REPORT ON OVERSEAS VISITS TO DISCUSS VEHICLE OCCUPANT PROTECTION

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Report on overseas visits to discuss vehicle occupant protection.

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Abstract

Visits were made to a number of American and European vehicle manufacturers, Research Centres, and Traffic Safety Administration Authorities during April and May 1988 to discuss current trends and developments in occupant safety world-wide. In addition, several invitations were made to overseas experts to visit the Monash University Accident Research Centre during 1988 and 1989 to hold similar discussions. The outcomes of these discussions are described in terms of types of collisions and occupant injuries of major concern currently to many of those committed to improving occupant protection. Improvements and current difficulties in international vehicle standards are also discussed, along with suggestions on how Australia can effectively contribute to the development of safe vehicles.

Keywords

ACCIDENT, VEHICLE, OCCUPANT, INJURY, SAFETY DEVICE, STRUCK ITEM, SPECIFICATION, TESTS, MECHANISM

NOTES.

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(a) reports generated as a result of research done within FORS are published in the OR series;

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There were also a number of other individuals who generously assisted in arranging for these visits. Our thanks go to Mr. Chris Van Wyk and Mr. Olie Laib of BMW Australia and Ms. Peilmann of BMW in Stuttgart, Mr. Barry Layton of Mercedes-Benz Australia and Mr. Kropen of BMW in Munchen, Mr. Graeme Adam, Volvo Australia and Ms. Inger Fjordgren of Volvo Sweden, Mr. Alan Quimby and Ms. Barbara Sabey of TRRL England, Professor Rumar, Swedish Road and Traffic Research Institute, and Dr. Kennerly Digges of the National Highway Traffic Safety Administration in Washington, D.C. for making these arrangements.

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1. BACKGROUND

During the early part of 1988, the authors made a number of visits to American and European vehicle manufacturers, research centres and the U.S. National Highway Traffic Safety Administration to provide up-to-date knowledge on current issues and developments in vehicle occupant protection in the United States, Britain, Sweden and Germany.

This document reports on the findings of discussions and site visits made by Dr. Peter Vulcan (in the U.S.) and Dr. Brian Fildes (in Europe) during their overseas visits in April and May 1988. It is augmented by further discussions in Melbourne with Dr. M. Mackay and Dr. K. Digges.

2. DETAILS OF THE VISITS

A number of motor vehicle manufacturers and research organizations committed to improvements in vehicle occupant protection were visited during the trip. These included:

- The Ford Motor Company, Dearborn, Michigan, U.S. Discussions were held with Dr. John Versace, Executive Engineer, Automotive Safety Office and several of his staff.

- General Motors Research Laboratory, Warren, Michigan, U.S. Discussions were held with Dr. John Melvin, Biomedical Science Department and several of his staff.

- Insurance Institute for Highway Safety, Washington, DC., U.S. Discussions were held with Mr. Brian O'Neill (President), Dr. Allan Williams (Vice President) and several of their staff.

- National Highway Traffic Safety Administration, Washington, DC. U.S. Discussions were held with Mr. Michael Finkelstein, Associate Administrator for Research and Development, Dr. Kennerly Digges, Deputy Associate Administrator for Research & Development, Dr. Carl Clark, Office of Vehicle Research, Mr. Ralph Hitchcock, Director Office of Vehicle Safety Standards, Dr. Carl Nash, Chief, Accident Investigation Division, National Center for Statistics and Analysis, Dr. Rolf Eppinger, Chief, Biomechanics Division, Office of Crashworthiness Research and several other staff.

- University of Michigan, Transportation Research Institute, Ann Arbor, Michigan, U.S. Discussions were held with Dr. Michael Sivak, Acting Associate Director, Dr. Lawrence Schneider, Head Biosciences Division and several members of staff.

- The Transport and Road Research Laboratories (TRRL) in Crowthorne, England. Discussions were held with Messrs. Ian Neilson, Richard Lowne and Slade Penoyre of the Vehicle Safety Division.

- The Volvo Car Corporation in Gothenburg, Sweden. Discussions were held with Messrs. Hans Norrin, Stefan Nilsson and Johnny Korner of the Automotive Safety Centre, Mr Lennart Svenson of the Driver Environment and Traffic Safety section, and Mr Antonio Paulli, Marketing Manager for Australia.

- Chalmers University of Technology in Gothenburg, Sweden. Discussions were held with Professor Bertil Aldman, Department of Traffic Safety, Centre for Transport and Traffic Research.

- The Swedish Road and Traffic Research Institute (VTI) in Linkoping, Sweden. Discussions were held with Mr Thomas Turbell, Road User and Vehicle Division and Dr Gabriel Helmers, Research Psychologist.

- The Automobile Insurance Division of the Folksam Insurance Group in Stockholm, Sweden. Discussions were held with Dr Claes Tingvall of the Traffic Safety Department.

- Daimler-Benz A.G. in Sindelfingen, West Germany. Discussions were held with Mr Ingo Kallina and Mr Roland Herrmann of the Development and Safety Department.

- BMW A.G. in Munchen, West Germany. Discussions were held with Mr Josef Harbel, Safety Development, Mr Hans Kocherscheidt, Accident Analysis, and Mr Gunther Klusmeyer, Technical Journalist.

From these discussions, a number of topical issues and developments in vehicle occupant protection in the U.S. and Europe were identified. These matters are described in detail below.

3. FRONT AND REAR COLLISIONS

Several issues arose from the discussions of frontal collisions and rollovers which are detailed below. Much of current thinking in this area involves active and passive occupant restraint improvements.

3.1 U.S. Passive Restraint Requirements

The passive frontal crash protection requirement of Federal Motor Vehicle Safety Standard (FMVSS) 208 (Occupant Crash Protection) has been "on the books" since the early 1970's but, as a result of various court challenges and changes in emphasis by the Congress and the National Highway Traffic Safety Administration (NHTSA), has only recently been implemented. The current version requires progressive application to an increasing proportion of production over several years, commencing with 10% of the 1987 model year cars, 25% of 1988 models, 40% of 1989 models, with full coverage after September 1, 1989.

This is an important step because it has brought into effect the performance requirements of FMVSS 208, namely that the approved dummy will meet the specified injury criteria in a 30 mph frontal barrier crash (i.e. the dummy shall not experience a Head Injury Criterion exceeding 1000, a chest acceleration exceeding 60 g, nor a femur load exceeding 2250 lbs. - all measurements being made as specified in the standard). The approved dummy at this stage is the Hybrid II, although later the much more sophisticated Hybrid III will be required and it may be used now (some US manufacturers are already certifying using the Hybrid III). This has paved the way for other countries to specify the performance requirements without the need for passive restraints.

Manufacturers are able to choose whether to meet the passive restraint requirement by an automatic belt or an airbag and different manufacturers are adopting different systems. It was suggested that the phasing in of the passive protection requirement over several years was a desirable approach because it enabled more development to be undertaken on a model by model basis, with the benefits of earlier experience being applied to later designs (Digges 1989).

3.2 Airbag Systems

The driver side airbags are all steering column mounted, one of the main differences being the types of sensors used. The type and number of sensors to be used is governed to a large extent by the need to take into account possible litigation in the U.S. Hence additional costs are incurred to guard against inadvertent deployment (there have been a couple of successful court actions already as a result of inadvertent deployment with a child out-of-position). This can be achieved by using two sensors in series and requiring both to be activated before deployment is initiated, which should not occur until a velocity change of about 8 mph has occurred. Similarly, it is considered necessary to have more than one sensor (in parallel) to ensure deployment does occur when it should (a velocity change of about 10 mph., depending on the deceleration-time curve). Some manufacturers consider even more sensors should be located in different parts of the structure to ensure deployment is initiated under the full range of crash circumstances, e.g. frontal pole to offset corner.

Various manufacturers are proposing different solutions to the reliability problem. It was considered that the above complex requirement would be unlikely to be met by the smaller, lower cost sensor systems such as the Breed mechanical system. It is understood that Mercedes Benz believe they can meet their requirements with one expensive but highly reliable Bosch sensor, while Ford see the need for at least four lower cost sensors.

In view of the above considerations, the cost of sensors in most cars marketed in the U.S. is likely to be quite high, at least in the early years.

