0.44	0.2%	0.2%
DOOR PANELS	9.91	4 9%	4.9%	19.67	8.4%	8.4%
OTHER INT. SIDE	37 94	18.6%		9.77	4 2%	
ROOF	5 62	2 8%		69 36	29.6%	
REAR OF VEHICLE	0 00	0 0%		0.13	0 1%	
OTHER	147 61	72.5%		127.11	54.2%	
TOTAL	203 65	100.0%	5 5%	234.36	100 0%	8.6%

ECE 95 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	1 31	0.6%		7.88	3 4%	
SIDE RAILS	1.27	0 6%		0.44	0.2%	0.2%
DOOR PANELS	9.91	4 9%	4 9%	19.67	8.4%	8.4%
OTHER INT. SIDE	37.94	18 6%		9.77	4.2%	
ROOF	5.62	2.8%		69.36	29.6%	
REAR OF VEHICLE	0.00	0.0%		0.13	0.1%	
OTHER	147.61	72 5%		127.11	54 2%	
TOTAL	203 65	100 0%	4.9%	234 36	100.0%	8.6%

COUNTERMEASURE ASSUMPTIONS

1. **For FMVSS 214**	Benefits from door contacts only Injury reduction = AIS 2; Relevance = 1.0 for AIS 1-6 (door)
2. **For ECE REG 95**	Benefits from both door and side rail contacts Injury reduction = AIS 2, Relevance = 1.0 for AIS 1-6 (all contacts)

BENEFIT SUMMARY - HEAD

CONTACT SOURCE	**FMVSS 214 BENEFITS**			**ECE 95 BENEFITS**		
	TOTAL BENEFIT OPPORTUNIT	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**	**TOTAL BENEFIT OPPORTUNIT**	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**
FRONT OF VEHICLE						
SIDE RAILS				0 1%	1.16	0.44
DOOR PANELS	6.8%	9.66	17.68	6 8%	9.66	17.68
OTHER INT SIDE						
ROOF						
REAR OF VEHICLE						
OTHER						
TOTAL BENEFIT		**9.66**	**17.68**		**10.82**	**18.12**

Table 3.2 *Estimated Harm reduction benefits to the face from the introduction of a side impact regulation based on FMVSS 214 or ECE Regulation 95*

FMVSS 214 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	0.66	3 4%		0.66	4.6%	
SIDE RAILS	0.07	0 3%		0 00	0 0%	
DOOR PANELS	0.69	3 6%	3 6%	0 07	0 5%	0.5%
OTHER INT. SIDE	7.11	36.4%		0 18	1.2%	
ROOF	0.08	0 4%		2 76	19 4%	
REAR OF VEHICLE	0.00	0.0%		0.00	0.0%	
OTHER	10.90	55 9%		10 58	74 2%	
TOTAL	19.51	100.0%	3 6%	14.25	100.0%	0.5%

ECE 95 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	0.66	3.4%		0 66	4 6%	
SIDE RAILS	0.07	0 3%	0 3%	0.00	0 0%	0.0%
DOOR PANELS	0.69	3 6%	3 6%	0 07	0 5%	0.5%
OTHER INT. SIDE	7.11	36 4%		0.18	1 2%	
ROOF	0.08	0 4%		2 76	19 4%	
REAR OF VEHICLE	0.00	0.0%		0.00	0 0%	
OTHER	10 90	55 9%		10 58	74 2%	
TOTAL	19.51	100.0%	3 9%	14 25	100.0%	0.5%

COUNTERMEASURE ASSUMPTIONS

1. For FMVSS 214	Benefit from door contacts only Injury reduction = AIS 1; Relevance = 1 0 for AIS 1-4
2. For ECE REG 95	Benefits from both door and side rail contacts Injury reduction = AIS 1, Relevance = 1.0 for AIS 1-6 (door) Injury reduction = AIS 1; Relevance = 1.0 for AIS 1-4 (side rails)

BENEFIT SUMMARY - FACE

CONTACT SOURCE	**FMVSS 214 BENEFITS**			**ECE 95 BENEFITS**		
	TOTAL BENEFIT OPPORTUNIT	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**	**TOTAL BENEFIT OPPORTUNIT**	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**
FRONT OF VEHICLE						
SIDE RAILS				0.2%	0.06	0.00
DOOR PANELS	2.3%	0.69	0.07	2 3%	0.69	0 07
OTHER INT SIDE						
ROOF						
REAR OF VEHICLE						
OTHER						
TOTAL BENEFIT		**0.69**	**0.07**		**0.75**	**0.07**

Table 3.3 *Estimated Harm reduction benefits to the hard thorax from the introduction of a side impact regulation based on FMVSS 214 or ECE Regulation 95.*

