WORKSHOP REPORT ON SIDE IMPACT REGULATIONS FOR AUSTRALIA

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Abstract

In consideration of future requirements for improved occupant protection for those involved in side impact crashes, a one day workshop was held in Munich in conjunction with the Enhanced Safety Vehicles (ESV) conference during May 1994. A number of key international research specialists, as well as members of the project team and the Federal Office of Road Safety, met to discuss current developments in side impact regulation in the USA and in Europe with a view to helping demonstrate which standard would be more suited for adopting in Australia and what the strengths and weaknesses are of both procedures. The meeting was also interested in locating current information about the likely costs and benefits of both procedures. The consensus view was that while these two standards are fundamentally different in many ways, either of them was more desirable than the current static requirements prescribed in ADR 29 Little real world crash data is currently available to show the injury reduction benefits of either standard. However, test data is currently available to show the improvements of the US FMVSS 214 regulation and preliminary estimates have also been made outlining the likely improvements of the European ECE 48 procedure These data would be sufficient to permit a Harm mitigation analysis to be carried out on the likely benefits if either or both regulations were to apply to Australian vehicles. Given the current world-wide interest in improved side impact protection, it would be timely to undertake such an analysis immediately

Keywords

SAFETY, ACCIDENT, VEHICLE OCCUPANT, INJURY, TEST METHOD, SIDE IMPACT, EVALUATION

Notes

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TABLE OF CONTENTS

1. INTRODUCTION

Previous research undertaken by the Monash University Accident Research Centre for the Federal Office of Road Safety has led to the introduction of a new frontal crash protection standard in Australia (ADR 69) modelled on the United States FMVSS 214 regulation.

Attention is now focussed on the need for additional side impact protection for occupants of passenger cars and their derivatives.

There are two different side impact standards which have been developed on either side of the Atlantic. The United States recently mandated a new dynamic side impact regulation FMVSS 214 for vehicles sold in the US. This regulation commenced a phased introduction in September 1993 for 10% of 1994 models, progressively increasing to 100% of 1997 models

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.

The Federal Office of Road Safety is now considering the introduction of an appropriate dynamic side impact procedure for Australia. As with ADR 69, FORS are keen for any new ADR to harmonise with existing standards overseas. The question arises then, which standard Australia should adopt for increased side impact protection in this country.

Under current arrangements, FORS will need to conduct a cost benefit analysis for the introduction of any new ADR.

One option would be to use the analysis developed by the National Highway Traffic Safety Administration in the US in justifying FMVSS 214 as the basis and adopt it to suit the Australian situation. However, reservations have been made about the expected benefits of FMVSS 214 as outlined in Fildes, Lane, Lenard and Vulcan (1994). Moreover, this analysis stopped short of predicting cost effectiveness and it could prove difficult in arriving at a likely BCR for Australia from these figures.

Furthermore, apart from one early (and now likely out-of-date) assessment, there has not been any published data on the likely costs and benefits, of the proposed European standard.

An alternative option would be to conduct a more thorough analysis of the expected benefits of both standards using similar Harm reduction methodology to that employed when justifying ADR 69. Given the lack of published studies of the likely benefits of both standards in terms of injury reductions, though, another form of benefit assessment may be necessary.

As a first step in considering which standard to adopt and what the likely costs and benefits would be for Australia, a one-day workshop was held in Munich in conjunction with the Enhanced Safety Vehicles (ESV) conference in May 1994. This report outlines the discussions and the conclusions and recommendations that emanated from the meeting

2. WORKSHOP PARTICIPANTS AND AGENDA

The following international and local vehicle safety specialists agreed to participate in the one-day workshop to consider side impact regulation for Australia:

- Dr. Dainius Dalmotas, Transport Canada,
- Professor Kennerly Digges, George Washington University, USA,
- Dr. Brian Fildes, MUARC, Australia,
- Mr. Alan Gascoyne, FORS, Australia,
- Mr. Ralph Hitchcock, NHTSA, USA,
- Mr. Richard Lowne, TRL England,
- Mr. Peter Makeham, FORS, Australia,
- Dr. Priya Prasad, FORD, USA,
- Dr. David Viano, GM, USA,
- Mr. Ron Wasko, American Automobile Manufacturers Association, USA,
- Professor Peter Vulcan, MUARC, Australia.

Professor Murray Mackay, Birmingham Accident Research Centre had also agreed to participate but unfortunately was delayed in arriving in Munich and was only able to provide subsequent comments on the day's deliberations.