In an Australian environment where there is already a high driver seat belt wearing rate, such stringent reliability requirements may not be needed for a steering column airbag. Furthermore, if the steering column airbag was regarded as a supplementary protective device, to provide improved head, facial, chest and abdominal protection for the belted driver, the high speed of deployment required for the U.S. systems would not be needed. This should result in reduced severity of injury (if any) for an out-of-position occupant in inadvertent deployment. There may also be a case to allow somewhat greater tolerances for non-deployment in marginal crashes. Both of these relaxations in sensor requirements should result in large cost savings for a steering column airbag system regarded as a supplementary protective device for the belted driver.

3.3 Automatic Belt Systems

The two most common types of automatic belt systems are those with a motorised upper anchorage which moves into place when the door is closed and those with the outboard anchorages attached to the door. The former are being used by Toyota, V.W. and Ford, with or without a detachable lap belt. In the two point version, the system requires a knee bolster to prevent submarining. The latter type, being used by G.M., requires strengthening of the door when closed.

In Europe not much development of automatic belt systems was seen. Autoliv in Sweden (Electrolux 1988) have developed a 3-point (motorised) automatic belting system for Saab vehicles that is applied immediately the front door is closed. The system is currently being evaluated on a small number of taxis in Stockholm (Aldman 1988).

Mackay (1988), however, noted that there are a number of problems encountered with these systems. These include an insensitivity to different body sizes, failure to account for drivers out-of-position, and inappropriate belt angles. Moreover, he argued that the anchorage systems, necessary to ensure speedy release of the belt in the event of a collision, also enable some of these systems to be disconnected by those who find them uncomfortable (contrary to the principle behind these devices).

In view of their shortcomings it seems that automatic belt systems in the present stage of development have little advantage for the Australian market.

3.4 The European Approach to Occupant Restraint

The Europeans were unanimous in support of seat belts as the primary occupant protection device for frontal collisions and rollovers. All of the countries visited have compulsory seat belt wearing laws in the front seat and Germany also has compulsory wearing in the rear as well. They report wearing rates similar to those experienced in Australia. They argued that it is important to make the belts easy to use and comfortable to wear to maximise belt usage in vehicles.

While Daimler-Benz are involved in the development of airbags and offer both a driver and front seat passenger unit, they still claim that airbags should only be secondary to properly fitted seat belts for ensuring maximium occupant protection from these crashes. The other two manufacturers also provide airbags for the driver primarily to satisfy the American requirements for import.

Aldman (1988) argued that, in fact, the current design airbag could be dangerous to out-of-position front seat passengers. He performed tests using pigs as subjects located close to an air bag as it was inflated and reported that all subjects were killed. The cause of death, he argued, was either suffocation or brain damage from the sudden inflation. He further claimed that the dust and material particles given off the bag during inflation were also potentially harmful. It is too early yet to see any evidence of this from actual road crashes.

All the Swedish and German centres visited, however, suggested that a smaller auxiliary airbag in conjunction with seat belts could be most useful as protection from secondary collision with the steering wheel.

3.5 Seat Belt Tensioners

The thrust for seat belt improvements in Europe seems to be in reducing the slack in the belt's restraint in these collisions. This slack comes from three sources; feed-out from the inertia reel before it locks, webbing unrolling from the spool as the belt tightens, and belt stretch. The second item currently appears to be receiving most attention.

Daimler-Benz in Germany have developed a belt tensioner that is activated automatically by an electronic sensor fitted to the vehicle and similar to the air bag sensor. The belt tensioner physically pulls the belt back by an amount roughly equivalent to the slack in the system thereby eliminating forward movement of the driver and front seat passenger. The system is an explosive device that needs to be replaced after use.

BMW have a mechanical caliper device fitted to their inertia reel that operates in conjunction with the inertia lock. As the belt lock is applied, the caliper comes together and grips the belt similarly to a disc brake operation. This prevents spool-out slack and has the added advantage of not needing to be replaced each time the unit is operated. It can be argued, however, that it is desirable for belt systems to have to be replaced after a major collision, although in practice, there is no guarantee that this will be done as a matter of course.

Electrolux in Sweden are one of the largest manufacturers of seat belts in Sweden and Europe (Aldman 1988). They have also developed a mechanical belt-tensioner that is simply operated from a cantilever fitted in the seat to sense bodily displacement (Electrolux 1988). In the event of the occupant being displaced by forward movement after a collision, the lever applies pressure to the belt system to pull back on the belt and restores equilibrium.

The biggest problem with this system though seems to be that it is retroactive and responds only after there has been forward movement by applying reverse forces (i.e., it applies additional forces to the occupant, rather than reduce forward movement by eliminating belt slack).

Volvo stated that they are about to fit a belt tensioner to their vehicles, too, but no details were available of this device.

Autoliv have designed a D-ring mechanical clamp that acts as a belt tensioner in the event of a collision (Mackay 1988). This device is very simple incorporating 2 fixed and one moveable roller, similar to that used for adjusting fixed sash belts. The biggest problem with this unit would seem to be its bulky size in an area close to the head. No information was available on whether any car manufacturers were fitting these units yet.

None of the vehicle manufacturers seemed to be concerned about belt tensioners (or pretensioners) for rear seat belt retractable units, presumably because of the cost involved and the low use of these belts. Given the tendency for rear seat passengers to collide with the front head restraint (Mackay 1988), there may be grounds for pursuing this requirement.

3.6 Seat Belt Anchorages and Webbing

Mackay (1988) pointed out the need for improved seat belt anchorage points in both front and rear seating positions. He maintained that current downward angles for the lap belt section were insufficient to maximise occupant support and to prevent submarining. He proposed that front seat lower anchorage points should be attached to the seat rather than the floor, and that the rear lower anchorage should be through the seat itself rather than between the seat and back.

BMW and Volvo offer a seat design incorporating lower belt anchorage points in front seats and a more contoured and inclined seat squab in both the front and rear seats which supposedly counters submarining. Mercedes-Benz also fit similar seat swabs to their seats but still attach their belts to the floor in the front. These manufacturers could offer no evidence however that this design prevented submarining.

None of the car manufacturers visited offer rear seat anchorage points throught the seat itself. BMW have reversed their two outboard retractable belt units such that the spool is inboard and the buckle assembly adjacent to the door. They maintain that this layout is preferable in that it allows a better belt angle for the lower belt support and facilitates belt wearing amongst children by simplifying the ease of positioning and locking for parents leaning in from the side doors. Mackay (1988), questioned the safety aspects of this arrangement.

Volvo, too, have apparently experimented with a similar layout for their vehicles. However, they chose not to proceed with this arrangement in their subsequent production models.

There was some concern expressed in Europe about the inadequacies of centre rear belts to offer adequate protection for occupants. Apart from eliminating this seating position altogether, however, there were few ideas expressed about how to overcome this problem.

In the U.S. there have also been a number of cases where lap belted occupants (in rear seats) have received severe abdominal injuries. One case, in which two children in the rear seat were killed while their unrestrained parents in the front survived resulted in a costly law suit being awarded against Ford (they sustained "Chance" fractures of the lumbar spine). There is a need to examine the types of injuries sustained by lap belt wearers in Australia, to determine whether belt angles or webbing width need to be changed.

Several people in the U.S. also mentioned that they believe that the sash portion of three point belts is causing multiple rib fractures and, in some cases, serious injuries of thoracic organs as a consequence of belt use in frontal collisions. The extent of this needs to be investigated thoroughly to determine whether any changes in the upper torso restraint or redistributing some of the forces in serious crashes by other means (eg. knee bolsters) are warranted. An inflated belt and/or webbing load limiters are other possible solutions to the problem if it exists.

The extent of abdominal injuries among three point belt wearers should also be investigated to determine whether changes in downward angle of the lap portion are needed. Knee bolsters would also help in taking some of the load.

3.7 Adjustable D-Ring Support

Both the German car makers visited were also concerned about belt position on the shoulder of their front seat occupants. They agree that the top support should be attached to the seat rather than the B-pillar but claim that the cost of providing a sufficiently strong seat and support would be prohibitive. However, they both currently offer an adjustable D-ring support unit on the B-pillar.

BMW's unit is an automatic device where the top support link moves up and down as the seat position is moved longitudinally. They claim this maximises shoulder support away from the neck area and minimises the space between the belt and the body, thereby improving safety and wearer comfort. They acknowledge that there is not perfect correlation between length of legs and length of torso but claim that their unit has been assessed suitable for 95 percent of the population.

Daimler-Benz currently have a manual adjustment of the top link where the occupant sets the position after belting-up to suit his or her own requirements. While this can provide more flexibility than an automatic system, they acknowledge that it is less likely to be used and makes the belting process more complicated. They are presently working on an automatic system that will allow a greater range of adjustment than their competitor's unit.