FMVSS 214 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	13.46	8 1%		5.49	13.3%	
INTERIOR SIDE	132.86	80.2%	80 2%	8.03	19.5%	19.5%
ROOF	0.00	0.0%		0.03	0.1%	
FLOOR/TOEPAN	0 00	0.0%		0 00	0 0%	
REAR OF VEHICLE	0 00	0 0%		0.00	0 0%	
OTHER	19.34	11 7%		27 68	67.1%	
TOTAL	165.66	100.0%	80 2%	41.23	100 0%	19.5%

ECE 95 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	13 46	8.1%		5.49	13 3%	
INTERIOR SIDE	132.86	80 2%	80.2%	8 03	19.5%	19 5%
ROOF	0 00	0.0%		0.03	0 1%	
FLOOR/TOEPAN	0.00	0.0%		0 00	0.0%	
REAR OF VEHICLE	0 00	0 0%		0.00	0 0%	
OTHER	19.34	11 7%		27.68	67 1%	
TOTAL	165.66	100 0%	80 2%	41 23	100 0%	19 5%

COUNTERMEASURE ASSUMPTIONS

1. For FMVSS 214	Injury reduction = AIS 2 Relevance = 0 9 for AIS 1-2, 0 45 for AIS 3-6
2. For ECE REG 95	Injury reduction = AIS 3 Relevance = 0.9 for AIS 1-2; 0.45 for AIS 3-6

BENEFIT SUMMARY - HARD THORAX

CONTACT SOURCE	**FMVSS 214 BENEFITS**			**ECE 95 BENEFITS**		
	TOTAL BENEFIT OPPORTUNIT	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**	**TOTAL BENEFIT OPPORTUNIT**	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**
FRONT OF VEHICLE						
INTERIOR SIDE	68.1%	54.43	3 16	68.1%	61.65	3 63
ROOF						
FLOOR/TOEPAN						
REAR OF VEHICLE						
OTHER						
TOTAL BENEFIT		**54.43**	**3.16**		**61.65**	**3.63**

Table 3.4 *Estimated Harm reduction benefits to the abdomen from the introduction of a side impact regulation based on FMVSS 214 or ECE Regulation 95.*

FMVSS 214 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM HARM $ million	 % NEAR-SIDE HARM	 BENEFIT OPPORTUNITY	FAR-SIDE HARM HARM $ million	 % FAR-SIDE HARM	 BENEFIT OPPORTUNITY
FRONT OF VEHICLE	0.05	0 5%		0.09	1 4%	
INTERIOR SIDE	8 56	82.4%	82.4%	0.04	0 6%	0 6%
ROOF	0.00	0 0%		0.00	0 0%	
FLOOR/TOEPAN	0 00	0.0%		0.00	0 0%	
REAR OF VEHICLE	0.00	0 0%		0.00	0 0%	
OTHER	1 77	17.0%		6.18	98.0%	
TOTAL	10.38	100.0%	82.4%	6 31	100.0%	0.6%

ECE 95 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM HARM $ million	 % NEAR-SIDE HARM	 BENEFIT OPPORTUNITY	FAR-SIDE HARM HARM $ million	 % FAR-SIDE HARM	 BENEFIT OPPORTUNITY
FRONT OF VEHICLE	0 05	0 5%		0.09	1.4%	
INTERIOR SIDE	8 56	82 4%	82.4%	0.04	0 6%	0.6%
ROOF	0.00	0.0%		0.00	0.0%	
FLOOR/TOEPAN	0 00	0.0%		0.00	0 0%	
REAR OF VEHICLE	0 00	0.0%		0.00	0 0%	
OTHER	1 77	17.0%		6.18	98.0%	
TOTAL	10.38	100 0%	82.4%	6 31	100 0%	0.6%

COUNTERMEASURE ASSUMPTIONS

1. For FMVSS 214	Injury reduction = AIS 1 Relevance = 1.0 for AIS 1-6
2. For ECE REG 95	Injury reduction = AIS 3 Relevance = 1.0 for AIS 1-6

BENEFIT SUMMARY - ABDOMEN (minus liver, spleen and kidney)

CONTACT SOURCE	**FMVSS 214 BENEFITS** **TOTAL BENEFIT OPPORTUNIT**	 **NEAR-SIDE HARM SAVED $ million**	 **FAR-SIDE HARM SAVED $ million**	**ECE 95 BENEFITS** **TOTAL BENEFIT OPPORTUNIT**	 **NEAR-SIDE HARM SAVED $ million**	 **FAR-SIDE HARM SAVED $ million**
FRONT OF VEHICLE						
INTERIOR SIDE	51.5%	6.48	0.04	51.5%	8 41	0 04
ROOF						
FLOOR/TOEPAN						
REAR OF VEHICLE						
OTHER						
TOTAL BENEFIT		**6.48**	**0.04**		**8.41**	**0.04**

