THE BENEFITS OF THE EUROPEAN OFFSET REGULATION

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ABSTRACT

A study was undertaken for the Federal Office of Road Safety to examine the benefits of Australia adopting the proposed European offset frontal regulation in addition to its current full frontal requirement ADR 69. A one-day workshop was held initially comprising a number of international specialists to determine the likely injury reductions of the proposed ECE offset standard. Using these estimates, a Harm Reduction analysis was then undertaken to arrive at the benefits for Australia mandating the proposed ECE offset regulation. The findings revealed considerable additional benefits between A$297million and A$460million each year, depending on the level of airbag usage. Unit Harm benefits ranged between A$296 and A$576 per car for 5% and 7% discount rates and for 15 to 25 year fleet life periods. On this basis, it would seem highly desirable for Australia to mandate for the standard as presently proposed. Any attempt to remove the lower limb injury criteria from this proposal would severely compromise these benefits and make it difficult to support.

AUSTRALIAN VEHICLES are currently required to meet Australian Design Rule ADR 69 which specifies a minimum level of protection that vehicle manufacturers and importers of passenger cars are expected to meet in a dynamic full frontal crash. This standard, based on the US standard FMVSS 208, is expected to lead to an increase in occupant protection within the range of 10 to 30 percent, depending on what new safety features manufacturers choose to fit as a result of ADR 69. However, it has always be recognised that while full frontal configuration tests the efficacy of the restraint system in a high deceleration crash, offset frontal crashes lead to a marked increase in vehicle deformation which is more than likely associated with an increase in intrusion injuries.

Since 1993, the Federal Office of Road Safety (FORS) have been participating in the European Experimental Vehicle Committee (EEVC) Working Group 11 research to develop a dynamic offset frontal test procedure. FORS has advised the manufacturing industry that the final EEVC test procedure would form the basis of an ADR for offset frontal impact protection, providing it can be shown to be cost effective. Under the arrangements for introducing new or amended ADRs, FORS is required to include a Regulatory Impact Statement for public comment.

The Monash University Accident Research Centre have undertaken a study recently for the Federal Office of Road Safety to estimate the benefits of Australia adopting this European offset frontal crash standard. Dr. Kennerly Digges of Kennerly Digges and Associates assisted in deriving the appropriate injury reductions and assumptions necessary to calculate these benefits. For the purpose of this study, it was assumed that this new offset standard would be in addition to ADR69, rather than to replace it.

OVERVIEW OF THE PROPOSED EUROPEAN OFFSET STANDARD

The proposed ECE offset requirement specifies a range of head, neck, chest, femur and lower leg criteria for two Hybrid III test dummies situated in the front seat of a passenger car impacting a deformable face fixed barrier offset 40 degrees on the driver's side. The proposed ECE offset standard differs from current full frontal standards such as the US FMVSS 208 and Australian ADR 69 in a number of ways (Lowne 1994).

First, and of major consequence, is the inclusion of lower leg injury criteria. This is truly a first attempt worldwide to control for these injuries which, while not necessarily life threatening, are very frequent injuries in frontal crashes, are disabling and painful for those who sustain them, and extremely costly for society in general. The proposed ECE standard includes a maximum knee movement criterion as well as a Tibia Index (TI) derived from axial compression and ankle movement criteria. Although TI has been criticised as not being a totally adequate measure of leg injury, nevertheless it is an important criteria as a first step in raising awareness and focussing attention on the need to protect this region of the body. It would be a poor outcome for occupant protection worldwide if this criteria was to be abandoned.

Second, the standard also specifies neck injury criteria which are unique. Measures of tension, shear and extension have been included which will lead to greater consideration of neck injuries in road crashes and are likely to promote increased use of driver (and possibly passenger) airbags. The proposed ECE offset standard also stipulates more comprehensive head and chest injury criteria. While maintaining HIC as the principal measure of head injury, it also incorporates a peak head acceleration criteria of 80g, averaged across a 3 msec clip. Welbourne (1995) has criticised the 3msec filtering as an unnecessary and unproductive constraint. Chest deflection has been decreased from 75 to 50mm and a chest acceleration (V*C) of 1.0m/s added. This is also likely to be a more stringent measure of chest injury than current criteria.

The test impact configuration of a 40 percent overlap using a deformable barrier face along with an increase in impact speed to either 56km/h or 60km/h will be a more severe structural test for current models manufactured to meet either FMVSS 208 or ADR 69 and is likely to lead to new designs which will emphasize greater structural integrity of the passenger compartment through better energy management.

Finally, the inclusion of a more stringent longitudinal steering column movement from 125mm to 100mm and the inclusion of a maximum 80mm vertical steering column movement criterion should also help to reduce cabin intrusions.