The Agenda for the meeting and background materials provided to each participant are attached in an appendix to this report. The subsequent description of the outcome of the workshop follows the agenda set for the meeting.

3. WELCOME AND THE AUSTRALIAN PERSPECTIVE (Peter Makeham)

Peter Makeham opened the meeting and thanked everyone for agreeing to attend the workshop and giving up their Sunday to help clarify the current situation with side impact regulations world-wide and how this might impact on Australia.

Side impact crashes in Australia account for 22% of fatalities on the FORS fatal file He noted that in conjunction with the Monash University Accident Research Centre (MUARC), FORS have just completed a major review of side impact injuries and sources of these injuries to Australian vehicle occupants and that a paper on this would be given at ESV by Brian Fildes and a full report would be available later this year.

He noted that the purpose of this workshop was to encourage a free exchange of ideas to assist FORS decide how best to conduct a cost benefit analysis to support a possible new ADR on dynamic side impact protection in Australia.

Key issues for the workshop included what information was available on benefits and costs of side impact regulations, the possibility of estimating the likely injury mitigation effects of both standards, and how manufacturers might re-design as a result of either of the two standards.

In addition, there were a number of other issues that FORS would appreciate information on, such as the likelihood of differential benefits from the two standards, other associated regulatory issues, the consequences of both standards in terms of dummies, test procedures, etc. and what other non-involved countries such as Japan and Canada were contemplating.

He noted that Peter Vulcan would Chair the workshop and asked everyone for a free and frank discussion of the issues raised by FORS. To help clarify what was under consideration at the workshop, it was felt that a full description of both standards would be worthwhile at the outset.

4. FMVSS 214 REGULATION (Ken Digges & Ralph Hitchcock)

The major components of the US dynamic impact test specified in regulation FMVSS 214 comprised:

- a moving deformable barrier of 3015lb,
- a crabbed barrier impact angle of 27deg,
- a barrier impact speed of 33.5mph, and
- SID dummies in the front and rear near-side seats

The regulation was first introduced last year with a 10% requirement for 1994 models, a 25% requirement for 1995 models, a 40% requirement for 1996 models and a 100% requirement for 1997 models and beyond. There is also an additional (optional) phasing that requires 100% for 1995 models to accommodate smaller manufacturers with fewer models.

Barrier stiffness was the first key issue discussed. The US barrier construction was essentially homogeneous with a protruding bumper layout. The main section comprised 45psi (±2 5psi) honeycomb material for the main section and 245psi (±15psi) for the bumper section. Because of its size and test arrangement, it was felt likely to stress A- and B-pillar stiffness with less emphasis on side door strength.

NHTSA argued that force vs. deflection characteristics of the barrier are important when simulating real world crashes. They noted that the US barrier is considerably stiffer than the European barrier(s) and that the European barrier(s) have experienced problems with repeatibility and reproducibility of their findings.

The SID dummy was a modified Hybrid 2 which had been developed following cadaver tests at FAT and Heidelberg. Biofidelity requirements had led to unequal mass in the dummy. It has a soft arm which is intended to incorporate rib characteristics. SID has been subsequently shown to be less sensitive to door padding stiffness due to its construction and injury criteria

In developing SID, measurement of deflection forces was difficult because of rotation, therefore acceleration became the major means of defining injury criteria (TTI and spine) This has since become a major criticism of SID.

Delta-V distributions from NASS showed that the 50th percentile was somewhere between 15 and 20mph which was used as the design speed. However, TTI is age-sensitive where an

85TTI is suitable for 90% of those aged 30 years but only 30% for 70 year olds. As an aside, TTI has age dependency built into it for benefit evaluation. It is accepted that all injury criteria (and the resultant countermeasures) are age sensitive

When examining padding selection using the three existing side impact dummies, both EUROSID and BIOSID show that 10psi material gives optimal performance. While 10psi would also be optimal for SID, so too would any material from 10 to 40psi.
Cavanaugh of Wayne State presented a paper at the 1993 STAPP conference which proposed an additional injury criteria of Average Spine Acceleration (ACA) which he claimed would overcome some of the insensitivity of SID.

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.

NHTSA argued that after extensive sled testing, padding requirements predicted by SID were no different to those prescribed by either BIOSID or EUROSID. However, David Viano has published two studies around 1987 and 1988 in J Trauma and STAPP which showed that SID has a difficult time sensing the benefits of protruding arm rests since SID was designed from a flat wall loading.

