# DEVELOPMENT AND BENEFITS OF A HARMONISED DYNAMIC SIDE IMPACT STANDARD

**K Seyer**
**M Terrell**
Federal Office of Road Safety
Australia
**B Fildes**
**D Dyte**
Monash University Accident Research Centre
Australia
**K Digges**
George Washington University
United States
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## ABSTRACT

This paper reviews the differences between the US and European regulations and describes the results of the Australian Federal Office of Road Safety's research program to propose a harmonised dynamic side impact standard that combines the better features of the US and European regulations and using the BioSID dummy. The paper also includes a Harm reduction analysis showing the likely benefits of the proposed harmonised standard over the US and European regulations.

## INTRODUCTION

After frontal impact crashes, side impacts are the greatest killers of vehicle occupants on Australian roads, accounting for over 25% of fatalities.

Australian Design Rule (ADR) 29/00 - Side Door Strength was introduced in 1977 to provide side impact crash protection. Australia was the only country outside North America to introduce this design requirement.

In 1995, the Federal Office of Road Safety released for comment a draft Australian Design Rule (ADR) for dynamic side impact protection. The draft ADR will be introduced in 1999 and allows compliance to be demonstrated to either the US Federal Motor Vehicle Safety Standard 214 or the Economic Community for Europe Regulation 95.

These two regulations were developed on either side of the Atlantic during the 1980s and early 1990s. Although their intent is the same (to improve side impact protection), their detailed requirements are quite different.

The current situation has forced manufacturers to "fine tune" their designs to ensure compliance with the US or European regulations, depending on the market into which the vehicle is sold. Manufacturers around the world have indicated general support for a single harmonised standard to which the car is designed.

## CURRENT OVERSEAS REGULATIONS

The US and European regulations specify two fundamentally different test procedures and test dummies.

Both use a mobile trolley with a deformable face to impact the car being tested. However, the mass of the trolley, specification of the deformable face, test speed, the test dummy and injury criteria are different. While Australian crashed vehicle studies have shown that head and neck injuries are prevalent locally, head injury is only addressed in the European regulation.

### US Standard FMVSS 214

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

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

**Trolley Configuration** - The trolley mass of 1365 kg was the US average fleet mass when the rule was being developed.

FMVSS 214 calls for the impacting trolley to be "crabbed" at 27 degrees and to strike the test vehicle at an impact speed of 33.5 mph (about 54 km/h). This is illustrated in Figure 1. The velocity component perpendicular to the target vehicle is 30 mph. The crabbed configuration was important to simulate real world intersection crashes where both vehicles are moving. This was subsequently confirmed by Dalmotas (1994) in comparative crash tests undertaken by Transport Canada using North American vehicles.

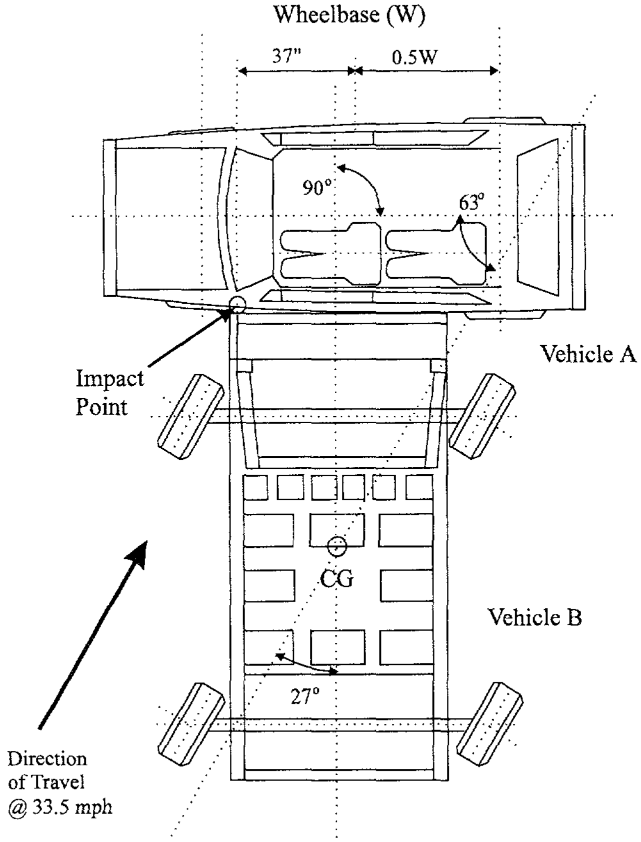


*Figure 1 – US Trolley Configuration*

**US Deformable Barrier Face** - The US barrier construction is essentially homogeneous with a protruding bumper layout as shown in Figure 2. The main section is constructed from 45 psi (±2.5 psi) honeycomb material with the bumper section in 245 psi (±15 psi) aluminium honeycomb material. The US barrier element is considerably stiffer than the European barrier.