Autoliv in Sweden (and Rover in the U.K.) also provide a manual upper anchorage adjustable system but very few details were available of this system. It does appear though to be similar to that used by Daimler-Benz (Autoliv 1988).

3.8 Steering Wheels

Head and chest injuries are still quite prevalent in road crashes in Europe, even with 90 percent seat belt wearing rates and among belt wearers in the U.S. TRRL have developed a safer steering wheel to reduce the incidence of head injuries in frontal collisions (TRRL 1987). The steering wheel is heavily padded and its 4 spokes and rim reinforcement are positioned as far away as possible from the driver's face. A production model of this unit has been developed for the Austin Metro vehicle in the U.K. There is considerable interest in this development in the U.S.

TRRL are also in the process of developing a proposed impact test procedure for steering wheels involving a pendulum swing and honeycomb crush test arrangement (Neilson 1988). The exact specifications for the test, however, are not yet available.

Volvo was particularly critical of the TRRL unit and testing procedures. Norin (1988) argued that the U.K. steering wheel failed in two areas; first, it was not able to realign with body contact in the event of a collision, and second, the test requirements were too severe resulting in a steering wheel that was not able to withstand the normal forces experienced in every day vehicle use.

Volvo subsequently designed their own padded steering wheel which generally follows the TRRL principles but has a different spoke layout and is marginally stronger in the rim section to overcome the weaknesses they claim exist in the English unit.

In addition, they are currently working on a load sensing face for the Hybrid II and III dummy which they argued is a more realistic measure of facial impact for specifying steering wheel impact standards (Nilsson and Planath 1987).

Mercedes-Benz and BMW also offer a similar padded steering wheel. The former, however, have used a relieved metal structure to further ensure that the wheel distorts and causes minimum damage if collided with (Lutze and Zeidler 1986).

Mackay (1988) and Aldman (1988) both argued, however, that padded steering wheels may not be the best solution to minimising head injuries. They proposed that ideally, a smaller airbag to that currently in use in passive restraint systems, could be used as a secondary restraint device and would be a better means of cushioning the head movement from frontal collisions.

The particular advantage of a smaller unit would be to reduce the rate of inflation and hence the forces applied by the bag. However, Mackay and Aldman claimed that the current passive restraint airbag would still be preferable to a padded steering wheel.

Given the large number of head injuries experienced in Australia, a secondary airbag seems to be a solution worth investigating in this country, too.

3.9 Steering Columns

The car manufacturers visited all offered some form of collapsible steering column necessary to meet existing standards. They maintained that there was practically no evidence of any steering column injuries from either their crash testing or accident investigations.

The current trend towards adjustable steering columns and front-wheel drives necessitates a knuckle joint in the steering column near the cabin floor which, in itself acts to prevent rearward movement of the steering column. However, as the head, chest and abdomen still seem to make contact with the steering wheel in many frontal collisions, it's hard to argue that the steering column has not contributed to occupant injury in these crashes.

General Motors are experimenting with a novel steering wheel mounting arrangement, which is claimed to overcome alignment problems and hence assist in limiting abdominal and chest loadings.

Mackay (1988) reported on a novel and interesting design for steering columns in Audi cars that actually shifts the column forward in the event of a frontal collision. A cable around the back of the longitudinal motor pulls the column towards the front of the vehicle via a system of pulleys if the engine moves towards the rear. This system also attaches to the front seat belts and further acts as a belt tensioner in this situation. There was considerable scepticism expressed about this design by various persons in the U.S.

There was no evidence of any research currently being undertaken in Europe and the U.S. on an alternative steering device to a wheel located in front on the driver (ie, a side or centre joy-stick arrangement).

3.10 Head Impact Padding

The NHTSA is considering a standard which would require that impacts by a headform on areas which could be hit by the head such as the header rail, A-pillar, and side roof rail do not exceed a specified HIC (or possibly g value). It is not yet clear whether the rigid headform will be covered with a thin layer of soft skin-like material. NHTSA believe the requirement can be met with about 1 inch of good quality padding, eg. urathane foam which will reduce HIC by 50% in a 20 mph impact. The foam used was Diatherm 3 or Sorbathane with an approximate cost of $9.30 per car and mass of 2 lb (Digges 1989).

The areas to be padded will not necessarily be within the normal contact area of a seated occupant to allow for intrusion (structural deformation) of a pillar and nearby roof structure.

3.11 Knee Bolsters

Most European manufacturers visited offer some form of knee support for their occupants either in the form of padded lower shelving or an optional padded bar. These units were usually only fitted to cars sold in the U.S. because of the lack of a European standard.

Mackay (1988) argued that knee bolsters could have a positive benefit in preventing submarining and improving belt restraint use. However, he suggested that people needed to be sitting upright with their feet on the floor to gain the full benefit from these devices.

Aldman (1988) in fact claimed that knee bars could be a safety hazard as they tend to generate knee injuries. He argued that knee damage tended to be serious (and costly) injuries to repair and often lead to long-term disability or permanent damage.

Given the lack of any real consideration for front seat passengers' knees in many Australian vehicles, a knee bolster support would seem to be a major improvement over current practices in this country.

4. SIDE IMPACT COLLISIONS

Both the Americans and the Europeans are very concerned about the inadequacies of current generation vehicles to protect occupants in side impact collisions. A number of the organizations visited are presently working on developments aimed at improving occupant protection in these crashes.

The NHTSA has circulated a Notice of Proposed Rulemaking to upgrade FMVSS 214 to include more extensive side impact requirements. The European Economic Community in Brussels (EEC) have also formulated a draft proposal specifying side impact requirements for vehicles.

Attachment A compares the EEC and NHTSA proposals for side impact requirements. There are several issues especially relevant here.

4.1 Crash Test Specifications

The new dynamic side impact test proposed for FMVSS 214 uses a 3000lb. moving deformable barrier, impacting the stationary test car at 33.5mph at an angle of 63deg to the longitudinal axis of the test car (i.e. 27deg forward of the perpendicular to it, see Figure 1). This simulates a striking car velocity of 30 mph and a struck car velocity of 15 mph. The face of the moving barrier consists of a flat slab of aluminium honeycomb with a smaller one representing the bumper attached to it (see Figure 2). It is parallel to the side of the test car (i.e. 63deg to the direction of motion of the barrier).