Examining the accident data in NASS from side impacts shows that the greatest source of severe injury is to the head, not the thorax. Thus, FMVSS 214 (and the European standard for that matter too) does not really address the major source of injury from side impacts. It was noted that 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.

This will require a head-form impact test which, while separate to FMVSS 214, is seen as an important and complementary regulation for side impacts. Contacts with these regions seems to be a major cause of head injury in side impacts in the US, although not so evident for Australian vehicle occupants, based on the local MUARC study.

It is unclear how long it will take for this Notice of Proposed Rulemaking to become a mandated standard as the US are presently in discussions with manufacturers about its requirements which can take some time to resolve. There is currently a congressional requirement that the notice be resolved by January 1995.

A pelvic acceleration criteria (max. 130g) was included in FMVSS 214 to overcome the potential problem of pelvic intrusions to minimise the loads on the rest of the thorax and/or abdomen.

US data analysis shows that car-to-car crashes are more common among older drivers, whereas younger drivers tend to have more pole and fixed object impacts Thus, side impact vulnerability is somewhat variable and current requirements fail to take account of these age-related differences. This is consistent for both the US and European procedures as they only address car-to-car crashes.

The age-crash type situation appears to be similar in Canada, as well as a higher incidence of multi-purpose vehicle impacts because of the greater proportion of these vehicles now appearing on Canadian roads.

The benefits analysis for FMVSS 214 showed a saving in lives of around 900 people annually and about twice that for serious injury. A good proportion of the current vehicle fleet in the US now advertise as meeting FMVSS 214.

5. THE EUROPEAN PROPOSAL ECE REGULATION 48 (Richard Lowne)

The main lesson that should be learned from the European experience is the need for closer co-operation, especially at the research stage. Before describing the proposed standard in detail, it is worthwhile discussing the structure of the regulation process in Europe first.

5.1 The European Procedure

Much of the research work undertaken for vehicle testing procedures and injury criteria in Europe is carried out by the EEVC, an independent collaboration of European National research laboratories with no regulatory function whatsoever

Regulation is the responsibility of two authorities, the ECE and the European Commission. First, the ECE is the oldest body and is really a United Nations organisation. It sets out regulations which member nations can adopt if they want to by signing agreement to these regulations. Changing a regulation subsequently requires all signatories to agree to the change.

The other European regulatory body is the European Commission or EC that generates directives which historically have been mandatory regulations on its member organisations. Thus, products which comply with an EC directive cannot be prohibited from import into a member country. Conversely, it can also insist that any product being imported into that country must meet an EC directive for safety performance.

In practice, most of the EC directives in vehicle safety have adopted ECE regulations Thus, a country requiring a vehicle to meet a particular ECE regulation will also have a product that complies with an EC directive where there is one.

5.2 Type of Dummy

Europe has developed its own dummy, the EUROSID, for compliance testing to the proposed standard. EUROSID came about for a number of reasons. First, the Europeans had been working on a side impact standard for quite a while and felt that there was a need for a sensitive measuring instrument at that stage Early tests from NHTSA suggested that SID would present difficulties for Europe which in part stemmed from the different regulatory procedures that operated in these two regions.

The regulatory processes in Europe and the US are really quite different The US have a "self-certification" procedure which is really only a minimum standard Europe, on the other hand, adopts a "type-approval" scheme which means that once the manufacturer has approval for a particular model, withdrawal of that approval would require very good evidence of a deterioration in performance and is likely to prove difficult in practice Type-approval means that you need to be quite sure of the safety performance of a new vehicle at the early design stage and, thus, there was a feeling that a more sensitive dummy was required for Europe.

5.3 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.

5.4 Dummy Criteria

EUROSID was a European design which attempted to simulate injuries observed in these crashes from accident data. European studies had shown that the most severe injuries in side impacts were to the head, thorax, abdomen and pelvis, so the dummy was required to detect injuries in these areas.

Head acceleration (HIC) was considered adequate for measuring head injury. For the chest, however, from tests undertaken by the Association Peugeot-Renault (APR) in France, it was felt that acceleration was not a sufficient measure and that peak deflection force was a better measure of injury. Early tests suggested that up to 55mm deflection of the dummy's chest would be required to measure adequately these forces. Peak force on the pelvis, too, was felt to be the best measure as this bony structure usually fails as a function of force loading Early tests at TRL showed that acceleration only correlates well with force for a constant mass and that generally, the two were not well correlated, since the effective mass of the pelvis is affected by the different possible load paths in the test.

