Curtin University MONASH University

CURTIN - MONASH ACCIDENT RESEARCH CENTRE

C-MARC

FACT SHEET NO. 12

PROMOTING VEHICLES WHICH OFFER ENHANCED OCCUPANT PROTECTION

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1. Purpose of this Fact Sheet

The purposes of this paper are to:

- describe the role ascribed to safer vehicles in Western Australia's *Towards Zero* road safety strategy for 2008-2020[1];
- describe some leading vehicle occupant protection technologies[i] which could contribute to the development of a safer vehicle fleet; and
- recommend some strategies for promoting vehicles which offer enhanced occupant protection.

2. Safer vehicles in Western Australia's *Towards Zero* road safety strategy

Western Australia's *Towards Zero* road safety strategy consists of four cornerstones:

- Safe Road Use – developing safer road user behaviour especially through education, enforcement and licensing strategies;
- Safe Roads and Roadsides – investing in Safe System infrastructure improvements.
- Safe Speeds – enhancing speed enforcement and reviewing current speed limits.
- Safe Vehicles – promoting the purchase of safer vehicles equipped with key safety features.

A key target of *Towards Zero* is to reduce the numbers of deaths and serious injuries on Western Australia's roads by 11,000 by 2020 – representing a reduction of around 40 per cent of current levels. It has been estimated that if the *Towards Zero* strategy is fully implemented, Safe Vehicles actions will result in 2,900 fewer deaths and serious injuries, around one-quarter of the total target reduction. In support of this stance, it has been estimated elsewhere that if all motorists upgraded their vehicles to the safest in their class, road trauma would immediately drop by between 26 and 40 per cent [2].

[i] This paper is focused upon recent and emerging technologies which offer enhanced occupant protection. Long-standing protective features (for example seatbelts, child capsules and standard head restraints) have been regarded as representing a base level of protection.

Specific actions mentioned in *Towards Zero* and relevant to promoting the purchase of vehicles offering enhanced occupant protection include:

- encourage the community to purchase safer vehicles with effective safety features;
- encourage corporate fleets to purchase safe vehicles and vehicle safety features;
- consider making safe vehicles and specific safety features (including side and curtain airbags) compulsory for government vehicles;
- influence car manufacturers to provide safety features as standard in new vehicles; and
- encourage and educate employees and communities about the benefits of safe vehicles.

3. Some leading vehicle occupant protection technologies

A previous paper in this series (Fact Sheet No. 4 – Safer Vehicles) showed that current vehicles as a group are almost three times safer than vehicles manufactured thirty or more years earlier. The paper explained this increased safety in terms of improved crashworthiness (a vehicle's capacity to protect its occupants from injury in the event of a crash) and improved crash avoidance (a vehicle's capacity to prevent a crash from occurring). In particular, it drew upon recent research conducted at the Monash University Accident Research Centre (MUARC) which had identified fourteen major available or emerging occupant protection technologies[3].

In identifying these technologies, MUARC researchers examined the main types of crashes and associated injuries occurring on Australian roads and estimated the likely impact each technology would have on the overall road toll. These estimates were based jointly on the prevalence of the relevant crash types and injury outcomes and on the protective effectiveness of each technology, as indicated by the research literature. The fourteen occupant protection technologies are described in Attachment 1 and their estimated levels of impact are shown in Table 1.

Table 1. Assessment of leading occupant protection technologies

Technology	Relevant crash types	Relevant injury locations	Estimated impact on total road toll
1. Seatbelt Pre-tensioners	Mainly frontal	Chest, Head	Medium
2. Seatbelt Load Limiters	All types	Chest	Medium
3. Motorised Seatbelts	All types	Chest, Head	Low
4. Anti-Whiplash Seats	Rear	Spinal	Medium
5. Active Head Restraints	Rear	Spinal	Medium
6. Frontal Airbags	Frontal	Chest, Head	High
7. Dual Stage Airbags	Frontal/ Side	Chest, Head	Low
8. Thorax (side) Airbags	Side	Chest	Low
9. Head and Thorax	Side	Chest, Head	Medium
10. Curtain Airbags	Side/ rollover	Head	High
11. Tubular Airbags	Side/ rollover	Head	Low - Medium
12. Knee Airbags	Frontal	Lower extremities	Medium
13. Knee Bolsters	Frontal	Lower extremities	Low
14. Anti-Submarining	Frontal	Chest, Head, Lower	Low - Medium

Note: The above list relates only to recent and emerging occupant technologies pertinent to light passenger vehicles. Long-standing forms of occupant protection (for example seatbelts, child restraints and standard head restraints) have been regarded as representing a base level of protection.