ESTIMATING INJURY REDUCTIONS

To estimate the benefits of the offset regulation, it was necessary to have details on what the likely injury reductions would be from the introduction of the standard. As there were no injury data available and very few test results, an expert panel was formed comprising international specialists from vehicle manufacturing, research organisations, and government agencies responsible for vehicle safety. A one-day workshop was held in Washington DC in December 1995 and a number of assumptions were arrived at on which to calculate the likely injury reductions of the offset standard by body region. The panel were also able to identify existing test results, some scant injury data, and biomechanics criteria on which to convert the assumptions developed into likely injury reductions.

There was consensus among the participants that the benefits would be derived from three sources, namely from a general improvement in structural integrity (the so-called universal benefit), from a greater use of driver side airbags, and from specific countermeasures to address particular injuries such as those to the lower legs. It was especially noteworthy that there was a high degree of consensus among the expert panel of the need for such a standard and likely injury reductions that would accrue. There was also a strong call from many of these organisations for a single worldwide offset standard to ensure the best possible outcome for vehicle occupants.

INJURY ASSUMPTIONS

A total of nine assumptions came out of the one-day workshop which were subsequently developed into specific injury reduction savings used to calculate the Harm benefits. These assumptions are fully developed and detailed in Fildes et al (1996) and are summarised below.

1. A universal benefit will be derived from the offset standard as manufacturers strive to improve crashworthiness generally. This universal benefit will be equivalent to a reduction in crash severity of 10% over the relevant crash speed range for a 56km/h test speed and 15% for a 60km/h test speed.

2. The offset standard will almost certainly force manufacturers to fit at least a driver side airbag to all models. Thus, it is appropriate to assume additional airbag benefits beyond those expected without the standard. Sensitivity analyses may be required here.

3. With more stringent chest criteria, the offset standard will result in fewer chest injuries as manufacturers will be forced into larger design tolerances to ensure compliance. Benefits will be derived essentially for small and midsize cars for crash severities up to the crash test speed.

4. Femur loads have been respecified to include time dependent criteria as well as maximum loads. These additional requirements will lead to extra reductions in pelvic and thigh Harm at all levels of injury severity.

5. The inclusion of knee injury criteria is likely to lead to countermeasures to reduce displacements below the A-P criteria with a resultant AIS 2 benefit for all levels of severity for existing Harm up to test speed delta-V.
6. Significant improvements would be expected in lower leg and ankle-foot injuries from the inclusion of the Tibia Index (TI). Improvements in the design of the Hybrid III leg will lead to reduced high severity leg injuries for crashes up to the test speed.
7. The Tibia Index (TI) is also likely to lead to structural improvements in the floor area and from increased use of shock absorbent padding to this region. The former will be part of the universal benefit expected while the latter will lead to direct reductions in ankle-foot injuries up to 60km/h.
8. Neck injury criteria in the proposed ECE offset requirement is a first and figures from EEVC and Transport Canada's offset tests suggest that up to one-quarter of current vehicles would need to improve to meet these criteria.
9. While the offset standard is primarily aimed at driver improvements, it was agreed that the standard would also result in equal benefits to all front seat passengers, other than for reduced steering assembly savings.

The EEVC and Transport Canada have conducted crash tests at both 56km/h and 60km/h using a number of existing vehicle models to gauge the likely impact of the standard. Many of these vehicles failed the tests on a number of criteria. The panel were unanimous that the offset standard would present new challenges and that manufacturers would need to adopt additional safety margins to ensure compliance. A 30% tolerance was felt to be the level necessary to meet this standard, that is, cars would be built to a level 30% lower than that nominated for the offset test criteria.

One of the expert panel members expressed some concern that large cars were likely to "bottom out" the deformable barrier at these test speeds. However, the available data failed to show any evidence of this. In fact, the larger cars performed better than the smaller ones in the limited data that were available. Additional, more extensive, testing is required to examine the significance of this concern, which was outside the scope of this study.

CALCULATING HARM REDUCTION

A Harm analysis was planned to calculate the benefits of proposed ECE offset standard. The Harm Reduction method developed by the Monash University Accident Research Centre in conjunction with Dr. Kennerly Digges for previous benefit studies was again used here. The national Harm database developed from previous studies (eg; Monash University Accident Research Centre, 1992; Fildes, Digges, Carr, Dyte & Vulcan 1995) was used as the basis for calculating the benefits of the proposed ECE offset standard. Allowances were made for subsequent vehicle safety improvements such as ADR 69 in arriving at these benefits.

Analysis by body region was undertaken using a 3-step cascading model. Harm saved from the universal benefit was first deducted, followed by increase in airbag usage (up to 100%) and finally specific countermeasure benefits. Given that the likely usage rate of driver airbags in 1998 was unknown, these benefits were calculated for a range of possible usage rates from 70% to 100%.

OFFSET BENEFITS

Benefits from Australia adopting the proposed ECE offset standard were expressed as the annual Harm saved assuming all vehicles in the fleet were compliant as well as the unit Harm benefits per car across its lifetime. In computing unit Harm benefits, 5% and 7% discount rates were employed for 15 year and 25 year fleet life periods.