Table 3.5 *Estimated Harm reduction benefits to the pelvis from the introduction of a side impact regulation based on FMVSS 214 or ECE Regulation 95.*

FMVSS 214 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	0 00	0 0%		0 51	16.6%	
INTERIOR SIDE	24.66	95.9%	95 9%	0.19	6 3%	6 3%
ROOF	0.00	0 0%		0 00	0.0%	
FLOOR/TOEPAN	0.00	0.0%		0 00	0 0%	
REAR OF VEHICLE	0.00	0.0%		0.00	0.0%	
OTHER	1.05	4.1%		2.37	77.1%	
TOTAL	25.71	100.0%	95.9%	3 07	100.0%	6.3%

ECE 95 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	0.00	0.0%		0.51	16.6%	
INTERIOR SIDE	24.66	95.9%	95 9%	0 19	6 3%	6.3%
ROOF	0.00	0.0%		0 00	0.0%	
FLOOR/TOEPAN	0.00	0.0%		0.00	0.0%	
REAR OF VEHICLE	0.00	0.0%		0.00	0.0%	
OTHER	1.05	4.1%		2 37	77.1%	
TOTAL	25 71	100.0%	95.9%	3.07	100 0%	6 3%

COUNTERMEASURE ASSUMPTIONS

1. **For FMVSS 214**	Injury reduction = All injuries reduce to AIS 1 Relevance = 0 2 for AIS 1-4
2. **For ECE REG 95**	Injury reduction = All injuries reduce to AIS 1 Relevance = 0.2 for AIS 1-4

BENEFIT SUMMARY - PELVIS

CONTACT SOURCE	**FMVSS 214 BENEFITS**			**ECE 95 BENEFITS**		
	TOTAL BENEFIT OPPORTUNIT	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**	**TOTAL BENEFIT OPPORTUNIT**	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**
FRONT OF VEHICLE						
INTERIOR SIDE	86.4%	4.35	0.05	86 4%	4 35	0.05
ROOF						
FLOOR/TOEPAN						
REAR OF VEHICLE						
OTHER						
TOTAL BENEFIT		**4.35**	**0.05**		**4.35**	**0.05**

Table 3.6 *Estimated Harm reduction benefits to the upper limbs (incl shoulders) from the introduction of a side impact regulation based on FMVSS 214 or ECE 95.*

FMVSS 214 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	FAR-SIDE HARM HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	4 69	10 0%		2.06	9.1%	
INTERIOR SIDE	21.08	45 0%	45.0%	6.01	26.5%	26 5%
ROOF	0 00	0.0%		0.51	2 2%	
FLOOR/TOEPAN	0 00	0 0%		0.00	0.0%	
REAR OF VEHICLE	0.00	0.0%		0.00	0.0%	
OTHER	21 06	45.0%		14 11	62.2%	
TOTAL	46 83	100.0%	45 0%	22.70	100 0%	26 5%

ECE 95 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	FAR-SIDE HARM HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	4 69	10 0%		2 06	9.1%	
INTERIOR SIDE	21.08	45 0%	45 0%	6 01	26.5%	26.5%
ROOF	0.00	0 0%		0.51	2.2%	
FLOOR/TOEPAN	0 00	0 0%		0.00	0.0%	
REAR OF VEHICLE	0 00	0 0%		0 00	0.0%	
OTHER	21.06	45.0%		14.11	62.2%	
TOTAL	46.83	100 0%	45.0%	22.70	100.0%	26.5%

COUNTERMEASURE ASSUMPTIONS

1. **For FMVSS 214**	Injury reduction = AIS 1 Relevance = 0.9 for AIS 1-2; 0.45 for AIS 3-4
2. **For ECE REG 95**	Injury reduction = AIS 1 Relevance = 0 9 for AIS 1-2, 0.45 for AIS 3-4

BENEFIT SUMMARY - UPPER LIMB & SHOULDER

CONTACT SOURCE	**FMVSS 214 BENEFITS TOTAL BENEFIT OPPORTUNIT**	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**	**ECE 95 BENEFITS TOTAL BENEFIT OPPORTUNIT**	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**
FRONT OF VEHICLE						
INTERIOR SIDE	39 0%	17.00	3 58	39.0%	17 00	3 58
ROOF						
FLOOR/TOEPAN						
REAR OF VEHICLE						
OTHER						
TOTAL BENEFIT		**17.00**	**3.58**		**17.00**	**3.58**

Table 3.7 *Estimated Harm reduction benefits to the lower limbs from the introduction of a side impact regulation based on FMVSS 214 or ECE Regulation 95*