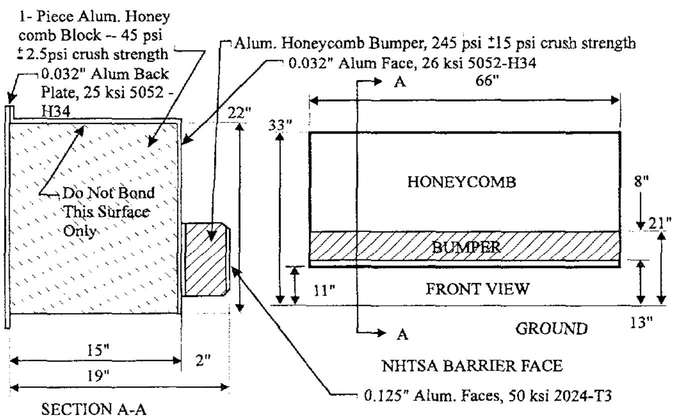


*Figure 2 – US Deformable Barrier*

The bottom edge of the US barrier is 280 mm from the ground. The bumper element is 330 mm above the ground and the barrier is 1676 mm wide.

**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 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.

**US Injury Criteria** - In developing SID, measurement of deflection forces was difficult because of rotation, therefore acceleration of the thorax and lower 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 20 mph which was subsequently adopted as the design speed.

The injury criteria are limited to:

- Peak lateral pelvis acceleration and the
- Thoracic Trauma Index (TTI(d))

where $TTI(d) = \frac{1}{2}(G_R + G_{LS})$

$G_R$ = greater of either upper or lower rib accelerations
$G_{LS}$ = lower spine (T12) peak acceleration

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.

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. Therefore, FMVSS 214 does not really address the major source of injury from side impacts. The US have issued a revision to FMVSS 201 which is effectively an upper interior padding standard for side rails and A- and B-pillars aimed at addressing at least part of these head injuries from side impacts.

**Impact Point** - FMVSS 214 requires the front edge of the impacting barrier to strike the test vehicle at a point dependent on the wheelbase (W) of the vehicle:

- 37 inches (940 mm) forward of the centre of the vehicle's wheelbase, if $W \leq 114$ inches (2896 mm),
- 20 inches (508 mm) rearward of the front axle centreline if $W > 114$ inches.

The majority of cars available in Australia fall into the first category.

**ECE Regulation 95**

The test procedure was developed by the European Experimental Vehicle Committee (EEVC) and the major components of the dynamic test specified in ECE Regulation 95 comprise:

- a moving trolley of 950 kg (2090 lbm)
- a perpendicular barrier impact
- a barrier impact speed of 50 km/h (30 mph)
- a non-homogeneous deformable barrier face
- EuroSID dummy in the front near side seat only.

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

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 simplest testing option and did not appear to compromise safe vehicle design.

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

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.

**European Deformable Barrier Face** - The European barrier design aims to represent the stiffness values of impacting passenger car front structures, ie front longitudinals, engine etc. 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 barrier face is 1500 mm wide (see Figure 3).

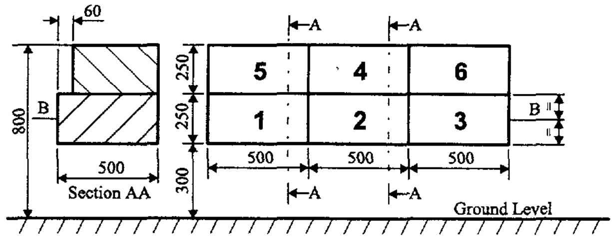

*Figure 3 – ECE Deformable Barrier*

The height of the barrier was originally set at 300 mm from the ground surface to the lower edge and practically all development work involved in ECE Regulation 95 was based on this barrier height. This was slightly above the bottom edge of the US barrier (280 mm) but below the US barrier's bumper height of 330 mm. Representations by a few European member countries led to the barrier height being lowered to 260 mm when Regulation 95 was first issued. However, the EC Directive for dynamic side impact protection has been finalised with a barrier ground clearance of 300 mm and ECE R95 has reverted to this figure.

**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. As a result, they set about developing EuroSID, a joint exercise involving several European countries. 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.

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 requirement for a rear dummy was subsequently dropped in the ECE regulation.

**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 Injury Criteria (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 chest deflection and 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 about the repeatability of the Viscous Criteria with the EuroSID dummy so it has been agreed to just record the readings for the first 2 years of the regulation without it being considered as a pass/fail criterion.

Regulation 95 also has abdominal and pelvic injury criteria which limit the peak abdominal and pubic symphysis force as measured by EuroSID.

Impact Point – The impact point of the barrier is centred on the front seat "R-point".

## EXAMINING THE FEASIBILITY OF A HARMONISED STANDARD

Australian field data also indicated that side impact crashes caused head, thoracic, abdominal and pelvic injuries. Therefore any harmonised standard from Australia's view needed to address these injuries.