Later on, following David Viano's work at GM on the tolerance of the chest, viscous criteria (V*C) was also added. Subsequent correlation of EUROSID with cadaver test results for TTI, chest deflection and V*C showed that V*C had the strongest correlation. TTI was also reasonably well correlated as was chest deflection. Thus, appropriate values of all these parameters 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 repeatibility of the V*C criteria with the EUROSID dummy.

It was also decided that the dummy should have arms but that they should be out-of-the-way during impact. This was based on the view that with the arms down, they play a protective role for the chest. Assuming the test should examine the most severe case, it was necessary to exclude arm protection. They are set at 40deg forward of the torso line for the driver.

5.5 Test Barrier

CCMC, a collection of automobile manufacturers, had been working on a barrier for side impact testing some time ago and the EEVC effectively took the principles of their barrier on-board in their early work on side impact, although the performance requirements differed slightly The barrier comprises six blocks (3 on the top and 3 on the bottom which slightly protrude) which effectively represent the stiffness values of impacting passenger cars.

These 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, then it was dropped to 250mm to allegedly encourage development of structures low down in the fronts of cars. In practice, it never happened so the barrier was then raised back to 300mm again and nearly all development work has been based on this barrier height.

However, recent deliberations by a few member countries have led to the barrier height being lowered again to 260mm The consequences of this will probably be that the impacting force of the barrier will essentially load the lower sill panel and not simulate the door intrusions normally experienced in a car-to-car collision

A barrier mass of 950kg which was about the average mass of European vehicles at that stage. There was very little effect observed in testing different European barriers up to 1100 or 1300kg because as has been noted already, 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 this has less effect on dummy performance compared to peak loading.

5.6 Impact Speed & Direction

An impact speed of 50km/h was chosen for the standard based on the distribution of impact speeds from real world accidents. There was some concern about CRASH3's ability to accurately measure impact speed in side impacts but in the end a pragmatic decision had to be taken.

A perpendicular impact configuration was chosen for mainly pragmatic reasons. Manufacturers have difficulty accepting regulations which they have to design to which they feel do not offer adequate protection to occupants of their vehicles in real world accidents. Ultimately, a perpendicular impact direction was chosen as it was the cheapest for manufacturers 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 which also showed that there was not a lot of difference in performance. This was because of the mass of the dummy and the difference in striking direction did not 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.

Head Injury Criteria (HIC) is measured 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). 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 test.

The European barrier is different than the US barrier which was chosen to reflect differences in the vehicle populations. 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 tended to confirm that the European barrier reproduced quite well the worst case outcomes for a European vehicle fleet.

5.7 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. This is because nobody really knows how to protect from impact with this member.

5.8 Implementation Date & Recent Changes

The ECE is still maintaining an implementation date of October 1995 despite some recent changes that have been agreed to 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 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 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

6. OTHER PROPOSALS

There is likely to be a European directive on side impact which may or may not replicate ECE 48. There's some pressure mounting by certain groups to re-introduce the 300mm barrier height. There is an implementation date of October 1995 for the European directive on side impact.

There was also an earlier move for component test procedures (CTP) to replace the need for full barrier crash testing in ECE 48. Three comparative tests between CTP and ECE 48 were initially scheduled which, if successful, were to lead to an additional 6 tests. It is understood that the 3, phase 1 CTP tests could not replicate the results of ECE and therefore the CTP program has been stopped

The International Standards Organisation (ISO) have also been attempting to specify a side impact standard. Current knowledge suggests that the ISO test procedure is now very close to that contained in ECE 48. It is a non-crabbed barrier of 1100kg, it uses the EEVC barrier face at the height of 260mm, impact speed is 50km/h, one dummy in the front seat position only, no performance requirements (this is normally left up to the individual countries) and will accept either BIOSID or EUROSID as the test dummy.

It was originally intended to be a mid-way position between the European and US standards but recent changes to the European standard mean that it now is very close to the current ECE 48 proposal, except perhaps for the difference in barrier mass Based on tests discussed earlier, though, these differences are not likely to have much effect on outcome The US have, in fact, already rejected the ISO test procedure.