ANNUAL HARM BENEFITS - The annual Harm reduction that would accrue from the offset standard in addition to that achieved from ADR 69 are shown in Table 1. These figures reveal that at worst, the offset standard will result in a A$297 million reduction in Harm (a 15% reduction in current frontal Harm) and at best, A$460 million or a 23% reduction in frontal Harm. These savings would apply when all vehicles in the fleet complied with both standards.

Table 1
Summary of Harm reductions estimated for the various outcomes dependent upon driver airbag fitment rates achieved in 1998.

PERCENT DRIVER AIRBAGS IN NEW CARS	56km/h TEST SPEED		60km/h TEST SPEED	
	ANNUAL HARM	% FRONT TRAUMA	ANNUAL HARM	% FRONT TRAUMA
70%	$418m	21%	$460m	23%
80%	$377m	19%	$420m	21%
90%	$337m	17%	$381m	19%
100%	$297m	15%	$342m	17%

UNIT HARM BENEFITS - Unit Harm benefits (the average savings per car across its lifetime) were then determined using 5% and 7% discount rates and fleet life periods of 15 and 25 years. Table 2 below shows unit Harm savings from A$296 to A$523 for a 56km/h crash test speed or A$341 to A$576 at 60km/h for this additional standard. In other words, the break-even cost for having to meet this new requirement would be somewhere between these figures.

It should be noted that the most conservative estimate was for a 15% reduction in frontal Harm attributed directly to this standard with no benefit from increased airbag use. This would seem to be a worthwhile improvement in occupant protection alone. The minimum break-even cost to achieve this benefit would be A$296 per vehicle which seems very reasonable (industry estimates for achieving the side impact standard improvements in Fildes et al, 1995, were A$100 per car).

Table 2

Summary of Unit Harm reductions for the various outcomes dependent upon discount rate, fleet life and driver airbag fitment rates achieved in 1998.

PERCENT	56km/h TEST SPEED				60km/h TEST SPEED			
AIRBAGS	15yr FLEET		25yr FLEET		15yr FLEET		25yr FLEET	
IN NEW CARS	5%	7%	5%	7%	5%	7%	5%	7%
70%	$471	$417	$523	$454	$518	$459	$576	$500
80%	$425	$376	$472	$410	$474	$420	$527	$457
90%	$380	$336	$422	$366	$430	$381	$478	$415
100%	$334	$296	$372	$322	$385	$341	$428	$372

DISCUSSION

The approach adopted in calculating the benefits of Australia adopting this standard attempted to use the best information available in arriving at these likely injury savings. The assumptions and the basis for them are clearly stated throughout the report based on the existing body of test data, scant injury data, biomechanics criteria, and expert opinion. This was the best information available at the time to estimate these benefits. As new information becomes available, these assumptions may be further refined and the benefits adjusted accordingly.

It is important to stress that the underlying basis for most of these additional improvements beyond those achieved from a full frontal standard lies in the lower limb injury criteria, essentially the Tibia Index. The expert group were at one in agreeing that these criteria are essential to ensure the structural improvements from the universal benefits. Moreover, without TI or some form of lower limb injury criteria, most of the specific countermeasure benefits claimed would also disappear. In short, it would be difficult to support this extra standard without a TI or equivalent requirement.

On the basis of the evidence, it would seem desirable for Australia to consider introducing an offset frontal crash standard similar to that proposed in Europe. The benefits likely to accrue would be somewhere between A$297 million and A$460 million annually with 100% fleet compliance. The break-even cost per car across its lifetime would be on average from A$296 to A$576. This finding is conditional on all aspects of the ECE proposal outlined here and is likely to be severely compromised if any of the injury criteria were to be removed or downgraded over that currently proposed.

REFERENCES

Fildes B., Digges K., Dyte D. & Gantzer S. "Benefits of a frontal offset regulation", Report by the Federal Office of Road Safety, Canberra (1996, in press).

Fildes B., Digges K., Carr, D., Dyte D. & Vulcan P. "Side impact regulation benefits", Report CR 154, Federal Office of Road Safety, Commonwealth Department of Transport, Canberra, 1995.

Fildes B. & Vulcan P. "Workshop report on side impact regulations for Australia", Report CR 149, Federal Office of Road Safety, Commonwealth Department of Transport, Canberra (1995, in press).

Lowne R. "EEVC Working Group on the development of a front impact test procedure", Paper 94-S8-O-05, Proceedings of the 14th Enhanced Safety of Vehicles conference, US Department of Transportation, National Highway Traffic Safety Administration, Washington DC, 1994, pp 1334-1351.

Monash University Accident Research Centre, "Feasibility of occupant protection measures", Report CR100, Federal Office of Road Safety, Canberra, 1992.

Welbourne, E. "Effects of filtering and clipping on head acceleration measures in contact and non-contact events", Technote 95/1, Transport Canada, 1995.