### Mobile Deformable Barrier Tests

The first stage of the research program was to conduct crash tests to the following requirements using a vehicle model understood to comply with FMVSS 214 to:

- US FMVSS 214
- ECE Regulation 95
- A harmonised standard described below.

The two tests based on current regulations were conducted in full accordance with test procedures set out for FMVSS 214 and ECE Regulation 95.

### Car to Car Tests

A second stage of the program involved two car to car tests with different bullet vehicles for comparison with the mobile barrier tests:

- Ford Falcon as a bullet car.
- Nissan Micra as bullet car.

The Ford Falcon was chosen because it has a stiff front structure and is of the size and mass typical of the vehicles from which the FMVSS 214 barrier was reportedly developed to represent.

The Nissan Micra is of the size and mass typical of the vehicles from which the ECE R95 barrier was reportedly developed to represent.

The impact point for both tests was the front seat R-point (same as R95).

## HARMONISED SIDE IMPACT TEST

The harmonised dynamic side impact procedure included the following features:

- BioSID dummies in the front and rear outboard seating positions on the impacted side.
- FMVSS 214 crabbed trolley with ECE R 95 deformable barrier element.
- FMVSS 214 impact geometry.
- ECE Regulation 95 injury criteria to the degree which BioSID is capable of recording.

This test configuration was chosen for the following reasons:

- FMVSS 214 crabbed barrier better reproduces a typical intersection side impact crash.
- FMVSS 214 test configuration requires countermeasures for both front and rear seat occupants.
- BioSID is generally considered to be the more biofidelic dummy.
- ECE R 95 barrier face better represents a vehicle front structure.
- ECE R 95 injury criteria more fully covers the range of injuries seen in side impact crashes.

US experience confirms that the benefits of having a rear dummy are really quite small since occupancy rates, like Australia, are quite low. It would be difficult to justify the need for a rear seat dummy on a cost benefit basis. 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.

For this project, a rear BioSID dummy was also used and the benefits determined. Because the US barrier is wider, there are expected to be benefits for smaller cars where the crush profile will encompass the rear seating position.

## TEST VEHICLES

### Target Vehicle

Ford EF2 Falcon Gli sedans (wheelbase 2791 mm) were used as the target vehicle for all the tests. This vehicle was chosen because it is a high volume Australian produced vehicle claimed to meet the requirements of FMVSS 214.

Seats and trim were removed from the non-impacted side as required to install data acquisition equipment etc. The vehicles were ballasted as necessary to the requirements of the particular test procedure.

**Bullet Vehicles**

The Ford Falcon was ballasted to the FMVSS 214 test mass and the Nissan Micra was ballasted to the ECE R95 test mass.

## TEST RESULTS

The results from the test series were used as part of the input data for MUARC to make Harm benefit calculations.

The injury data is summarised in Table 1. Overlay plots of the following are presented at the end of the paper:

- Vehicle intrusion at H-point
- B-pillar bottom acceleration
- Pelvic acceleration
- Lower spine acceleration
- Upper rib acceleration

The results of the 3 mobile barrier tests and the 2 car to car tests indicated that:

- The onset of vehicle decelerations and dummy readings in the 214 test always led the other tests.
- The onset of vehicle decelerations and dummy readings in the car to car test with the Micra always lagged the other tests.
- The onset of vehicle decelerations and dummy readings in the R95, Hybrid and the car to car test with the Falcon are similar.
- Car/barrier stiffness is more important in determining intrusion and injury severity than whether the impacting car/barrier is crabbed or perpendicular.
- The car/barrier stiffness determines the onset of vehicle decelerations and dummy readings. Higher stiffness means earlier onset.
- Barrier (car) mass does not appear to have an effect on load onset.
- Barrier (car) mass does affect amount of intrusion.
- Spine responses peak between 30-45 msec.
- Rib responses peak between 30-35 msec.

## TEST SERIES CONCLUSIONS

The following conclusions have been drawn from the test series:

- Peak dummy responses are reached before 45 msec.
- R95 barrier element's stiffness correlates well with a typical large Australian passenger car.
- Vehicle (barrier) stiffness determines load onset timing.
- Higher stiffness means earlier loading of vehicle structure and dummy.
- Crabbed configuration loads the rear occupant more than a perpendicular impact.