It should be remembered that ISO is a standards and has no regulatory status, thus, it relies on countries taking up its proposals for them to become mandated. It is highly unlikely that either Europe or the US will take up the ISO proposal because of their own pursuits in this area and the procedures involved in adopting the ISO recommended procedure.

6.1 Future Dummies

The original side impact proposal by NHTSA allowed for the BIOSID and EUROSID dummies as alternative dummies to SID However, there did not seem to be much interest by the manufacturers in the States to take up this proposal so NHTSA subsequently dropped the whole idea. It was suggested that in the light of real world accident data on FMVSS 214 performance, NHTSA might reconsider the question of test dummies.

NHTSA are currently in the process of undertaking basic research work again in the area of side impact crashes, mainly aimed at developing more sophisticated side impact injury criteria. This has been brought about because of improvements in measuring techniques for basic cadaver work and because of recent progress in finite modelling the human thorax. It could lead to a re-evaluation of the whole question of which dummy is suitable or it could lead to the development of a completely new dummy altogether. It is unlikely, though, that this will happen for several years yet.

A potential problem raised of EUROSID is its calibration focus against individual tests and its failure to look at holistic performance. Hybrid 3 and its derivations such as BIOSID do take account of overall performance (at least in the impactor test requirement to the rib cage) which could be more desirable. The Europeans argued that while a full impactor test requirement would be easy to introduce, it was important that each separate rib performance be correct to cope with potential hard spots, such as badly designed side beams.

If Australia adopts the US FMVSS 214 procedure, copies of its compliance test procedures required to implement the standard will be made available by NHTSA.

7. **HARM REDUCTION METHOD** (Ken Digges & Brian Fildes)

Calculating the potential benefits of a new countermeasure is always difficult because often the potential injury savings of a new injury reduction device are not fully realised prior to its introduction. One method which has been used to calculate the benefits of a new measure is the potential Harm mitigation from introducing the measure.

Harm is simply the frequency of injury times the cost of that injury and is expressed in millions of dollars annually. In its most broad sense, Harm can be thought of as the total cost of road trauma (estimated to be around A$6 billion annually in Australia in 1991). However, it is also possible to break this down by type of injury, level of severity, type of crash, etc.

In assessing the benefits of a range of frontal crash counter-measures, Monash University Accident Research Centre (1992) utilised Harm reduction to compute the financial benefits to society if each measure or combinations of measures were to be introduced. These benefits could then be weighed against the cost of the measure to demonstrate its cost effectiveness.

Details on the method were elaborated upon fully in this report (FORS Report Number CR100) and will not be repeated here. In essence, the method involves an analysis of the likely injury mitigation effects for each occupant built up by a separate body region and restraint condition analysis for each affected region. The basis for these assessments is normally test figures from real world crashes or other relevant findings such as cadaver test results. Where published figures are not available, however, expert panel assessments have been used to arrive at the likely savings.

There is little published data on the likely effectiveness of either standard using real world experiences. Preliminary test data are available on FMVSS 214 benefits from calculations undertaken for the Notice of Proposed Rule Making (NHTSA 1990). However, translating these benefits into injury mitigations is not straight forward and there has also been some criticism raised about whether the level of benefit claimed is achievable

Apart from very early figures published in Wall (1992), there is practically no assessment of the benefits likely from the European proposed standard ECE 48 Thus, the need for expert panel estimates of these benefits was recognised as an important step in undertaking a cost-benefit analysis of a dynamic side impact standard for Australia.

8. CANADIAN COMPARISON STUDY (Dainius Dalmotas)

Transport Canada are in a similar situation to Australia in that, as a relatively small country too, they want to decide on what is a suitable side impact for them. Consequently, they undertook a side impact crash program comparing FMVSS 214 with the proposed European standard in an attempt to demonstrate which was most beneficial and whether there were particular components of either that were more or less desirable The full report on this program is described in detail in Dalmotas (1994) ESV paper and highlights of relevance to this discussion are outlined here.

The crash testing program focussed on comparing EEVC and US test procedures using both barriers and bullet vehicles and included comparisons of EUROSID, BIOSID and SID dummies. As well as comparing dummy performance, they also measured residual crush at the height of the mid-door (this was felt to be an important test of intrusion for comparing with real world crash data).

Intrusion data showed that for the vehicles tested (mainly North American vehicles), the US barrier was more similar to car-to-car impact intrusions than was the European barrier.