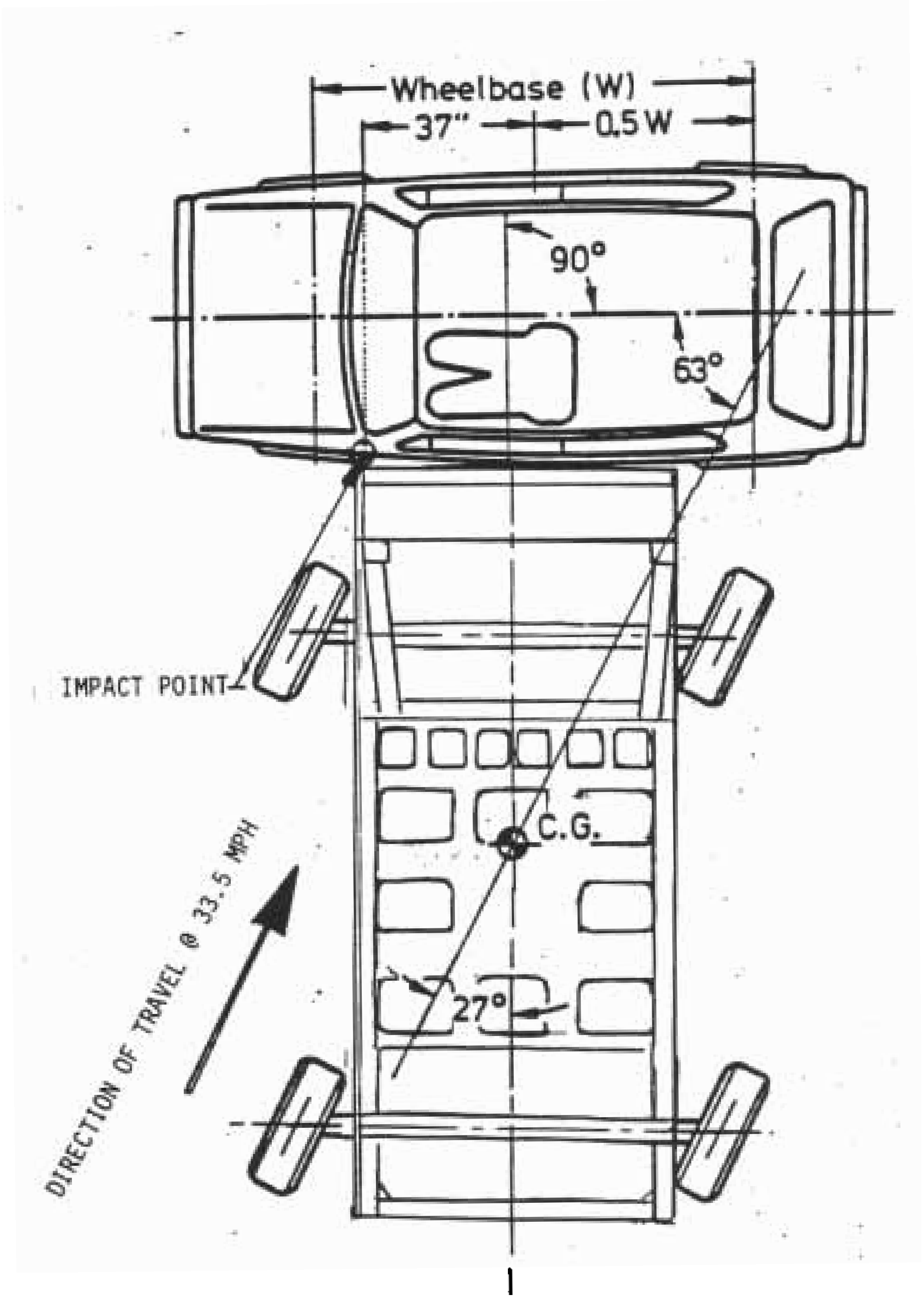
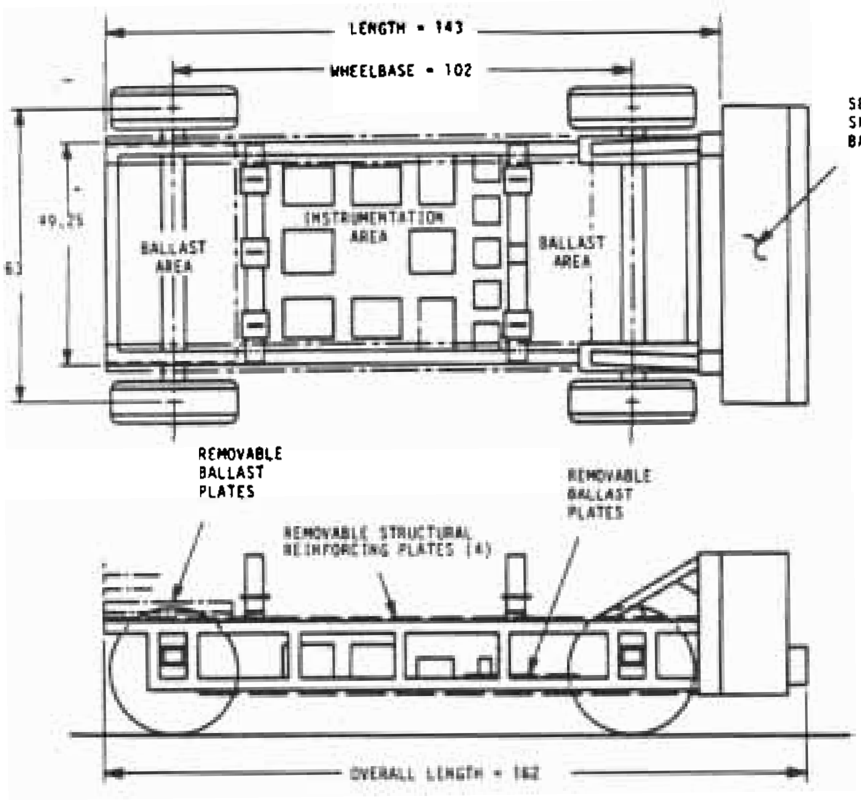
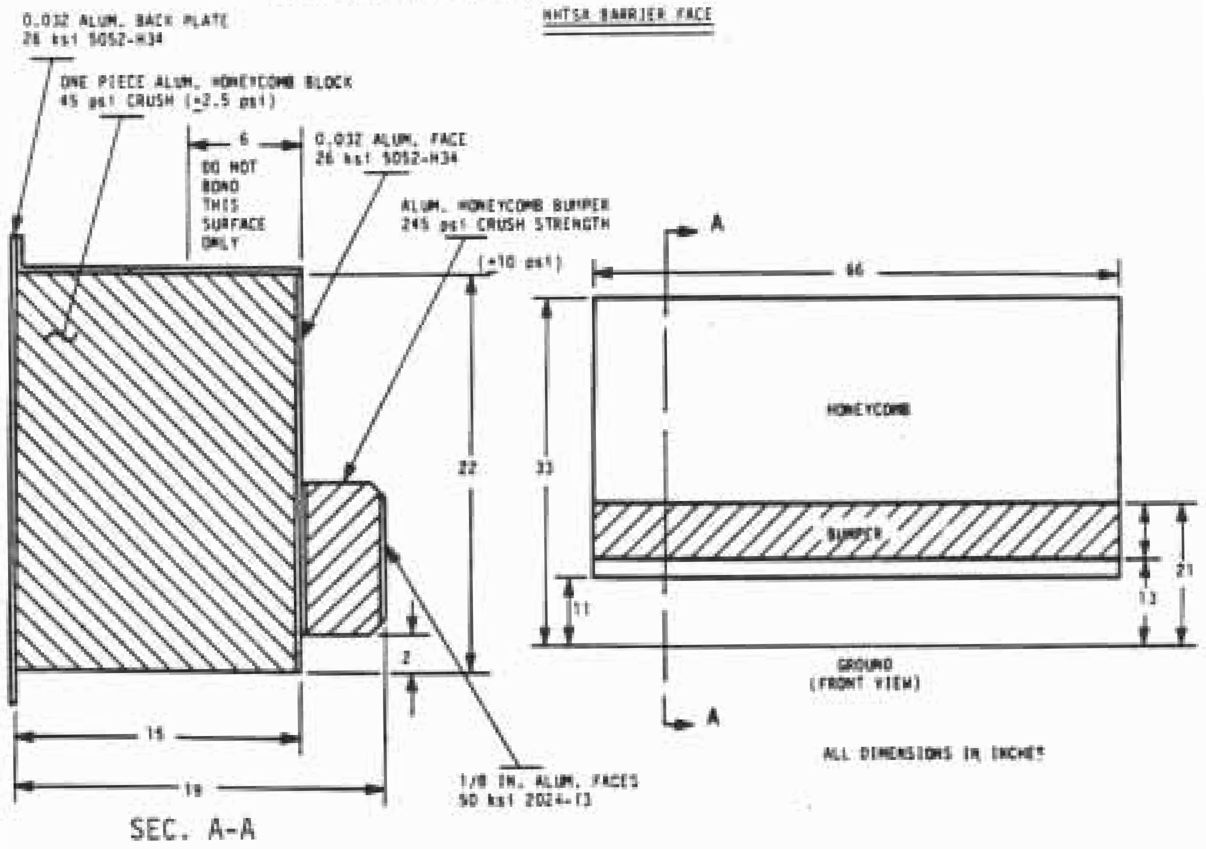


FIGURE 1 Crab test configuration proposed for side impact testing in the FMVSS 214 proposal (from NHTSA, 1988)



NHTSA VEHICLE CONFIGURATION - MOVING BARRIER SIDE IMPACTOR CONCEPT (4-WHEELED VEHICLE SIMULATOR)



NHTSA side impactor - moving deformable barrier

FIGURE 2 NHTSA's proposed vehicle configuration for crab testing side impacts in the FMVSS 214 proposal (from NHTSA, 1988)

The Europeans in general are not satisfied with the "crabbed configuration" of the impact test proposed for FMVSS 214. They propose a similar impact test procedure but with three fundamental differences.

First, they argue that a 90deg collision angle gives essentially the same results to the 63deg angle proposed for FMVSS and is much more practical and easier to perform (Aldman et al 1985).

The European car companies, however, were less satisfied with full surface perpendicular crash conditions as they argued they were not what generally happens on the road. They suggested that if a 63deg impact was to become the standard, then the vehicles should be travelling in those directions at the time of collision to enable them to ricochet as they claim they do in typical on-road crash situations (Kallina 1988; Harbel 1988).