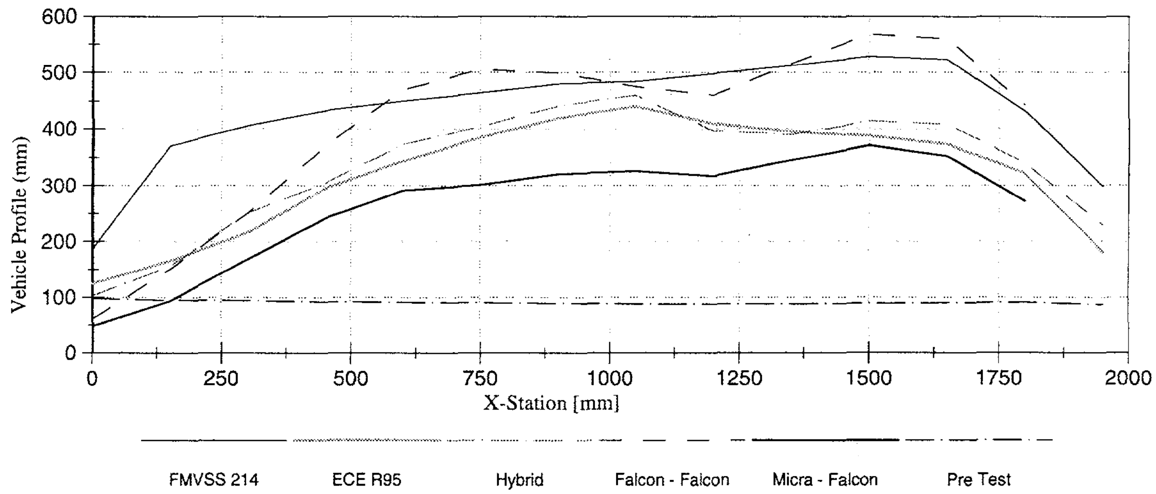


*Figure 4 – Vehicle Crush*

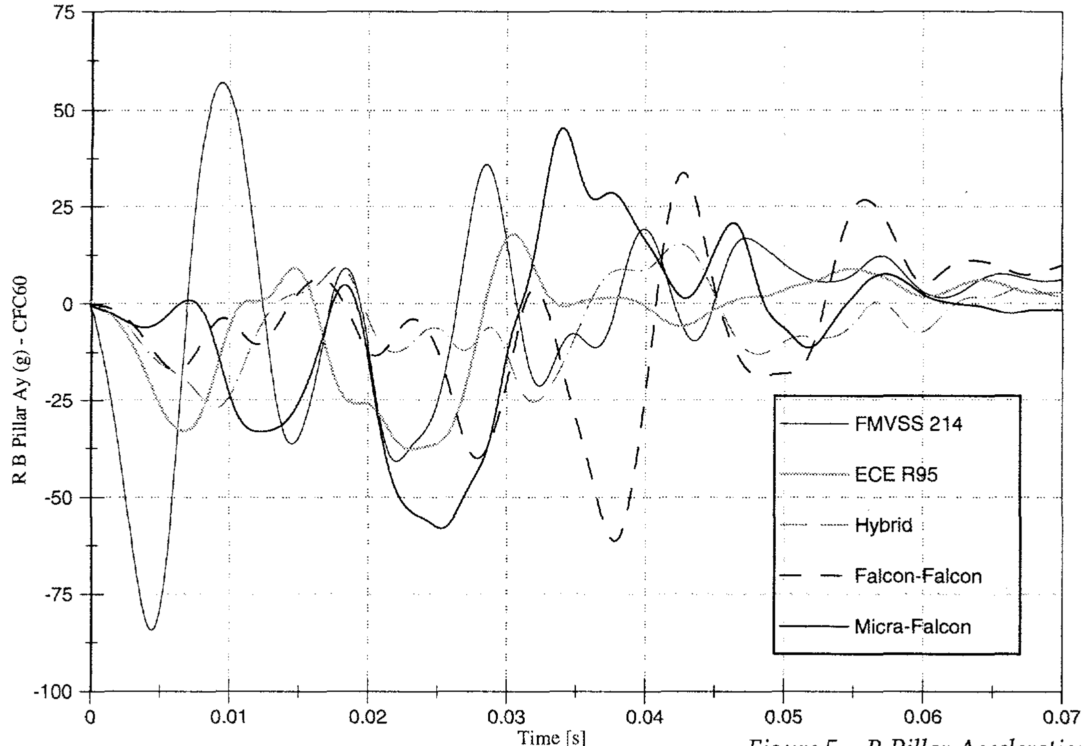


*Figure 5 – B Pillar Acceleration*

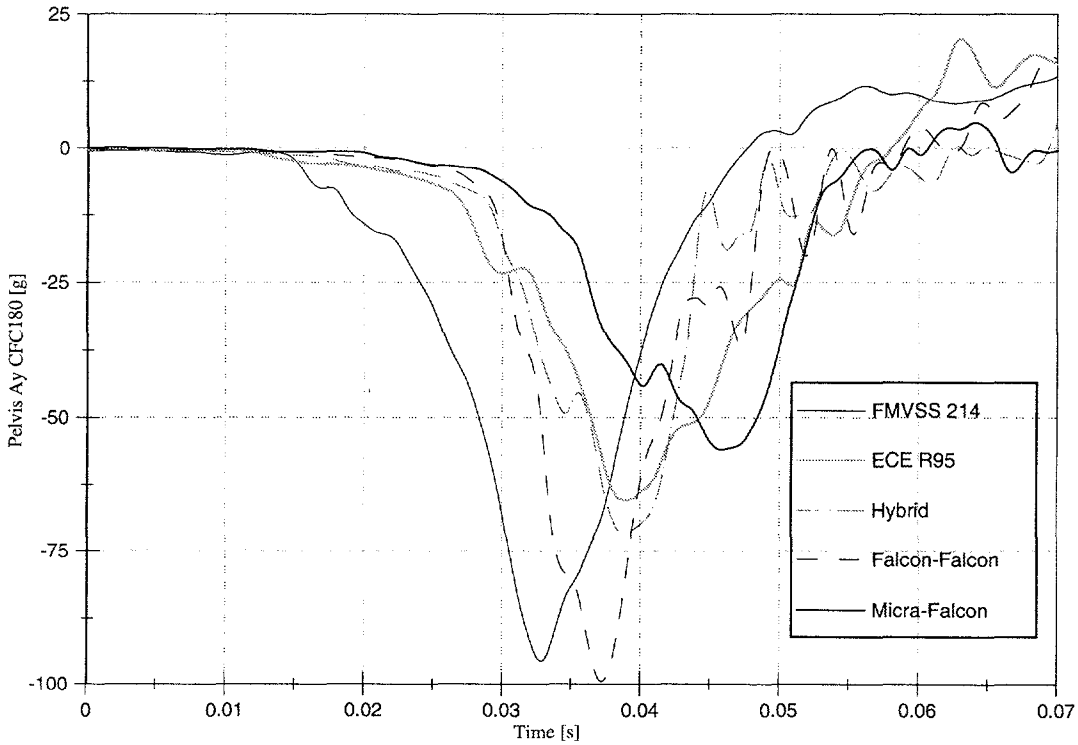


*Figure 6 – Pelvis Acceleration*

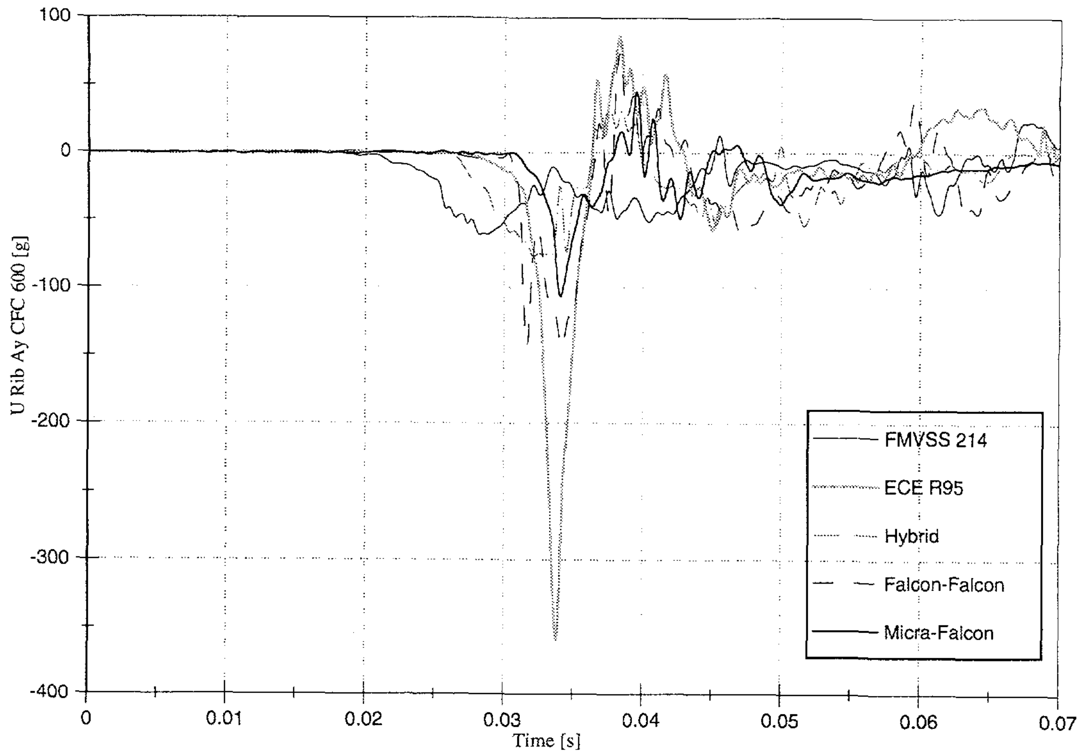


*Figure 7 – Upper Rib Acceleration*

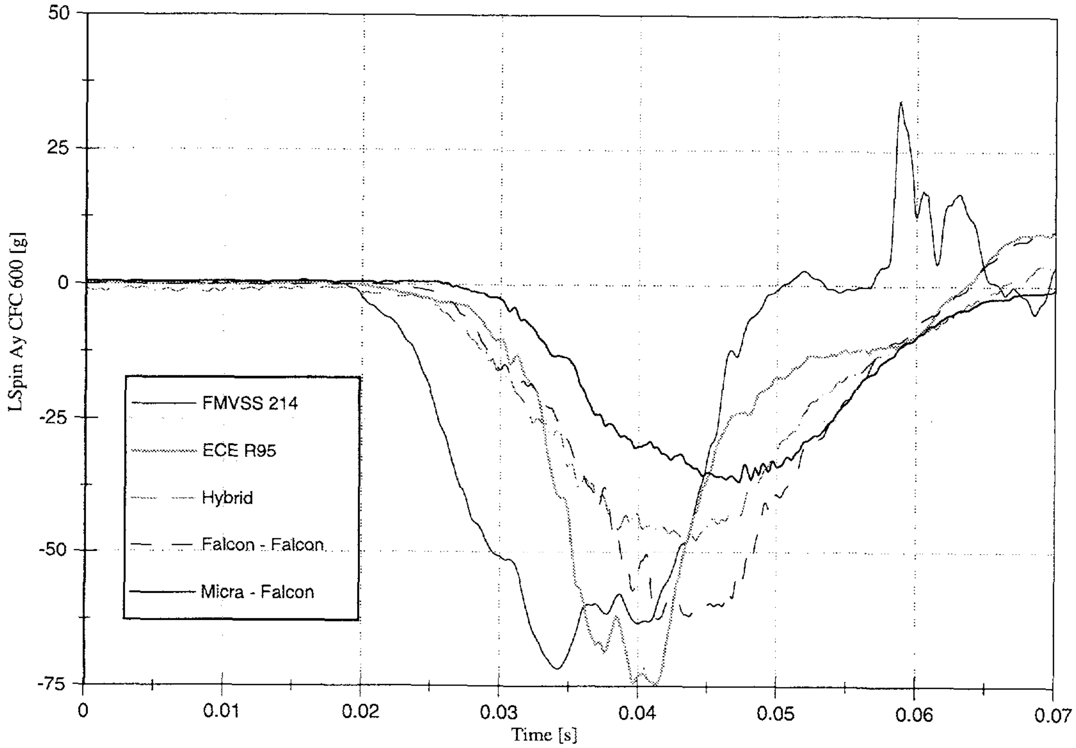


*Figure 8 – Lower Spine Acceleration*

## HARM ANALYSIS

To demonstrate the likely cost effectiveness of the proposed harmonised side impact standard, a Harm benefit analysis was undertaken using the *Harm Reduction* method previously used in other side impact benefit analyses (Fildes et al 1995 and 1996).

The Harm Reduction method has been used previously for estimating the likely benefits of new occupant protection countermeasures (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 the existing two candidate regulations or the proposed harmonised side impact standard.

### 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 5 or 6 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 Reductions

As in the previous side impact benefit analysis (Fildes et al, 1996), there