FMVSS 214 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	11.36	19 6%		12 49	56 2%	
INTERIOR SIDE	32.62	56 4%	56 4%	0.98	4.4%	4 4%
ROOF	0 00	0 0%		0 00	0 0%	
FLOOR/TOEPAN	11 37	19 7%		0 56	2.5%	
REAR OF VEHICLE	0 00	0.0%		0 00	0 0%	
OTHER	2 51	4.3%		8 19	36 9%	
TOTAL	57 86	100 0%	56 4%	22 22	100 0%	4 4%

ECE 95 - COUNTERMEASURE OPPORTUNITIES

CONTACT	NEAR-SIDE HARM			FAR-SIDE HARM		
	HARM $ million	% NEAR-SIDE HARM	BENEFIT OPPORTUNITY	HARM $ million	% FAR-SIDE HARM	BENEFIT OPPORTUNITY
FRONT OF VEHICLE	11 36	19 6%		12 49	56.2%	
INTERIOR SIDE	32.62	56.4%	56 4%	0 98	4 4%	4 4%
ROOF	0 00	0.0%		0 00	0 0%	
FLOOR/TOEPAN	11 37	19 7%		0 56	2 5%	
REAR OF VEHICLE	0 00	0 0%		0.00	0 0%	
OTHER	2 51	4.3%		8.19	36 9%	
TOTAL	57 86	100 0%	56.4%	22.22	100 0%	4 4%

COUNTERMEASURE ASSUMPTIONS

1. For FMVSS 214	Injury reduction = AIS 1 Relevance = 0 9 for AIS 1-2, 0.45 for AIS 3-4
2. For ECE REG 95	Injury reduction = AIS 1 Relevance = 0.9 for AIS 1-2, 0 45 for AIS 3-4

BENEFIT SUMMARY - LOWER LIMB

CONTACT SOURCE	**FMVSS 214 BENEFITS**			**ECE 95 BENEFITS**		
	TOTAL BENEFIT OPPORTUNITY	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**	**TOTAL BENEFIT OPPORTUNITY**	**NEAR-SIDE HARM SAVED $ million**	**FAR-SIDE HARM SAVED $ million**
FRONT OF VEHICLE						
INTERIOR SIDE	42 0%	17 64	1.24	42 0%	17 64	1 24
ROOF						
FLOOR/TOEPAN						
REAR OF VEHICLE						
OTHER						
TOTAL BENEFIT		**17.64**	**1.24**		**17.64**	**1.24**

TABLE 3.8
Summary of Harm Benefits- Dynamic Side Impact Regulation

BODY REGION		U.S.A. STANDARD FMVSS 214	EUROPEAN STANDARD ECE Reg 95
HEAD INJURIES	near-side	9.66	10.82
	far-side	17.68	18.12
FACIAL INJURIES	near-side	0.69	0.75
	far-side	0.07	0.07
HARD THORAX INJURIES	near-side	54.43	61.65
	far-side	3.16	3.63
ABDOMINAL INJURIES	near-side	6.48	8.41
	far-side	0.04	0.04
PELVIC INJURIES	near-side	4.35	4.35
	far-side	0.05	0.05
UPPER LIMB & SHOULDER	near-side	17	17
	far-side	3.58	3.58
LOWER LIMB INJURIES	near-side	17.64	17.64
	far-side	1.24	1.24
NEAR-SIDE HARM SAVED EACH YEAR ($mil)		110.25	120.62
FAR-SIDE HARM SAVED EACH YEAR ($mil)		25.82	26.73
TOTAL SIDE HARM SAVED EACH YEAR ($mil)		136.07	147.35

UNIT HARM PER VEHICLE ($) (7% discounted method)	147.20	159.40

3.2 BENEFIT CALCULATIONS

Table 3.8 shows the summary of Harm benefits assuming Australian vehicles were required to meet either the current United States FMVSS 214 side impact regulation or European ECE Regulation 95.

The FMVSS 214 benefit would be A$136 million annually or a 4.7% reduction in vehicle occupant trauma. The unit Harm benefit is A$147 per car, in A$1991 figures and based on a 7% discount rate. The ECE Regulation 95 benefit would be A$147 million annual which would amount to a slightly higher 5.1% reduction in vehicle occupant trauma annually. The unit Harm benefit for this standard would be $159 per car.

The assumptions involved in these benefit calculations have been described in detail earlier in this Chapter. In particular, they assume a 300mm barrier height for the European standard based on all available test data. The consequences of this being reduced to 260mm as recently proclaimed by ECE Regulation 95 is unclear as no testing was involved in the lead up to that decision in Europe. However, as noted earlier, recent Australian tests by the Federal Office of Road Safety (Higgins et al, 1995) suggests that lowering the ECE barrier face may not significantly reduce the benefits in the Australian context.

Estimating implementation costs was outside the scope of this project. However, the unit Harm benefits indicate the likely break-even costs for the standards should be cost-effective, given sufficient lead time.