Second, the mass of the movable barrier should be 950kg (2090lb) to represent the lower average mass of European cars.

Third, TRRL claimed that the deformable aluminium honeycomb face on the face of the impact vehicle in the NHTSA proposal was too stiff and too wide (Lowne 1988). The ECE proposal includes a smaller and softer collapsible impact surface using a much deeper polystyrene structure. Hobbs et al (1987) argued that this design will more accurately simulate vehicle damage from side impact collisions. A softer, more deformable impact surface has also been used by other European investigators (Aldman et al 1985).

The draft proposed standard for crash testing in Europe is being prepared by the TRRL for the European Experimental Vehicles Committee (EEVC) to debate prior to a full presentation at a future ECE Working Party 29 meeting. It would seem that there is still much to do before an ECE draft standard would be available.

4.2 Side Impact Dummy and Injury Criteria

The side impact dummy (SID) which has been proposed for FMVSS 214 is described by NHTSA as having been developed from extensive laboratory and in-vehicle side impact tests involving cadavers and prototype dummies. It is based on the Part 572 dummy specified in FMVSS 208 for frontal crash tests but with a modified thorax and knees. This includes accelerometers for ribs, spine and pelvis, a shock absorber between the rib and the spine and a rubber hinge where the ribs attach to the spine. The SID has urethane foam "stump areas" but no articulating arms or shoulders (NHTSA 1988).

The NHTSA considers that the biofidelity of the SID is excellent, but this view is not shared by sections of the U.S. motor industry nor in Europe.

The EEVC committee have formed an AD-Hoc Group to develop an alternative side impact dummy to SID. They believe that the American model is inadequate in simulating side impact injuries (Aldman 1983).

They have undertaken a joint venture involving TRRL and a number of other European agencies to develop an alternative test dummy Eurosid (Lowne and Neilson, 1987). Eurosid aims to provide a response in a collision much closer to human response than SID.

A final version of this dummy is currently under test at various locations throughout Europe and it is expected to be operational within 12 months or sooner (Neilson 1988). It is understood that the U.S. motor industry is interested in Eurosid's performance as they consider there are aspects of SID that do not perform well.

The NHTSA has indicated in its Notice of Proposed Rulemaking (Federal Register January 27, 1988) that if the Eurosid is found to equal or exceed the U.S. SID in its capability for measuring occupant side impact responses, it will consider adopting the Eurosid in its side impact rulemaking. This argues well for international standardisation.

Moreover, Volvo are currently developing an alternative face section for Hybrid II and III that is capable of measuring facial impact and penetration forces for face injuries (Nilsson and Planath 1987). While this extra feature is more for use in frontal collisions, they claim it could also be relevant for side impact crash measurement and Eurosid.

The proposed injury criteria are the pelvic lateral acceleration and the Thoracic Trauma Index derived from upper rib, lower rib and lower spine accelerations.

General Motors and others have argued the the Viscous Injury Criterion (V*C) which utilises a product of the lateral chest velocity and compression is a more appropriate injury criterion. The NHTSA consider there is no evidence for this at this stage.

There are fundamental differences between these two approaches to injury criteria and it will be necessary for these to be resolved.

4.3 Side Door Structure and Padding

All of those interviewed agreed that the major problem for side impact collisions is the lack of space between the impacting vehicle and the occupant of the impacted vehicle (there is much less distance available for providing crumple zones than there is for both front and rear collisions). Thus, countermeasures need to emphasise more rigid door structures and increased padding in the doors to minimise injury.

What form the increase in door rigidity should take seemed to be a vexed question. The guard rails currently fitted to front doors to satisfy FMVSS 214 was considered to be far from optimum by European car makers and others. They provide them along with test results but they believe the solution to improved door structures lies in stronger door sections (the total structure has to withstand the forces) and improved padding between the door and the front seat occupant.

The three European car manufacturers were currently looking at how to improve padding in their front doors. Daimler-Benz have a combination of foam padding and collapsible plastic cup sections in the upholstery and arm rest door panels. BMW and Volvo are currently looking at ways of increasing existing padding although the latter believe that padding needs to involve sections made up of different densities of padding material.

4.4 Bumper Bar Structure and Height

There is general recognition in England, Sweden and Germany that a partial solution to injury reduction from side impact collisions was in bumper bar structure (and subsequent door and sill panel reinforcing) and its height from the ground (Aldman 1983, 1988; Kallina 1988; Harbel 1988).

Aldman (1988) argued that the most effective means of providing space between the impacting vehicle and the impacted occupant was to introduce early acceleration of the impacted vehicle (i.e., to push the side impact vehicle away from the front impact vehicle. He thought that a lower bumper height with adequate structural support in the sill and lower door areas of the impacted vehicle would be an effective countermeasure here.

He claimed that any increased tendency for the impacted occupant to be propelled out of the side window would be controlled for by the seat belt and reduced by the roll of the vehicle.

Both Daimler-Benz and BMW are actively involved in looking at ways of strengthening the lower sill panel and the lower regions of the doors (mainly in the front compartment). They maintain that this involves making the A and B column stronger too, especially in the low to mid range of the columns.

4.5 Side Door Airbags

One apparent solution to side impacts might be to fit airbags to side doors to provide increased occupant protection and some development work is being done in the U.S. This countermeasure was dismissed by the car manufacturers because they argued that the impacting vehicle would have reached the occupant before the airbag had time to inflate.

Aldman (1988) and NHTSA (Digges 1989), however, argued that it would be possible to develop sensors in the doors (e.g., dopler radar devices) to provide sufficient time to allow the bag to inflate before the collision. These sensors however would need to be fairly complicated devices to prevent false firings and hence may be an expensive solution.

It is understood that testing is current proceeding in the US under the auspices of the NHTSA to develop a side airbag for cars. Initial testing is promising (Digges, 1989).

5. OTHER COLLISIONS

The design of head restraints to prevent whiplash and measures to minimise truck under-run resulting from other types of collisions, are issues to which attention is currently directed in Europe.

5.1 Head Restraints

Car manufacturers and research organisations visited are perplexed about how to reduce whiplash injuries. The biggest problem they claim is the complete lack of knowledge about the injury mechanisms and causes.

Aldman (1988) hypothesises that whiplash is the result of injury to the spinal canal and nerve tissues caused by the abnormal accelerations and forces on the neck during a crash. The lack of any previous observations of damage in these regions, he claimed, is partially the result of not having suitable and sufficiently sensitive diagnostic equipment.

He noted there were two medical studies currently underway in Sweden. The most comprehensive of these is a long-term detailed examination and treatment programme underway in the North of Sweden involving the Folksam Insurance group. Patients suffering from whiplash are being thoroughly examined by both medical and psychological officers using the most sensitive equipment available. They are subsequently assigned to different treatments to assess potential benefits and injury causation.

In addition, there is a doctoral project just commenced at Chalmers University involving both engineering and medical examination of spinal injuries and vertebral force transmission. Unfortunately, the results of these studies are not expected for two or three years yet.

Aldman (1988) claimed that the most promising countermeasure for whiplash from rear collision seems to lie in providing close contact between the head and the restraint (a better designed head and seat unit) and matching the amount of cushioning between the head and shoulder supports. In this respect, a single seat and head restraint unit would be preferred, especially one that could also be adjusted to suit different seating heights.

The results of a limited whiplash study at Monash University generally support such an approach.

The vehicle manufacturers visited seemed to offer good fitting head restraints, although some were separate to the seat and with different cushion densities between the seat and restraint. BMW actually offered a motorised adjustment of the head restraint. Interestingly, none of these makers supported the hollow head restraint concept prevalent in Australia; while Volvo cars in Australia are sold with hollow restraints, they have a cushion attached to the unit in Sweden as standard equipment.

Unfortunately, there were very few suggestions of suitable countermeasures for whiplash from frontal collisions. There was a general acceptance that seat belt use may promote whiplash in these collisions. The only possible candidate might be in the general use of steering wheel airbags as a secondary restraint unit. Mackay (1988) argued that the accelerations on the neck were greatest as the belt tensioned and the head continued to accelerate and that these movements may be eliminated with the addition of a steering wheel airbag.

5.2 Side and Front Under-run

The TRRL have been looking at the problem of truck under-run for both side and front collisions. Neilson (1988) argued that side under-run was particularly a problem for bicycles and pedestrians while front under-run was especially dangerous for cars involved in head-on collisions with trucks.