was again very little published data available that reported on injury reductions associated with a harmonised standard, apart from the test results reported earlier in this study and some figures published by Dalmotas, Newman and Gibson (1994). Thus, it was deemed necessary again to assemble a panel of international experts to establish the likely injury benefits that would accrue to Australia for the harmonised standard.

A one-day workshop was organised in May 1997 in Washington DC comprising representatives from the car industry, government researchers, representatives of consumer groups and the study team. The workshop provided an up-to-date account of recent side impact regulation developments as well as the likely injury benefits to Australia by adopting the harmonised standard.

It was clear from the discussion at the meeting that many of the assumptions made in the earlier side impact benefit study (Fildes et al 1995) had not been substantiated by more recent published data and experience. Therefore it was decided that part of the task of assessing harmonised benefits should also involve adjusting the earlier figures for FMVSS 214 and ECE 95 in line with more recent expectations.

### Relevance Assumptions

Hence, a number of assumptions were agreed to for determining the likely benefits of a hybrid side impact regulation for Australia, as well as more recent expectations for the existing two dynamic side impact standards FMVSS 214 and ECE 95 and these are outlined below.

**1.** The three standards all requires a test at a crash severity of around 27km/h that will provide benefits at crash speeds up to 64km/h. No benefits are assumed above this speed.

**2.** The benefits will apply equally to both car-to-car and car-to fixed-objects in side impact collisions.

**3.** The benefits will apply equally to occupants involved in both non-compartment and compartment struck side impacts.

**4.** 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.

**5.** All head injuries (to survivors) in side impacts from contact with the door panel are reduced by 2 AIS and face injuries by 1 AIS over the crash severity range of 0-64km/h. For EuroSID (and BioSID), an additional benefit of 2 AIS applies for head contacts with the side rails.