Chapter 4 Discussion & Recommendations

The study set out to estimate the benefits likely to accrue if Australia was to mandate either the current United States FMVSS 214 or the proposed European ECE Regulation 95 dynamic side impact standards. Differential benefits were to be calculated where possible and conclusions and recommendations for implementation and areas where further research or consideration was required were to be highlighted.

4.1 OVERVIEW OF BOTH STANDARDS

As noted in the Introduction to this report, the current US and the proposed European side impact standards are the only two dynamic side impact candidates for Australia to adopt to maintain international harmonisation. It is unfortunate that these two standards are fundamentally different and in their current forms, are incapable of being incorporated into a single standard. This presents a challenge not only to manufacturers who sell their cars in both regions of the world but also to countries like Australia who wish to adopt existing international standards to promote and ensure harmonisation with the rest of the world.

4.1.1 FMVSS 214 Regulation

The US standard calls for a moving "crabbed configuration" deformable barrier to be propelled into a stationary test vehicle at 33.5mph (54km/h) at an angle of 27deg. Two Side Impact Dummies (SID) as defined by the National Highway Traffic Safety Administration in Washington DC are positioned in the front and rear near-side seating positions and instrumented to record peak accelerations of the spine and ribs, [TTI(d)] and pelvis (g force). Acceptance criteria specify dummy measures not exceeding a TTI(d) value of 85 and pelvic accelerations or forces not exceeding 130 g's. The impacting barrier is essentially a homogeneous construction of 45 psi honeycomb material with a harder protruding bumper section. It is 3000lb (1360kgm) in weight, 66" (1.68 metres) long and has a ground clearance height of 11" (280mm).

4.1.2 ECE Regulation 95

The European procedure requires a perpendicular test of a movable barrier into a stationary vehicle at 50km/h. The barrier is to be 950kgm in weight, with a 1500mm wide barrier face made up of 6 variable density sections which supposedly represent the stiffness values of European cars. The barrier height was originally 300mm but was dropped to 260mm when the regulation was pronounced. The specifications call for a single dummy (European designed EUROSID model) positioned in the front seat on the struck side of the test car. Injury measures include a maximum head performance criterion (HPC) of 1000Hz and 150g, a peak chest deflection on any rib of less than 64mm with a peak viscous response V*C measure (the future of this last criterion is still to be determined as a result of the pronouncement process in Europe), and peak abdominal and pelvic force criteria.

The US standard was first implemented for 1994 model vehicles and prescribed a phased introduction of 10% in the first year, 25% for 1995 vehicles, 40% for 1996 vehicles and 100% for 1997 models and beyond. The European procedure has been promulgated for introduction for all European vehicles manufactured after September 1995 and recent information still confirms this introductory date.

4.2 BENEFITS OF BOTH STANDARDS

The likely benefit to Australia if it were to adopt either of these two standards, based on existing Australian Harm patterns and vehicles was computed in Chapter 3 using the Harm Reduction approach used previously in establishing the benefits of a range of frontal crash measures for the Federal Office of Road Safety (Monash University Accident Research Centre, 1992). This was outlined in Chapter 2. In computing these benefits, it was necessary to make a number of assumptions of the likely consequence of these standards and these were thoroughly documented in the early part of Chapter 3. The resultant Harm benefits for both dynamic side impact standards were summarised in Table 3.9 in the previous Chapter and these findings are again outlined below.

4.2.1 FMVSS 214 Benefits

For the US standard, FMVSS 214, the total Harm saved annually in Australia, assuming all vehicles were to comply, would amount to A$136 million based on 1991 crash patterns and A$1991 costs of injuries. It was suggested that these figures are still current today. This amount represents a 4.7% reduction in vehicle occupant trauma annually if FMVSS 214 were to apply in Australia.

The unit benefit per car, assuming a 7% discount rate and current sales and scrappage figures would be $147; that is, this amount could be spent on each new vehicle for injury savings to break-even with the additional manufacturing costs imposed by the standard.

There was a high degree of confidence in calculating the benefits of FMVSS 214 as there were data available on the likely effectiveness based on US crash patterns and vehicle population which was able to be converted into equivalent Australian figures using the Crashed Vehicle File data and other sources of suitable information.

4.2.2 ECE Regulation 95 Benefits

If the proposed European standard were to apply to Australian vehicles, the Harm benefit is estimated to be A$ 147 million each year based on A$1991 figures and assuming all vehicles meet the standard. This would amount to a slightly higher 5.1% reduction in vehicle occupant trauma annually over the US standard. The unit benefit per car (break-even cost effectiveness) for the European standard is $159, again assuming a 7% discount rate and current sales and scrappage figures.

Unlike the US standard, the was practically no information available on the likely effects of this standard in reducing injuries. Hence, these figures can only be viewed as indicative estimates at this stage. It is fair to say, though, that these estimates have a degree of validity, given input from European experts and comparative research performed by Transport Canada.