Frontal and curtain airbags have been identified as the two occupant protection technologies likely to make the biggest impact on the road toll, given the high numbers of frontal crashes resulting in especially head and chest injuries. In contrast, knee bolsters were considered likely to make only a low impact – especially given that they serve essentially as a supplement to knee airbags which alone are likely to responsible for most preventable lower extremity injuries. It is stressed that these levels of estimated impact relate to total numbers of injuries either prevented or reduced in severity and do not relate to the effectiveness of individual technologies in specified crash circumstances.

4. Availability of occupant technologies in the market place

As has been described in Fact Sheet No. 4 – Safer Vehicles, the Australasian New Car Assessment Program[4] (ANCAP) rates all new vehicles primarily for crashworthiness based on the occupant protection provided in several crash scenarios. Ratings are expressed in terms of stars, whereby the greater the number of stars (up to five), the higher the level of occupant protection. ANCAP ratings are prepared separately for different categories of vehicles, based mainly on vehicle size and design.

A minimum of five passenger cars rated as 5-star under ANCAP crashworthiness assessment procedures between 2008 and 2010, were randomly drawn from each of the major vehicle categories (light, small, medium, large, small-medium four-wheel drives and large four-wheel drives). In total, thirty-seven vehicles were selected. Manufacturers' websites and other data sources were then used to determine which of the identified occupant technologies were present in each vehicle. It emerged that all vehicles in the sample were equipped with seatbelt pre-tensioners and frontal airbags – with 35 vehicles equipped with either thorax or head/thorax airbags; and 34 vehicles with curtain airbags. Dual-stage airbags remain a relative rarity and were present in only 9 of the vehicles, with other occupant technologies largely absent.

5. Recommendations

It is axiomatic that all else being equal, the more vehicles on the road offering enhanced occupant protection, the better from a safety perspective. Accordingly, the broad actions identified in *Towards Zero* and outlined in Section 2 of this paper are endorsed in principle. However care needs to be taken in translating these actions into practice, as individual occupant protection technologies represent but one aspect of a safer vehicle:

- arguably the best form of occupant protection is to avoid involvement in a crash in the first instance. Many crash avoidance technologies with proven histories of effectiveness, especially Electronic Stability Control, are becoming standard vehicle features[ii]. Any program of actions which focuses exclusively on occupant protection technologies will ignore the recent advances in crash avoidance;
- it also needs to be recognised that a vehicle with high occupant protection might well pose a heightened threat to other road users. Any action aimed at putting

[ii] For a listing of these features, see Table 2, Fact Sheet No. 4 – Safer Vehicles

safer vehicles on the road that fails to consider vehicle aggressivity to other road users could well be promoting for example, the continued proliferation of large four-wheel-drive vehicles, thereby substantially increasing the overall risk on the roads[5];

- along similar lines, an exclusive focus on individual occupant protection technologies will overlook other criteria, including the level of protection offered especially by body design features and the safety implications of vehicle mass and vehicle handling features;
- even in the specific context of occupant protection, criteria for a safe vehicle can be derived from multiple sources and are invariably promoted via different avenues. If the optimum consumer response is to be expected, it is critical that the safety actions be consistent and represent one overall strategy – as distinct from separate (and potentially conflicting) approaches.

In light of these considerations, it is recommended that actions aimed at encouraging the purchase of vehicles with enhanced occupant protection continue to be based on promotion of the ANCAP ratings – and individual occupant protection technologies, if mentioned at all, be presented as secondary to the overall ratings. ANCAP results represent in the main, the total occupant protection offered by a vehicle under different crash scenarios. While it may be reasonable to assume that the more occupant protection technologies present in a vehicle, the higher the probability of a five-star rating, this association is not guaranteed. To a more limited extent, ANCAP ratings also provide some measure of vehicle aggressivity, thereby further contributing to overall safety benefits.

It is also recommended that any promotion of vehicle crashworthiness through reference to ANCAP ratings, be complemented by actions which highlight the safety benefits of crash avoidance technologies, currently not reflected in ANCAP assessment procedures. In particular, vehicles equipped with Electronic Stability Control are recommended for consideration: in support of this, US researchers have estimated that if all vehicles were equipped with ESC, almost one-third of all fatal crashes in a given year could be avoided[6].