Using only the US barrier but comparing the results of the 3 dummies, SID had a higher TTI than EUROSID, and EUROSID was higher than BIOSID. The performance of all 3 dummies at measuring peak pelvic acceleration was roughly equivalent.

Abdominal deflection was only able to be measured by EUROSID and BIOSID. For both dummies, abdominal deflections were generally quite high, reflecting poor performance. All vehicles tested showed particularly poor design for abdominal protection. The lack of ability of SID to measure abdominal performance is perceived to be a major difficulty with this dummy in side impacts.

There was considerable discussion of the disadvantage of no abdominal criteria of SID. One view was that it didn't much matter as an abdomen measurement would simply mirror pelvic acceleration effects. Thus, it would not lead to any different solutions than pelvic acceleration on its own would The counter view was that without abdominal deflection, it would be difficult to test any spurious injurious effects to the abdomen such as a narrow arm rest that overrides the pelvis but would be likely to cause severe injury.

There was also some concern expressed about whether SID's ability to measure pelvic acceleration (and the consequential incentive for manufacturers to allow pelvic accelerations close to the injury criteria) would necessarily ensure no severe spinal injuries as a consequence.

Another related issue was the ability to inadvertently use the shoulder of SID as a load path, especially with the increased use of side airbags and their tendency to migrate loads to the shoulder EUROSID and BIOSID, on the other hand, while not perfect may give designers a little better direction for improvement.

The Canadians undertook a simple padding exercise to see the effects on baseline vehicles in meeting the standards. Using 75mm pelvic padding, the two vehicles tested showed considerable improvement in TTI and pelvic accelerations, sufficient to meet the US acceleration criteria. However, these modifications had little effect on abdominal deflection.

In summary, Dalmotas (1994) concluded that the US barrier and crash configuration outlined in FMVSS 214 is a suitable dynamic standard for testing on Canadian vehicles. However, either EUROSID or BIOSID would be better test dummies in that they measure abdominal deflection (and therefore focus attention on abdominal injuries) as well as providing other desirable criteria (such as V*C).

9. LIKELY BENEFITS (Ken Digges)

One of the main objectives of the workshop was to see if it was possible to specify what the likely injury mitigations would be for both standards. This was to be by consensus of the participants at the meeting. The following represented agreed likely performance characteristics of both standards.

There was general agreement that side impact improvements are much more complex to specify (and hence achieve) than those from frontal impacts Nevertheless, it should be possible to derive side impact benefits including differential benefits from both standards if they were to apply in Australia.

9.1 Structural Consequences

A sound body structure is always desirable, however what constitutes the best design structure at this stage is unclear.

TRL believe the best designs are those that load the occupant early in the collision and over as long a period as possible so that he or she eventually reaches about half of the impacting velocity. A light weight door achieves this with appropriate padding so that the force is distributed evenly over the whole upper torso

Manufacturers need to fashion their individual designs to suit their particular vehicles (what is the right solution for one vehicle may not be suitable for another). There was some concern expressed that the Volvo SIP's system seems to be counter to the principles expressed by TRL for appropriate side impact design by preferentially loading the thorax by not allowing the door to collapse. However, there was some debate about how well SIP's performed in European and US tests.

Many of these design changes need not necessarily add substantially to the cost of the car. Some of the changes may require taking materials away rather than simply building stiffer structures. It was felt that FMVSS 214 may generally push manufacturers to stiffer designs and counter to what might be best for European vehicles.

A stronger peripheral structure (increased integrity) around the door would seem to be desirable in terms of protecting the occupants of the vehicle. However, this may not always be optimal for passing a particular test. There is a view also that a stronger peripheral structure may not always be optimal as it could delay the time at which the occupant starts to accelerate (this is similar to the seatbelt slack argument where slack needs to be taken up as soon as possible to minimise injury). Optimal test conditions should always reflect optimal conditions for occupant protection.

It was agreed that EEVC barrier and test configuration would lead to early loading of the A-pillar and that it would be loaded for a longer time than the US barrier. It was agreed, however, that there would be no observable differences for B-pillar performance.

Sill panel intrusions would be worse for large and 2-door cars with ECE 48 while small (and maybe 2-door cars as well) would perform badly in FMVSS 214.

There was a view expressed that the European barrier is not desirable for large cars generally However, this may be more of a problem for countries which have a large vehicle fleet (there was one example offered of a large GM vehicle which performed well in a ECE48 test recently).