The side under-run problem has already been well discussed at the European Experimental Vehicles Committee (EEVC) and there is currently a proposal tabled to fit side under-run guards to trucks, similar to those fitted to the rear. This proposal is apparently close to being submitted to Working Party 29 for ECE formulation. It was not possible to obtain a copy of this proposal.

TRRL is now currently developing a similar device for the front of trucks, comprising a 300mm front guard and an energy absorbing structural support (Riley, Farwell and Burgess 1987; TRRL 1987). It is argued that this will increase the maximium survivable closing speed for car occupants by reducing cabin intrusions of the truck riding over the car engine and bonnet. Crash testing suggests that this should protect belted front seat occupants from fatal or serious injuries at closing speeds up to 65km/h.

The vehicle industry argue that it is impossible to fit lower guards to all trucks because they travel over rough terrain. Given the trend towards truck cabins over the front wheels with very little front overhang, it is difficult to sustain this argument (Mackay 1988).

6. OTHER SAFETY RELATED ISSUES

A number of other issues related to vehicle occupant protection were also identified and discussed during these visits and these are described further.

6.1 NCAP 35MPH Tests

Since 1979 the NHTSA has conducted 35 mph barrier crash tests of various vehicle makes and models under the New Car Assessment Program (NCAP). The tests are designed to indicate, for vehicles within the same size class, the relative levels of occupant protection. Data similar to that measured in the 30 mph. frontal barrier crash test specified in FMVSS 208 are published for dummies in the driver's and outboard front passenger's seating position.

The Europeans were concerned about these NCAP 35mph barrier tests and the effect they were having on their vehicle design. They maintained that since most European manufacturers aim to sell their vehicles in the U.S., 35mph had become the defacto standard for vehicle design (most manufacturers want their vehicles to perform well in an NCAP test).

Thus, they argued the additional stiffening required in their vehicles to meet this "standard" was likely to have a detrimental effect for occupants involved in collisions at slower speeds (a situation they claimed to be more common). Moreover, they maintained that a full front-on barrier test was not typical of most accident situations and the structure necessary to withstand these impacts was quite inappropriate for partial head-on and angular collisions.

They were, however, unable to table any evidence to support these claims. In fact, Digges (1989) considers that in practice the types of design changes which manufacturers have made to improve their performance in the 35 mph NCAP tests have generally also improved occupant protection in lower speed collisions.

6.2 Mass Accident Data

The National Accident Sampling System (NASS) contains a structured sample of all police-reported crashes in the U.S. Some 10-11,000 crashes are investigated each year by teams stationed in the sampling areas and added to the system. For each crash, the accident scene is inspected and photographed, the vehicle is inspected and photographed, structural deformation is measured and the velocity change calculated where possible. In addition, drivers (or other persons) are interviewed about crash circumstances and consequences, medical autopsy and police reports are obtained.

The data base contains information about alcohol, seat belt use, details of injuries (AIS) and occupant contact points in the vehicle etc. A copy of the 1986 report of NASS and the forms used has been obtained (NASS 1986) and access for the purpose of research can be obtained.

The system is a very powerful data base for quantifying the accident and injury situation, setting priorities, measuring effectiveness of countermeasures and identifying scope for further safety initiates.

It differs from the Australian mass data systems in having detailed information on the vehicle deformation, impact points and injury outcomes.

The Fatal Accident Reporting System (FARS) contains information on all fatal motor vehicle crashes. The information is supplied under contract by the States from police, hospital, coroner's and emergency medical service reports, together with data extracted from vehicle registration, driver licence, highway department records and death certificates. It is similar to the Australian mass data systems for fatal crashes, except that it has more detailed information on a few items such as response times of emergency medical services, time between crash and death and previous accident and offence records of the drivers involved. Access to this data base is also available for research purposes. A copy of the 1986 report of FARS was obtained (FARS 1988).

6.3 Accident Analysis

Most of the research centres visited and all of the car manufacturers, in particular, argued that the only effective way of determining the relationships between vehicle design and occupant injuries from crashes is to conduct a full analysis of a range and number of vehicle crashes, comprising site visits, vehicle inspections of all vehicles involved (as soon as possible after the crash), analysis of the vehicle damage and distortions (including computation of the velocity change involved [dV] or its equivalent), and a full medical analysis of all the vehicle occupants' injuries.

Each of the manufacturers conduct these tests routinely for their own vehicles, either at the crash site or within 1 or 2 days after the crash and were willing to supply copies of procedures and techniques they employ (c.f., Norin, Nilsson-Ehle and Gustafsson 1982; Zeidler, Schreier and Stadelmann, 1985). They have developed a substantial data base of real world crash outcomes for their vehicles over the last 10 to 15 years which they use in improving the safety features of their cars.

6.4 Measuring Accident Severity

The measurement of accident severity is still very much debated by those involved in assessing vehicle and occupant damage. The range of measures employed by the various Centres visited are shown in Table 1. There are two different aspects of accident severity that need to be addressed.

6.4.1 The Different Measures Employed

By far the most popular measure used in crash analysis is the change in vehicle velocity as a result of the collision, normally expressed as dV. This measurement is estimated for the crashed vehicle, taking account of the zone and amount of deformation sustained, and damage of any other vehicles involved.

The use of dV for assessing accident severity, however, is not without criticism. While it is possible to specify objectively deformation profiles from known crash tests, it is almost impossible to include all possible crash configurations and vehicle combinations. Thus, estimating dV can be subject to considerable error in some cases.

This was highlighted recently at Volvo in Sweden when a number of experienced crash investigators were asked to estimate dV for a particular angular test crash situation. Norin (1988) noted that there were enormous differences in dV reported between the

TABLE 1
RANGE OF VEHICLE CRASH SEVERITY MEASURES EMPLOYED BY OVERSEAS RESEARCH CENTRES

Centre	Severity Measures
1. TRRL - United Kingdom	. change in velocity (dV) . peak velocity (m/s) . peak acceleration (g)
2. Volvo - Sweden	. CDC system of analysis (dV estimate of crash)
3. Chalmers Institute	. change in velocity (dV) (not a good measure though) . forward displacement better
4. VTI - Sweden	. change in velocity (dV) (not absolutely sure)
5. Folksam Insurance	. peak forward forces (child seats only) . not controlled for otherwise
5. Daimler-Benz - FRG	. Accid. Reconst. Meth. (ARM) . Energy Equiv. Speed (EES) (equivalent to EBS)
6. BMW - FRG	. Energy Equiv. Speed (EES) (dV problem for side crashes)
7. NHTSA - US (NASS)	. dV using the CRASH 3 program

experts (more than a 10 fold difference at the extremes). On the other hand, Digges (1989) stated that those with considerable experience with the technique obtained much better accuracy. This view is supported by Mackay (1988).

As a result of the litigation situation in the U.S., it appears that independent investigators are keen to support the usefulness of the dV calculation while, in general, vehicle manufacturers are likely to gain from casting doubts on its accuracy.

The German manufacturers use the NATO format of accident analysis involving the computation of the Energy Equivalent Speed (EES) for determining severity (Zeider, Schreier and Stadelman 1985).

This measure is a variation of the equivalent barrier speed used in crash testing which they claim is easier to estimate than dV. Unfortunately, though, it also relies on "expert experience" in interpreting the results and, thus, is subject to the same criticism as dV.

In any event, it is important that some measure of accident severity be attempted when comparing the effects of crashed vehicles to control for impact effects. In this respect, dV is probably the most useful measure available at this time. The software and instruction manual for computing dV using the CRASH 3 program was obtained from the NHTSA.

6.4.2 Accident & Injury Severity

Mackay (1988) argued that accident severity is not always a good indicator of injury severity. In some situations, unrestrained occupants sustain serious injuries from relatively minor collisions; conversly, restrained occupants often escape with only minor injuries from major collisions involving substantial vehicle damage.