4.3 DISCUSSION OF BENEFITS

The two sets of figures are relatively similar and either would lead to modest reductions in the road toll. They suggest an improvement in an individual's risk of injury (and severe injury) in side impacts of the order of 5 percent and would help to alleviate pain and suffering to those unfortunate enough to be involved in a side impact collision. These crashes are particularly severe, given the lack of structure available in the side of the car and the countermeasures that would result from manufacturers having to meet this standard could only be an improvement in outcome for the vehicle's occupants.

It was unfortunate that no installation cost data was available to judge the likely cost effectiveness of both standards. On the figures presented above, the break-even cost would be of the order of $150 per car. It is difficult to assess what the cost of implementing either standard would be and it could vary from model to model. However, it would not be totally unreasonable to assume an average cost below $150 with sufficient lead time, building on the experience gained from the US and Europe. In short, the additional unit cost does not seem to be an abnormal extra burden for the car manufacturers to meet, given the injury savings that would accrue to the occupants of their vehicles that crash.

In addition, as many of the cars imported into Australia will be expected to meet at least one of these standards for similar models sold overseas, it is likely that many of them will meet one or both of these standards anyway in the years ahead. Thus, the additional costs imposed on them will only represent relatively small marginal cost increases. Local manufacturers are the ones most likely to be adversely affected from the introduction of a dynamic side impact regulation. However, at least one of these makers (FORD) already advertises that their latest model Falcon meets FMVSS 214 criteria. It is unclear whether the others do too at this stage, although crash testing would quickly demonstrate this.

In arriving at the estimates of the benefits of a dynamic side impact standard, it was necessary to make a number of assumptions about the likely improvements in performance and countermeasures that manufacturers would use to meet this regulation. Some documented evidence was available from overseas on aspects of having to meet FMVSS 214 and changes in the injury patterns that would result. As noted earlier, it was possible to adapt these figures to Australia. However, it needs to be noted that the likely benefits of FMVSS 214 outlined in the Notice of Proposed Rulemaking (NHTSA 1990) have not been universally accepted, either outside or within the United States. Figures published by manufacturers and other researchers suggest that NHTSA's estimate is an over-statement and that SID is not the best test dummy to ensure optimal benefits (see Fildes & Vulcan 1994). To the degree possible, some of these concerns have been incorporated in the assumptions adopted in Chapter 3.

It was noted above that the calculation of the likely benefits of ECE Regulation 95 was even more tenuous, given that very few reports were available on the likely effectiveness. Findings from the side impact workshop meeting in Munich in May 1994 (Fildes & Vulcan, 1994) were especially helpful in determining these Harm reductions. Moreover, the comparative crash tests carried out by Transport Canada (Dalmotas, 1994) were also very useful in demonstrating relative performance differences between the two test procedures, test dummies and injury criteria. Nevertheless, these figures need to be viewed with a degree of caution.

4.4 AREAS WHERE FURTHER WORK IS REQUIRED

4.4.1 Head, Neck & Spine Injuries

FMVSS 214 does not include a head or neck injury criterion whatsoever and NHTSA have recently issued a Notice of Proposed Rulemaking outlining a proposed head injury test for a number of likely front and side contact regions (header rails, side rails, pillars, etc.). The standard would involve a static head form test involving these regions with a maximum acceptable HIC criterion. This additional standard (FMVSS 203) is in part recognition of the lack of head impact protection in FMVSS 214. It is understood that while ECE Regulation 95 does include a Head Performance Criterion measure, the Europeans, too, are presently considering an additional head form test requirement along the lines of that currently under consideration in the US (Fildes & Vulcan, 1994). Obviously, there is considerable agreement that neither side impact standard is sufficient for reducing these potentially life threatening injuries to vehicle occupants.

There would seem to be merit in Australia also considering the need for additional regulations in this area to ensure that head injuries are minimised. As a first step, an analysis of the patterns of head and neck injuries sustained in passenger car crashes in this country and the likely costs and benefits of countermeasures that could flow from such a standard would be worthwhile.

4.4.2 Hybrid Standard

The adoption of internationally recognised standards (harmonisation) seems a sensible approach for Australia to take generally in specifying Australian Design Rules, given its size and the proportion of imported vehicles on the road. While it might be expedient to simply adopt FMVSS 214 and/or ECE Regulation 95 in upgrading its side impact protection, there is considerable concern overseas that these two standards may not be optimal for vehicle occupants in Europe or the US, let alone Australia. Thus, there might be a case for Australia adopting a slightly different approach in respect of side impact regulation requirements.