**6.** Benefits will apply to the chest, pelvis, femur, shoulder, upper extremity, head and face injuries caused by contact with the door panel, hardware or armrest.

Internal organ benefits will vary depending on the test dummy used.

**7.** An incremental reduction in TTI or V*C on injuries to the chest from door contacts for near-side occupants can be expressed as a crash severity change.

**8.** 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.

**9.** Forty-five percent of AIS 3-6 and 90% of AIS 1-2 chest injuries over the crash severity range of 0 to 64km/h are expected to be affected by a side impact standard, based on NHTSA pre-standard crash tests.

**10.** A reduction of AIS 2 in chest injuries is expected by the use of SID and TTI over the crash severity range and an AIS 3 reduction is expected by the use of EuroSID and V*C measures.

**11.** It was assumed that there is some heart benefits approximating 25% of that relevant to the hard thorax for SID and EuroSID but 50% for BioSID given its superior injury criteria and test performance.

**12.** New Australian test data show that V*C is a more critical parameter than TTI and this should lead to additional countermeasures to protect the abdomen. Thus, an overall injury reduction for abdominal injuries of AIS AIS 3 for V*C from EuroSID across the relevant crash severity range is expected (no benefit was claimed for FMVSS214 as SID does not measure abdominal injury).

**13.** Only upper extremity injuries from contact with the door panel or hardware at or below the crash severity range are relevant. As no test data were available on the likely reductions in contacts, a modest AIS 1 injury reduction is assumed.

**14.** 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 of 0-40km/h.

**15.** As the European test procedure does not include a rear seat dummy, no rear seat benefit should be awarded to the ECE Reg 95 standard and similar benefits would apply to front and rear seat occupants in both FMVSS 214 and the proposed Hybrid test.

## RESULTS OF THE ANALYSIS

A detailed system of spreadsheets was assembled for calculating the benefits of both the existing and harmonised 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 both a 5% and a 7% discount rates with fleet life estimates of 15 and 25 years. The results of the analysis are shown in Table 2 below and discussed below for each of the three regulations.

### Revised FMVSS 214 Benefits

The revised benefit estimate for the US standard, FMVSS 214, assuming that all vehicles in the Australian fleet were to comply instantaneously was A$117 million. This is 86% of the original figure previously published (A$136 million) essentially due to reductions in expected savings in abdominal, chest and head injuries because of revised performance criteria. This still a 3.7% reduction in vehicle occupant trauma annually if FMVSS 214 were to apply in Australia. The unit benefit per car would be between $116 and $145.60 per car, depending on the discount rate and fleet life figures used in the calculation. At $100 expected installation cost per vehicle, adopting this standard would still be cost-beneficial.

### Revised ECE 95 Benefits

The equivalent revised figure for the European standard is A$122 million each year if all vehicles in the Australia fleet instantly complied. This is also only 83% of the figure originally estimated based on more recent evidence of performance expectations. It should be noted that most of the reduced Harm for the European standard comes from exclusion of any rear seat benefit because of the lack of a rear seat dummy (this was not anticipated at the original workshop held in Munich in 1994). On this basis, the unit Harm benefit would be somewhere between $121.40 and $152.40 per car, would still be cost-beneficial, and would yield a slightly higher reduction in occupant trauma annually of 3.9%.

### Harmonised Proposal Benefits

Finally, the harmonised proposal outlined at the start of this paper is expected to save A$142 million annually, based on the assumptions listed by the expert panel. This is 16% greater than ECE 95 and 22% greater than FMVSS

214 because of the expected more stringent test procedure, the inclusion of a rear seat dummy, and the likely improvements from the use of BioSID test dummies. This would amount to an improved 4.5% reduction in vehicle trauma annually and with a unit Harm benefit of between $141.70 and $177.50 per car, would yield a Benefit-Cost-Ratio of 1.5 or greater. The harmonised proposal is clearly superior to either of the two existing standards and would overcome the difficulty of having different side impact standards in different continents.

### Benefits for ECE 95 with Rear Dummy

An alternative to the harmonised standard proposal outlined in this paper could be a modified ECE 95 regulation that included a rear seat EuroSID dummy. While this is unlikely to provide all the benefits expected from the harmonised standard, it might nevertheless be a suitable first step to combining the two existing standards that could be acceptable to both regulatory authorities. Naturally, the harmonised standard would still be more desirable in the longer term.

It is difficult to know what additional benefits would accrue to the modified ECE 95 standard because of the lack of test data available on rear seat tests with the European procedure. Results published by Ohmae, Sakurai, Harigae and Watanabe (1989) for one car showed that its performance was well under current requirements for front seat dummies. It might be that with a rear seat dummy installed in a ECE 95 test, some global improvement in rear seat protection would be forthcoming as responsible manufacturers would be expected to respond to this requirement with a range of suitable countermeasures. Assuming a 15% improvement was achieved by this global improvement, the annual benefits in Australia would be A$129 million with a unit Harm saving of between $128.60 and $161.40 per car.