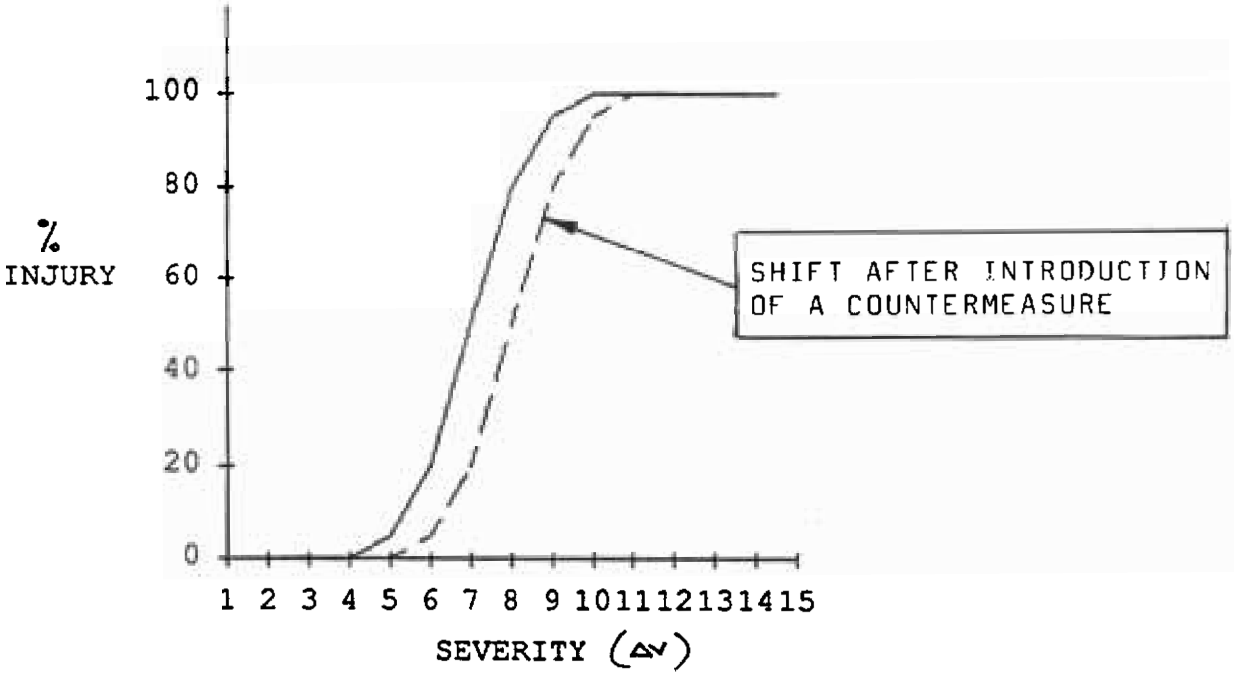
Tingvall (1988) suggested that the relationship between accident and injury severity is as shown in Figure 3.

For dV to be a serious measure of accident severity, he argued, variance can only be apparent in the level of injury for a given level of crash severity. However, he claimed that plus and minus 20 percent variance is also not unusual for dV for a given level of injury severity.

6.5 Measuring Injury Severity

The measurement of injury severity, too, is also a contentious issue in this area. Most of the organisations visited assess the extent of occupant injuries in terms of AIS scores which they code from hospital and medical records. There were four problems identified with this procedure during discussions.

Firstly, there is the question of accuracy of the data. Coding AIS from hospital and medical records requires skill and experience in using medical information to assign AIS. This is a particular problem for head injuries apparently requiring comprehensive medical records which are not always available.



↕ Should only have variance in this direction

↔ Found they were getting variance this way

(+ or - 20% variance)

FIGURE 3 **Theoretical relationship between accident & injury severity (Tingvall, 1988)**

Secondly, is the inadequacy of AIS to distinguish between severity and disability. While an AIS 2 injury to an occupant's knee is a relatively minor injury, it is, nevertheless, particularly crippling and requires considerable treatment and recovery. What is required, therefore, is a disability or impairment component in conjunction with AIS to explain injury severity fully.

Thirdly, AIS coding only takes account of the most serious injury in a particular body region and overlooks all others. This means that there are many occupant injuries from vehicle components that are ignored in the final analysis.

Finally, AIS coding does not take into account the physiological condition of the patient. Hence it is argued by those involved in trauma management in the U.S. that if probability of survival is to be estimated, the Trauma Score must be taken into account as well as the AIS (Boyd, Tolson and Copes 1987).

As Chairman of the International Research Committee on the Biokinetics of Impacts (IRCOBI), Aldman (1988) argued that there is too much emphasis on the threat to life in vehicle occupant safety and that there is a need to be more concerned with occupant disability, especially long term.

6.6 Modelling and Crash Testing

There is substantial interest in the use of computer modelling for crash analysis instead of conducting crash tests using dummies. A number of aspects of this issue are pertinent here.

Once the human injury tolerance criteria are agreed, the debate over which dummy is the most appropriate for which test would disappear with computer models. Programmes could be written incorporating a range of measures of injury for different body areas and directions of applied forces. This would be a positive move towards refocussing the efforts of international researchers and policy makers on occupant protection improvements.

In addition, there should be considerable savings for the community if modelling could replace crash testing. Vast resources are currently spent by research organisations and car manufacturers on crash testing to improve safety. A significant portion of this would surely be saved with computer simulations.

The speed with which safety improvements would be incorporated into current model vehicles would be enhanced with computer simulation. A new model could be tested before production to assess its safety features.

One problem for computer modelling is the state of current technology. TNO Road-Vehicle Research Institute are developing a Madymo 2D and 3D general program simulation package of occupant dynamics in crashes which appears reasonably comprehensive. Unfortunately, though, it only examines occupant forces in collisions and cannot simulate vehicle intrusions at this stage.

The other problem is a better definition of the tolerance of various segments of the human body to applied forces of various durations and with various contact pressures. Such tolerance figures are also known to vary for persons of different ages and probably also other characteristics.

7. SAFETY AND STANDARDS

The question was raised on a number of occasions about the role of vehicle design standards in occupant safety.

It could be argued that vehicle design standards are the only means of ensuring a satisfactory level of vehicle safety for its occupants. However, this disregards initiatives by vehicle manufacturers themselves to improve the level of safety of their own vehicles.

A number of the car manufacturers visited obviously regard the vehicle standards as the minimum level of safety requirement. It was apparent that many of them spent considerably more resources on development and testing than that needed simply to meet the requirements.

It was comforting to see that many of these vehicles in fact offered considerably more occupant protection than the legal requirements either overseas or locally. It should be recognised that some of these manufacturers do consider safety to be a "marketable feature" of their vehicles.

7.1 Future Directions for Vehicle Standards

Mackay (1988) argued that occupant safety researchers and administrators needed to address a number of key issues in future if they are to play a leadership role in vehicle safety improvements.

First, the matter of international accident patterns and type of vehicle crashes which result in injury should be identified and reported widely to ensure that current attempts to improve vehicle safety are of benefit to all countries.

They also need to be identifying new problem areas and proposing possible countermeasures or directions for finding solutions. For example, are present day standards suitable for all populations of drivers? In this regard, he claimed, there is a real need for greater coordination of the occupant protection research literature.

There is an urgent need too for improving the specification of occupant injuries in crashes. This includes such topics as the relationship between accident and injury severity, more definitive coding of occupant injuries and computer modelling of crashes.

Many people in Europe claimed that the Vehicle Standard process requires substantial improvement. The introduction of new ECE standards can (and does) currently take up to 5 years or longer depending on how individual countries view each proposal.

In addition, local regulations such as EEC and British Standards are to be phased out by 1993 to ensure uniformity. However, in many cases, these standards were introduced to shortcircuit the cumbersome ECE process, hence, there is a strong likelihood that progress with vehicle standards will be slower after that.

In short, the European system of vehicle standards is far from satisfactory in terms of providing maximum safety to vehicle occupants.

Similarly, it was claimed that the rulemaking process in the United States has been too slow in the past. In essence the legal and political actions associated with the frontal protection standard (FMVSS 208) have tied up the NHTSA and the industry for more than a decade and slowed down other aspects of vehicle safety standards.

This raises the question of the extent to which vehicle standards are the best mechanism for improving occupant protection further, or whether some improvements could be better achieved through provision of public information about performance of different makes and models in real world crashes or simulated ones.

7.2 The Role That Australia Can Play

Given the fact that Australia is a relatively small player internationally in influencing vehicle design, the matter of the role that Australia can play internationally needs further consideration.

It appears that properly documented results of research relating to vehicle safety would be of interest to the NHTSA, if relevant to the situation in the United States. There is scope for Australia to comment on Notices of Rulemaking, as well as provide information directly. Also, there is scope for Australia to make proposals to the ECE process of regulation development through its participation in WP.29.