The Canadians are also currently examining the need for an improved side impact standard in their country. From tests carried out by Dalmotas (1994) on North American vehicles, the FMVSS 214 test procedure was shown to be the most suitable for Canada (it most closely matched the types of damage experienced in real-world collisions in their country) but that the European dummy (or the GMH BIOSID model) would provide a better measure of injuries. In short, Dalmotas argued for a compromise between the two regulations, rather than simply adopting either or both as they currently sit.

It would be useful, therefore, if Australia were also to examine the likely consequences of a hybrid standard for improved long-term side impact protection. If such a model was seen to offer improved protection over either current standards, this would provide strong evidence for a more universally accepted standard in future and perhaps offer a gleam of hope for harmonisation of these two disparate standards. Perhaps the Australians and the Canadians together could provide some impetus for resolving this untenable situation.

4.5 RECOMMENDATIONS

The results of this study show that there are likely to be modest benefits to Australians in reduced vehicle trauma of around 5% per annum if all vehicles on the road were to meet either the existing US dynamic side impact standard FMVSS 214 or the proposed European equivalent ECE Regulation 95. The break-even cost effectiveness figure would be approximately $150 per car with a possible marginal advantage for the European standard. While estimating implementation costs was outside the scope of this study, these figures would not seem unreasonable, given sufficient lead-time for adoption of a new dynamic side impact regulation. Three recommendations therefore seem warranted from this study:

1. *That the Australian Design Rule system include a new or revised regulation mandating that all vehicles sold in Australia be required to meet either FMVSS 214 or ECE Regulation 95. A suitable lead time would need to be negotiated with the manufacturers.*

2. *That further research be undertaken to examine whether a hybrid standard would lead to further improvements in occupant protection. In the event that there are sizeable benefits, these results be used to bring about a harmonised side impact standard in the long-term.*

3. *That further research be carried out into the need for additional regulations aimed at reducing head, neck and spinal injuries further in front and side impacts.*

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APPENDIX A
An Example of the Harm Reduction Method

This illustration is taken from Monash University Accident Research Centre (1992) and Figure A-1 shows a typical summary Harm spreadsheet page for face injuries by restrained occupants in frontal crashes. While it was necessary to make some minor changes in using these spreadsheets for determining side impact benefits, the example is still quite applicable for the processes used in this study.

The first table (Table A) shows the adjusted national distribution of face injury Harm by contact sources and the opportunities available for each countermeasure to reduce face injury Harm to restrained occupants in frontal crashes in Australian vehicles. For example, it is argued that full size driver airbags offer opportunities for face injury reductions to restrained drivers from steering assembly, windscreen, and A-pillar, contacts.

The likely injury reductions for each of these opportunities was then analysed separately in another section of the spreadsheet. Table B shows a sample of one such calculation (full size driver airbags with the steering assembly) and Table C, the assumptions made in that calculation. The opportunity for injury reduction at each AIS level was reduced through the use of a *relevance* factor (0.8 for AIS 1 up to 0.95 for AIS 3 and above injuries). This relevance factor is used to include only that Harm which is within the injury mitigation capability of the measure and is determined by the proportion of Harm within the crash severity range for which the measure is judged to be effective.

The *Basis* column is the product of relevance and % Harm and is the actual Harm expected to be saved by the measure for that particular AIS level. However, as the Harm reduction in this example is a shift in the Harm distribution of -2 AIS rather than a total mitigation of injury, the *basis* therefore needs to be corrected for the *Residual Harm*. This is done in the column headed *-2 AIS* where the Residual of existing AIS 3 is shifted to AIS 1 injuries and adjusted to reflect reduced cost of injury at that level (0.20 basis at AIS 3 is shifted to AIS 1 and multiplied by 4/78 which is the cost of AIS 1 over AIS 3 injuries to the face). Thus, the total *Harm Units Reduced* is then the product of the total Harm experienced ($74.4million) by the difference between the total basis and the residual Harm:

ie., 0.87 - 0.01 = 0.86 x 74.4 = $63.95million

The assumptions in Table C show that the airbag was expected to reduce injuries for the specified body regions and vehicle contacts. The injury reduction was assumed to occur over the crash severity range of 16 to 64k/h (10-40mph). Ninety-five percent of AIS 4 and above injuries for the body regions and vehicle contacts specified occur over this severity range. It was assumed that 95% of these AIS 4 and above injuries would be reduced by 2 AIS. A relevance factor of 0.95 was therefore used in Table B. It is recognised that some injuries will be reduced more, and others, less. However, based on airbag crash tests with dummies, injury measures corresponding to 2 AIS levels are common. Accident experience supports this order of injury reduction. Relevance factors were selected for the other AIS levels in a similar way. The airbag had the lowest relevance factors (0.8) for AIS 1 injuries because many of them occur below 16k/h, the threshold for airbag deployment.