A crabbed crash configuration is more punishing than a perpendicular impact. This is especially so for 2-door cars and for rear seat passengers.

It is possible that designing for ADR 69 in Australia will lead to stiffer side rails which will therefore lead to different side impact patterns and injuries than that seen at present. This will have some consequence for the likely performance of both standards in Australia.

9.2 Injury Consequences

Introducing a side impact standard was likely to have maximum benefit to the chest, pelvis and abdomen. There may also be some additional benefit to the head (especially from tests requiring dummies that measure head impacts), although these improvements may require additional form test requirements beyond the dynamic test standard.

There is a limited number of crash tests available of vehicles crash tested using the entire European procedure and the entire US procedure (2 from Ford, 4 from Canada and 8 from AAMA, maybe INRETS too). It should be possible to bring all these results together to show the differential advantages or disadvantages between these two test procedures. Participants expressed willingness to share these data with FORS as there was a recognition of the need for such an analysis.

Differential benefits should be possible for chest injuries from both standards For pelvic injuries, it is not so easy. European results may show some benefit, given its force deflection characteristics. However, there is little systematic pattern of any difference in pelvic acceleration (hence benefit) using the US procedure.

For the abdomen, the European procedure is at least recording measurement which might have some benefits. The US procedure, however, will not help here given SID's lack of measurement capacity.

It is not possible to demonstrate any lower limb effects for either standard. However, given that both standards address pelvic injuries probably means that there would be some spin-off benefit for the femur.

HIC head measurements in EUROSID and BIOSID would come from strikes with the window or the impacting object. However, there have been strikes with the B-pillar which can be minimised by padding the upper end of this member. Thus, some head benefit should be possible from ECE 48.

There is not likely to be any neck benefits from either standard, nor is it considered to be a significant injury in these crashes.

9.3 Calculating Benefits

What is required in subsequent research into the benefits of both standards is to bring together the known cases of comparative test results to quantify the differential benefits likely from either standard and apply these to Australian Harm. This was considered to be the best approach to take to arrive at objective data on the benefits of both standards.

It should be possible to estimate the likely relevance figures from previous NHTSA and subsequent manufacturers analysis (such as General Motors published figures) undertaken for FMVSS 214. David Viano kindly agreed to provide estimates GM have arrived at in determining side airbag benefits.

TRL have available estimates of the likely injury reductions if a European standard was to apply in the UK. The assumptions behind these estimates would be appropriate for use in a Harm reduction analysis of introducing ECE 48.

There was support for the view that the Harm approach is likely to be sensitive enough to show differential benefits if either standard were to apply in Australia.

10. MANUFACTURING IMPLICATIONS & EXPECTED COSTS

Many of the manufacturing implications of both standards have been alluded to in the earlier discussion. However, a few points are worth stressing here

Firstly, while current standards may not drive car design towards the optimum solution, they do nevertheless focus attention on side impact and lead manufacturers to address the issue and ultimately improve performance.

Current standards seem to be in the right direction; they force manufacturers to worry about padding, door thickness, structural improvements, etc. What is at doubt is how much improvement are you going to get and how these improvements are going to be achieved.

It needs to be recognised that there are a number of manufacturers who are doing more than simply trying to meet these standards. They undertake considerably more tests than those required to meet FMVSS 214. It is clear that in many situations, they crash test with a range of test dummies to ensure not only certification but crashworthiness as well. In addition, the more reputable manufacturers are also engaged in fundamental research on the problems of side impact.

The likely countermeasures and hence cost implications of Australia introducing a dynamic test standard are going to be complex to predict. As witnessed here from earlier discussions, there was no clear evidence on what is the best vehicle design to protect occupants in side impact crashes.

Moreover, many of the solutions will be, to a large degree, dependent on the size and specific vehicle under question. What may be a suitable solution for a 4-door small passenger car may be totally inappropriate for a large 2-door model.

Performance standards, by their very nature, shift responsibility for design to manufacturers, rather than regulatory agencies.

In summary, for structure, padding and interior in side impact, both procedures would be a benefit in terms of structural improvements. The European standard would be a plus for interior head impact improvements and the US procedure would be questionable, while door padding is likely to be improved by both standards, although not necessarily the same padding.

11. OTHER ASSOCIATED ISSUES

Regarding what others are contemplating, it is not clear what the Japanese are considering in side impact regulation. They have been closely watching happenings in Europe and undertaking tests to see how their vehicles are likely to perform. Obviously, those that export to US would also be ensuring that these vehicles meet FMVSS 214 as a minimum.