## CONCLUSIONS

The harmonised test proposal provides greater benefits than either of the two existing standards and would overcome the difficulty of having different side impact standards in different.

The mass of the impacting trolley does not have an effect on ultimate injury outcome.

For a modified ECE R95 test with a rear seat dummy to realise a benefit for rear seat occupants, it is believed that a crabbed trolley would need to be employed.

There is a strong argument for further research into developing an agreed harmonised regulation on dynamic side impact protection. The two major areas of work would appear to be on:

- An agreed harmonised dummy.
- An agreed harmonised barrier element design (stiffness).

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**TABLE 1**

*Summary of injury data*

| | FMVSS 214 (US SID) | ECE R95 (EuroSID) | Harmonised (BioSID) | Falcon (BioSID) | Micra (BioSID) | Limit |
|---|---|---|---|---|---|---|
| TTI Driver (g) | 64.1 | 131 | 75.7 | 88.2 | 61.8 | 85 |
| TTI Passenger (g) | 52.3 | N/A | 57.5 | 43.4 | 42.8 | 85 |
| Pelvic Decel Driver (g) | 92.1 | 64.4 | 72.3 | 95.2 | 56.4 | 130 |
| Pelvic Decel Passenger (g) | 92.0 | N/A | 44.3 | 49.1 | 30.8 | 130 |
| HPC Driver | N/A | 99 | 147 | 221 | 67 | 1000 |
| HPC Passenger | N/A | N/A | 125 | 289 | 160 | 1000 |
| V*C Driver | N/A | 1.02 | 0.80 | 0.89 | 0.76 | 1.0 |
| V*C Passenger | N/A | N/A | 0.49 | 0.22 | 0.19 | 1.0 |
| Rib Deflection Driver (mm) | N/A | 40.4 | 42.4 | 46.8 | 41.3 | 42.0 |
| Rib Deflection Passenger (mm) | N/A | N/A | 34.0 | 25.9 | 22.3 | 42.0 |
| PSPF Driver (kN) | N/A | 1.0 | 2.59 | 5.02 | 2.02 | 6.0 |
| PSPF Passenger (kN) | N/A | N/A | 3.51 | 0.17 | 0.23 | 6.0 |

<u>LEGEND</u>

| | |
|---|---|
| *Thoracic Trauma Index* | *TTI* |
| *Head Performance Criterion* | *HPC* |
| *Viscous Criterion* | *V*C* |
| *Pubic Symphysis Peak Force* | *PSPF* |

## TABLE 2

*Summary Table of Harm Benefits*

| BODY REGION INJURED | | U.S. STANDARD FMVSS 214 $million | EUROPEAN ECE Reg. 95 $million | HARMONISED PROPOSAL $million |
|---|---|---|---|---|
| HEAD INJURIES | near-side | 8.7 | 9.7 | 10.8 |
| | far-side | 16.1 | 16.3 | 18.1 |
| FACIAL INJURIES | near-side | 0.6 | 0.7 | 0.8 |
| | far-side | 0.1 | 0.1 | 0.1 |
| HARD THORAX INJURIES | near-side | 43.3 | 43.8 | 48.8 |
| | far-side | 2.9 | 2.9 | 3.2 |
| INTERNAL ORGANS | near-side | 0.4 | 3.2 | 7.2 |
| | far-side | 0.3 | 0.4 | 0.4 |
| ABDOMINAL INJURIES | near-side | 0 | 5.3 | 8.4 |
| | far-side | 0 | 0 | 0 |
| PELVIC INJURIES | near-side | 4.4 | 3.9 | 4.4 |
| | far-side | 0.1 | 0 | 0.1 |
| UPPER LIMB INJURIES | near-side | 17.0 | 15.2 | 17.0 |
| | far-side | 3.6 | 3.2 | 3.6 |
| LOWER LIMB INJURIES | near-side | 17.6 | 15.8 | 17.6 |
| | far-side | 1.2 | 1.1 | 1.2 |
| **TOTAL NEAR-SIDE HARM SAVED ($million)** | | **92.0** | **97.6** | **115.0** |
| **TOTAL FAR-SIDE HARM SAVED ($million)** | | **24.6** | **24.4** | **27.1** |
| **TOTAL HARM SAVED ANNUALLY ($million)** | | **116.6** | **122.0** | **142.1** |
| **UNIT HARM - $ per car (7% @ 15yrs)** | | **$116.00** | **$121.40** | **$141.40** |
| **UNIT HARM - $ per car (5% @ 25yrs)** | | **$45.60** | **$152.40** | **$177.50** |