TABLE A HARM DIST. BY CONTACT

CONTACT	FRONTAL HARM	% HARM FT. OCC.		COUNTERMEASURE OPPORTUNITIES DRIVER AIRBAG	PASS. AIRBAG	DRIVER FACEBAG	E-A WHEEL
STEER A	74.45	68.72%		68.72%		68.72%	68.72%
INS.PANEL	16.15	14.91%					
WINDSCR.	3.48	3.21%		3.21%	3.21%		
A PILLAR	5.85	5.40%		5.40%	5.40%		
B PILLAR	0.00	0.00%					
HEADER	1.09	1.01%					
FLOOR	0.00	0.00%					
BELT	0.00	0.00%					
NON-CONT.	1.37	1.26%					
OTHER	5.95	5.49%					
TOTAL	108.34	100.00%		77.33%	8.61%	68.72%	68.72%
SENSITIVITY ANALYSIS			-2 AIS	70.5	1.5	42.6	6.6
			-1 AIS	61.3		36.9	5.8

TABLE B SAMPLE HARM CALCULATION - AIRBAG FOR STEERING ASSEMBLY CONTACTS

INJURY SEVERITY DISTRIBUTION AIS	DIST.	% DIST.	INJURY REDUCTION RELEVANCE	BASIS	RESIDUAL -2 AIS
1	30.5	40.9%	0.80	0.33	0.01
2	27.7	37.2%	0.90	0.33	0.00
3	16.0	21.5%	0.95	0.20	0.00
4	0.2	0.3%	0.95	0.00	0.00
5	0.0	0.0%	0.95	0.00	
6	0.0	0.0%	0.95	0.00	
UNK.	0.0	0.0%			
TOTAL	74.4	100.00%		0.87	0.01
			HARM UNITS REMOVED		63.95

TABLE C SAMPLE INJURY REDUCTION ASSUMPTIONS

1. 20% OF AIS 1 INJURIES OCCUR BELOW 10 MPH
2. 80% OF AIS 1 INJURIES OCCUR BETWEEN 10 AND 40 MPH
3. 90% OF AIS 2 INJURIES OCCUR BETWEEN 10 AND 40 MPH
4. 95% OF AIS 3+INJURIES OCCUR BETWEEN 10 AND 40 MPH
5. INJURY REDUCTION FOR ALL RELEVANT CRASHES IS -2 AIS
6. FULLSIZE AIRBAG DEPLOYS AT 10 MPH
7. RELEVANT INJURY RANGE FOR FULLSIZE AIRBAG =10 TO 40 MPH

TABLE D HARM DIST. BY CONTACT

CONTACT	FRONTAL HARM	%HARM F.S.OCC.	DRIVER AIRBAG	DRIVER FACEBAG	PASS. AIRBAG	E-A WHEEL
STEER A	74.45	68.72%	63.9	42.6		5.8
INS.PANEL	16.15				0.6	
W'SCREEN	3.48	3.21%	2.4		1	
A PILLAR	5.85	5.40%	4.1			
HEADER	1.09	1.01%				
NON-CONT	1.37	1.26%				
OTHER	5.95	5.49%				
TOTAL	108.34	100.00%	70.4	42.6	1.6	5.8
BENEFIT ASSUMED			2 AIS	2 AIS	2 AIS	1 AIS

Figure A-1 *Sample Harm reduction spreadsheet for face injuries to restrained front seat occupants in frontal crashes (from Monash University Accident Research Centre, 1992)*

The benefit for each measure for that particular body region and restraint condition is finally summarised in Table D, where the Harm mitigated by each individual contact source was added to provide total Harm saved for that body region and restraint condition. Again for the full size driver airbag, Table D shows that this measure was judged likely to save A$70.4million annually from reduced face injuries to restrained front seat occupants, most of which would be derived from reduced contacts by the driver with the steering wheel (A$63.9million).

Harm Reduction Changes for Side Impact

In adapting the method to compute the likely benefits of a dynamic side impact standard for Australia, it was necessary to make a number of changes to the spreadsheets used previously. First, the body region definitions used in the earlier study were changed slightly to focus the analysis on more relevant side impact regions. In particular, the liver, spleen and kidney organ injuries were separated from the previous abdomen and added to the chest (renamed to Hard Thorax) and the shoulder was taken from the chest and added to the upper extremity.

As seat belt wearing was less relevant in side impact crashes, there was also no need to conduct separate analyses for restrained and unrestrained occupants. However, given the divergent patterns of injuries for occupants in near- and far-side crashes and the likely disparate benefits of side impact regulation countermeasures on these injuries, it was necessary to conduct separate analyses this time for near-side and far-side occupant injuries. All occupants were able to be included in this analysis, although there was no need to separate front from back seat occupants (near- and far-side occupants comprised both front and back seat passengers to the extent they were included in the databases used in deriving the existing baseline Harm distributions.