The Canadians are clearly in a similar situation to Australia They have been undertaking basic research as reported earlier to see how these standards might impinge on their vehicles. They have identified strengths and weaknesses with both standards for Canadian vehicles.

The Canadians current position outlined in Dalmotas (1994) is that the best solution for Canada might be a FMVSS 214 test procedure but involving either a EUROSID or BIOSID dummy for maximum injury protection. Given their close overlap with the American vehicle fleet, it is not clear how relevant this decision would be for Australia. It would be interesting to assess this using the Harm reduction approach.

New Zealand are also currently considering the need for side impact protection but are well behind Australia in their deliberations.

12. CONCLUSIONS

While neither of the two standards currently seems optimal for occupant protection, there is little doubt that either one would be better than none at all Thus, introducing a dynamic side impact test requirement that allows manufacturers to meet either standard seems desirable for Australia at this time. The two standards are different in almost every respect. Both standards have their strengths and weaknesses.

The US regulation seems to be best at mimicking car-to-car crash patterns and intrusions, at least for US vehicles. The crabbed crash configuration was more punishing on the vehicle and ensured a degree of protection for rear seat occupants.

The SID dummy appears to be disadvantaged by its reliance on measures of acceleration alone and by its inability to measure abdomen injuries. Both the EUROSID and BIOSID dummies appear to offer improved measurement capabilities and higher biofidelity

It was felt that the FMVSS 214 under certain circumstances could allow inappropriate countermeasures (more stiff structures), although this view was not universal.

The proposed European standard appears to have the better crash dummy in terms of its biofidelity. However, at least for US vehicles, its barrier and crash configuration did not always simulate real world crash patterns.

The lowering of the barrier height to 260mm was felt to be a backward step and disregards most of the development work behind ECE 48. Early testing suggests around a 30% drop in sensitivity in V*C and pubic force from this height reduction. This is likely to have negative implications for side impact countermeasures.

The European standard (at least for European vehicles) was likely to lead to cars with more rigid surrounding structures but with weaker highly padded doors.

12.1 Harmonization

It is hoped that there will be moves towards greater harmonization of the two standards in future to optimise occupant protection from side impact crashes. As a first step, allowing EUROSID and BIOSID as an alternative test dummy in FMVSS 214 would seem to have considerable merit.

Perhaps Australia can play a part in this as a consequence of introducing a dynamic side impact standard. Undertaking further cost-benefit analysis work on the desirability of an FMVSS 214 procedure using SID, EUROSID and BIOSID dummies might help stimulate further debate. From the evidence that is available, it should be possible to show differential benefits for each of these different scenarios.

12.2 Costs and Benefits

The Harm reduction method of calculating benefits seems to be well received by authorities and manufacturers alike in the US, Europe and Australia. It is appropriate for determining differential benefits of both side impact standards if they were to apply in Australia.

While the workshop was unable to pin-point precise sources of injury mitigation for either standard, sufficient evidence seems to be available to do this and further work is clearly justified.

There was strong support among the workshop participants for the approach taken by Australia in introducing new design rules. In particular, the reliance on a thorough cost-benefit analysis and the consultative approach with industry were especially praised.

13. RECOMMENDATIONS

There seems to be strong grounds for pursuing a dynamic side impact standard for Australia. Whether it should simply be to accept either the US FMVSS 214 or the proposed ECE 48 European standard or both is still not clear. Further work is required to help clarify the benefits (and costs if possible) of Australia adopting these procedures.

In the event that benefit analysis shows that a "hybrid" procedure is desirable for improved side impact protection, it may be possible for Australia to play a role in promoting a modified regulation such as an FMVSS 214 test procedure using a European test dummy as recommended by Dalmotas (1994). In conjunction with others who might support this approach (eg; Transport Canada), it might be possible to hold discussions with the appropriate authorities to help promote the need for change.

The enhanced side impact procedure could also be incorporated in any future side impact testing undertaken by FORS and others (eg; the NSW's NCAP program) to further demonstrate its desirability by providing additional crash evidence of the added benefits.

Clearly, there is enough data to undertake a benefit analysis (and possibly cost-benefit analysis) of what the likely effects would be of introducing either FMVSS 214, ECE 48 or a combination of the two using the Harm reduction method. It would be timely to undertake such an analysis immediately.