The approach taken in *Towards Zero* of distinguishing between different audiences when promoting safer vehicles, is also endorsed as different sections of the community require different safety actions.

In particular, it is considered that purchasers of fleet vehicles need to be a key target group in any strategy aimed at putting safer vehicles with enhanced occupant protection on the road. Since 1986, the majority of new cars in Australia have been sold as fleet vehicles, with Ford and Holden each selling almost three-quarters of their new cars to fleets[7]. Clearly, the purchase of safer fleet vehicles will have immediate benefits for fleet drivers (a Queensland study found that commercial vehicles were involved in around one-quarter of fatal crashes and in a sixth of serious injury crashes[8]) that over time will spread throughout the whole community.

Although even standard vehicles are increasingly including more safety features, it remains that buying a safer vehicle may entail additional initial cost. Too often, fleet purchasers may decide upon the cheaper alternative. Promoting safer vehicles to fleet managers will be easier if there are accompanying economic incentives to select safer vehicles – perhaps direct incentives in the form of reduced registration and insurance premiums for example, perhaps supplemented by evidence-based arguments demonstrating the economic benefits of safer fleet users.

As a final comment, it needs to be emphasised that road injuries often result from the interplay of many factors other than vehicle safety features - not the least important being individual driving skills and behaviours, the use to which the vehicle is being put, which part of the road network is being used, the quality of the road infrastructure and the vehicle mix on the road network. While it is beyond the scope of this paper, any concerted movement towards reducing road trauma and in accordance with Safe System principles needs to take into account all key components of the transport system. Put another way, individual occupant protection measures must be considered as but components in an overall safety system, the exact features of which might vary from vehicle to vehicle and from user to user.

6. References

[1] 'Towards Zero – Road Safety Strategy 2008-2020': link at http://www.ors.wa.gov.au/StrategiesRoadSafety/Pages/NewStrategy2008-2020.aspx.

[2] At: http://www.officeofroadsafety.wa.gov.au/documents/TowardsZeroRecommendationFinal.pdf

[3] Langford, J., Bohensky, M., Koppel, S. and Taranto, D. (2009). Safer vehicles for older drivers. Report to the Royal Automobile Club of Victoria and the Victorian Transport Accident Commission. Monash University, Clayton,Victoria.

[4]For full details, see: http://www.ancap.com.au/.

[5]Newstead, S., Cameron, M. and My Le, C. (2000). Vehicle crashworthiness and aggressivity ratings and crashworthiness by year of vehicle manufacture: Victoria and NSW crashes during1987-98 and Queensland crashes during 1991-98. Monash University Accident Research Centre Report No. 171, Clayton, Victoria.

[6] Insurance Institute for Highway Safety (2006). 'Update: Electronic stability control'. Status Report, 41, 5, pp 1-3.

[7]Haworth, N., Tingvall, C. and Kowaldo, N. (2000). Review of the best practice road safety initiatives in the corporate and/or business environment. Monash University Accident Research Centre Report No.166, Clayton, Victoria.

[8]Meers, G. (2001). Queensland crash data on work-related crashes and injuries. Symposium conducted at the Work-related Road Trauma and Fleet Risk Management, Brisbane.

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ATTACHMENT 1: LEADING OCCUPANT PROTECTION TECHNOLOGIES

(SOURCE: Langford, J., Bohensky, M., Koppel, S. and Taranto, D. (2009). Safer Vehicles for Older Drivers. Report to the Royal Automobile Club of Victoria and the Transport Accident Commission, Monash University Accident Research Centre, Clayton, Victoria.)

SEATBELT ENHANCEMENTS

1. Seatbelt Pre-tensioners

Slack in seatbelts is a common problem. The purpose of seatbelt pre-tensioners is to reduce this slack during a crash so that the seatbelt restrains the occupant more effectively. Upon sensing a crash, small pyrotechnics are fired which quickly tension the belt thus reducing the amount of travel forward by an occupant and also reducing the chance of the occupant submarining under the belt.

2. Seatbelt Load Limiters

Load limiters complement pre-tensioners and are able to absorb much of the load during a crash. After the pre-tensioner has fired following a crash, the load limiter will reel the belt webbing out slightly when the load on the occupant becomes too high - thus decreasing the chance of injury to the occupant from the seatbelt.

In vehicles with occupant weight sensors, it is possible to adapt the system for different occupant body weights. Therefore, especially smaller and more fragile occupants will not be exposed to a higher seatbelt force than they can withstand.

3. Motorised Seatbelts

Motorised seatbelts perform the same function as seatbelt pre-tensioners but instead of being activated by pyrotechnics they use a small motor. As is the case for pre-tensioners, motorised seatbelts are able to predict an imminent crash and take up the seatbelt slack before the collision occurs.

SEAT ENHANCEMENTS

4. Anti-Whiplash Seats

Whiplash occurs predominantly during rear impact crashes when the occupant's head travels in a backwards movement, forcing the neck towards the headrest. Anti-whiplash seats reduce the rebounding phase of the impact and reduce the gap between the head and the head restraint.

One such example is the WHIplash Protection Study (WHIPS) seat which was developed by Volvo and Autoliv. The seat works by reclining in two phases (see Figure A). The first phase translates the backrest rearward with the occupant, as a means of reducing overall acceleration to the occupant. This also allows the occupant to settle into the seat and bring the head closer to the headrest. In phase two, the seat reclines back to further reduce the amount of energy absorbed by the occupant, with most of the energy absorbed by the seat itself.

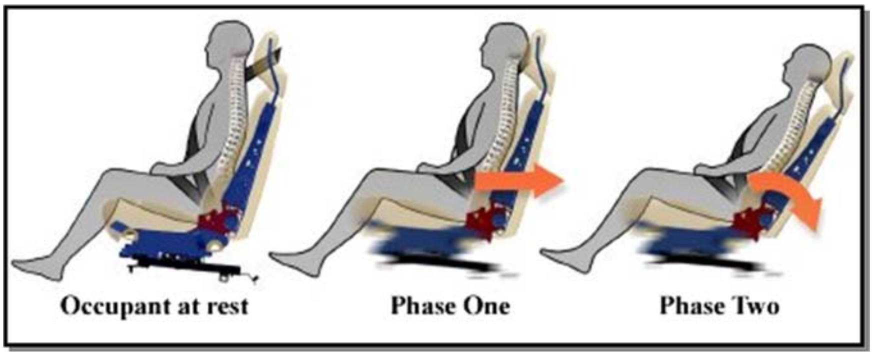

Figure A1: Phases of the WHIPS seat (Image from Clarke, 2008)

5 Active Head Restraints

Another method of reducing whiplash due to a rear impact is by an active head restraint. This device works by reducing the gap between the occupant's head and the head restraint thus minimising the amount that the head can roll back and extend.

One example is SAAB's Active Head Restraint (SAHR). The padded head restraint here is connected to a lever mechanism in the seatback. This level contains a pressure plate that is activated by the rearward motion of the occupant. When pushed rearward the head restraint moves forwards and upwards to a position which is much closer to the occupant's head and thus providing more support to the head (Figure A).

The SAHR seat also contains energy absorbing padding which is able to hug the occupant's body and thus reduce the amount of crash energy transferred to the occupant.

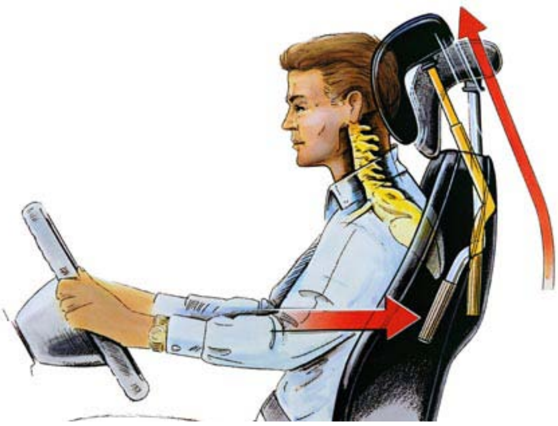

Figure A2: SAHR (image from Clarke, 2008)

AIRBAGS

Airbags are safety systems designed to absorb the kinetic energy of an occupant during a crash and thus prevent or reduce any consequent injury. Sensors mounted on the vehicle are able to detect acceleration and deceleration forces that may be produced by a crash. If these forces exceed a certain threshold, the airbag will be deployed. At least in Australia, airbags are often known as supplementary restraint systems (SRS) as they are designed to work most effectively in conjunction with seatbelts. There are different types of airbags that are mounted in different areas of a vehicle and designed to provide protection in different types of crashes.

6 Frontal Airbags

Frontal airbags are designed to protect the occupants of a vehicle during a frontal collision. They are usually mounted within the steering wheel (driver) or in the dashboard (passenger), as shown in Figure A, and when the crash severity exceeds a predetermined limit, the airbags have the capacity to inflate within 50 thousandths of a second.

Figure A3: Frontal Airbags deploy from the steering wheel and dashboard (image from Honda.co.za)

7 Dual Stage Airbags

More intelligent airbags have now entered the market. These airbags are known as dual-stage airbags and are able to be deployed at two intensities. During impacts of lower severity, the airbags may be deployed at approximately 70% of maximum intensity. For more severe crashes, both stages will deploy and the airbag will inflate at its maximum intensity.

8 Thorax (side) Airbags

Thorax airbags are usually mounted within the seat and were developed to protect the chest and in near-side impact collisions. This airbag type needs to inflate even more quickly than frontal airbags, due to the small gap between the occupant and the striking vehicle.

9 Head and Thorax AIRBAGS

A head/thorax airbag is essentially an extension to the thorax bag. Again these bags are mounted in the seat but they also inflate upwards towards the occupant's head so as to also protect the head from contact with the side window (refer to Figure A).

Figure A4: Deployed head/ thorax airbag (image from dexigner.com, 2005)

10 Curtain Airbags

Curtain Airbags are designed to protect the driver's and passenger's heads during a side impact or rollover crash. They are mounted along the roof rail and usually span the whole distance from the A-pillar to the C-pillar (shown in Figure A). When a side impact occurs the airbags are able to inflate down the window forming a cushion between the occupant and the vehicle. If the vehicle rolls over, the airbags are designed to hold their position to maintain protection.

Figure A5: Curtain Airbags deploy from side roof sill (photo from http://world.honda.com)

11 Tubular Airbags

Tubular airbags provide protection to complement that provided by the thorax airbag. As Figure A shows, the airbag is stored in the B-pillar and when inflated, rolls out from the top of the B-pillar to the bottom of the A-pillar providing head protection to the occupant. These airbags are designed to remain inflated for several seconds to protect the occupant in the case of a rollover. They represent a relatively early form of head protection airbags and have been largely superseded by curtain airbags.

Figure A6: Tubular airbag used in conjunction with a thorax airbag (image from Mello, 2008)

12 Knee Airbags

Knee airbags deploy from under the steering wheel and dashboard, to protect the occupants' knees and hips during a collision (see Figure A). However, knee airbags also assist the occupant maintain optimal positioning during a crash, thereby reducing the risk of submarining. (Depending on the angle of the impact, an occupant may be at risk of sliding or submarining, under the lap part of the seat belt, hitting their knees on the dash and perhaps hitting a lower part of the frontal airbag which would not provide optimal protection.)

Figure A7: Example of a deployed knee airbag (photo from airbagsystems.org)

13 Knee Bolsters

Knee bolsters work in conjunction with knee airbags. The knee airbag, when inflated, pushes a padded bolster out from under the dash and against the occupants' legs. The size of the bolster is such that it runs from the knees to the ankles thus spreading the crash force along the whole leg rather allowing the force to be concentrated on only one part of the leg.

14 Anti-Submarining Airbags

Anti-submarining airbags represent a relatively new type of airbag and are located in the front of the cushion seat (as shown in Figure A). When they inflate, they cause the seat cushion to rise creating an incline in the front of the seat. This is helps stop the occupant from sliding forward and submarining during a frontal collision. This airbag inflates within the seat cushion and does not come into direct contact with the occupant.

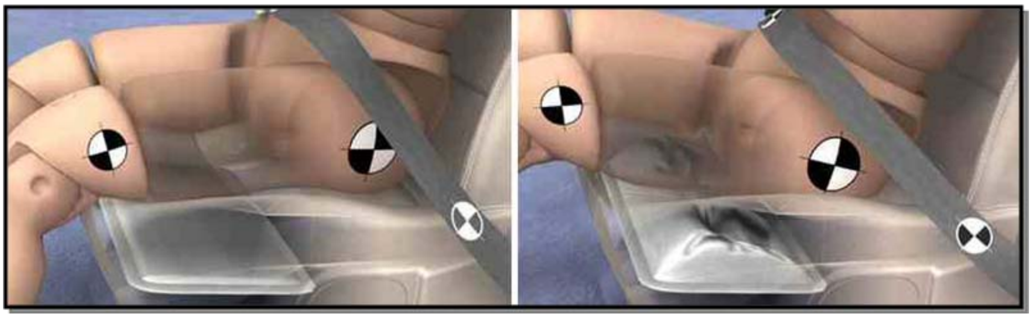

Figure A8: Anti-Submarining airbag un-deployed (left) and deployed (right) (image from airbagsystems.org).