In addition, occupant safety can be improved by local actions which do not necessarily require changes in international vehicle safety standards. Just as Australia has in the past played a major role in compulsory seat belt and child restraint wearing legislation, there are other areas, such as control of bull-bar use, truck frontal bumper design and possible use of helmets by motorists, which warrant further investigation.

8. CONCLUSION

It is clear from what has been observed overseas that the technology exists for improved occupant protection, particularly in frontal crashes.

Some of these improvements such as steering column airbags, belt tighteners, knee bolsters and improved padding, are already built in to some models. The questions which need to be answered are which of these improvements are likely to be cost-effective in Australian vehicles, given our hgh seat belt wearing rates.

The current study by the Monash University Accident Research Centre into occupant protection in passenger cars will provide some of the information needed to answer these questions.

REFERENCES

ALDMAN, B. (1983). Synthesis report of the EEC Biomechanics programme, Paper presented to a Seminar on the Biomechanics of Impacts in Road Accidents, Gothenburg, Sweden, 21-23 March 1983.

ALDMAN, B. (1988). Notes from discussions held with Dr. Brian Fildes from MUARC during his visit to Sweden in May 1988.

ALDMAN, B., ANDERLIND, T., KAJZER, J., MALMQVIST, J., MELLANDER, H. & TURBELL, T. (1985). Load transfer from the striking vehicle in side and pedestrian impacts, *Proceedings of the 10th International Technical Conference on Experimental Safety Vehicles*, *10*, 567-584.

AUTOLIV (1988). Autoliv Klippan Vehicle Safety Systems, Internal Publication, Sweden; Ljunglofs Offset.

BOYD, C.R., TOLSON, M.A. & COPES, W.S. (1987). Evaluating trauma care: The TRISS method, *The Journal of Trauma*, *27(4)*, 370-378.

DIGGES, K. (1989). Notes from discussions held with Dr. Peter Vulcan and Dr. Brian Fildes during his recent stay in Australia in January 1989.

FARS (1988). Fatal accident reporting system: A review of information on fatal traffic accidents in the United States in 1986, DOT HS 807 245, National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington DC.

HARBEL, J. (1988). Notes from discussions held with Dr. Brian Fildes from MUARC during his visit to Germany in May 1988.

HOBBS, C.A., LANGDON, M.G., LOWNE, R.W. & PENOYRE, S. (1987). Development of the European side impact test procedure and related vehicle improvements, *Proceedings of the 11th International Technical Conference on Experimental Safety Vehicles*, *11*, Washington D.C., May 1987.

KALLINA, I. (1988). Notes from discussions held with Dr. Brian Fildes from MUARC during his visit to Germany in May 1988.

LOWNE, R.W. (1988). Notes from discussions held with Dr. Brian Fildes from MUARC during his visit to England in April 1988.

LOWNE, R.W. & NEILSON, I.D. (1987). The development and certification of Eurosid; validation of the first prototype and design of the production prototype, *Proceedings of the 11th International Technical Conference on Experimental Safety Vehicles*, *11*, Washington D.C., May 1987.

LUTZE, H. & ZEIDLER, F. (1986). Konsequenzen aus der Unfallforschuntg fur die Fahrzeugsicherheit am Beispiel der neuen Mittelklasse von Daimler-Benz, *Automobil Industrie*, *3*, 11 pages.

MACKAY, M. (1988). Notes from discussions held with Dr. Peter Vulcan and Dr. Brian Fildes at MUARC during Dr. Mackay's visit to Australia in July 1988.

NHTSA (1988). Preliminary regulatory impact analysis new requirements for passenger cars to meet a dynamic side impact test FMVSS 214, DOT HS 807 220, National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington DC.

NEILSON, I. (1988). Notes from discussions held with Dr. Brian Fildes from MUARC during his visit to England in April 1988.

NILSSON, S. & PLANATH, I. (1987). Facial injury occurrence in traffic accidents and its detection by a load sensing face, Internal Volvo Publication PR/PV 871403, Gothenburg, Sweden.

NORIN, H. (1988). Notes from discussions held with Dr. Brian Fildes from MUARC during his visit to Sweden in May 1988.

NORIN, H., NILSSON-EHLE, A. & GUSTAFSSON, C. (1982). Volvo traffic accident research systems as a tool for side impact protection and development, <u>Proceedings of the 9th International Technical Conference on Experimental Safety Vehicles</u>, <u>9</u>, Kyoto, Japan, November 1982.

RILEY, B.S., FARWELL, A.J. & BURGESS, T.M. (1987). Front underrun guards for trucks, <u>Proceedings of the 11th International Technical Conference on Experimental Safety Vehicles</u>, <u>11</u>, Washington D.C., May 1987.

TINGVALL, C. (1988). Notes from discussions held with Dr. Brian Fildes from MUARC during his visit to Sweden in May 1988.

TRRL (1987). The safer steering wheel, Leaflet LF1064, Transportation and Road Research Laboratory, Department of Transport, Crowthorne, Berkshire.

ZEIDLER, F., SCHREIER, H.H. & STADELMANN, R. (1985). Accident research and accident reconstruction by the ESS-accident reconstruction method, 850256, SAE Technical Paper Series, Society of Automotive Engineers, Warrendale, PA.

ATTACHMENT 1a

CCMC (1988)

SYNOPSIS OF EEC VS. NHTSA PROPOSED SIDE IMPACT REQUIREMENTS

CHARACTERISTIC	EEC	NHTSA	HARMONIZED
I. PROCEDURE			
∘ Orientation MDB C.L vs. Test vehicle C.L.	Perpendicular	Perpendicular	Yes
∘ Direction of MDB Movement relative to vehicle C.L.	Perpendicular	27°	No
∘ Initial impact point of "front" edge of MDB face	N.A.; MDB C.L. to coincide with R-point	37" forward of centre of wheel base	No
∘ Position of driver's seat	R-point	Midway between forwardmost/rearmost	No
∘ Test configuration	Perpendicular	Crabbed	No
∘ Test velocity [km/h]	50	54 (33.5 mph)	No
II. MOVING DEFORMABLE BARRIER			
∘ Shape	Flat with "bumper"	Flat with "bumper"	No
∘ Dimensions [mm]			
- Height	500	559 (22")	No
- Width	1500	1679 (66")	No
- Thickness	500	483 (19")	No
- Ground clearance	300	279 (11")	No
∘ Mass [kg]	950	1360 (3000 lbs)	No
∘ Material	PU foam	Honeycomb	No
∘ Stiffness	Variable	45 psi ("soft structure")	No
		245 psi ("bumper")	No

C.L = Centre Line
psi = pounds per square inch

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CHARACTERISTIC	EEC	NHTSA	HARMONIZED
III. DUMMY			
◦ Type	EUROSID	HSRI-SID	No
◦ Number to be used	2	2	Yes
◦ Restraints/belts to be used during test	Yes	No, unless automatic restraints installed	No
IV. PERFORMANCE REQUIREMENTS			
◦ Head			
- HIC	< 1000	None	No
- Peak resultant acceleration	(*) (1)	None	No
◦ Thorax			
- Chest deflection on any rib	< 42 mm	None	No
- Peak viscous response V.C	< 1 m/s	None	No
- Upper (T1) peak lateral spine acceleration	(*)	None	No
- Lower (T12) peak lateral spine acceleration	(*)	Yes	Yes
- TTI [g]	(*) (1) (To be calculated from peak acclera-tion on each rib and T12 peak lateral spine acceleration)	80-115 (To be calculated from the higher of either the "upper" or "lower" rib peak acceleration, and T12 peak lateral spine acceleration)	Yes

(*) recommended additional measurements
(1) no limit value specified yet

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CHARACTERIST	EEC	NHTSA	HARMONIZED
IV. PERFORMANCE REQUIREMENTS (CTD)			
∘ Abdomen		None	No
- Peak force [kN]	< 4.5 (2)	None	No
- Peak compression [mm]	< 39 (2)	None	No
∘ Pelvis			
- Peak force on ilium [kN]	< 10	None	No
- Peak force on pubic symphysis	< 10	None	No
- Peak lateral accleration [g]	(*) (1)	130-190	Yes

(*) recommended additional measurements
(1) no limit value specified yet
(2) indicated by no contact of any of the event switches

MOTOR VEHICLE INSPECTIONS

The need for some form of compulsory periodic inspections of passenger vehicles as an effective means of reducing road crashes and the severity of associated injuries.

BACKGROUND

Currently in Australia some jurisdictions (New South Wales and the Australian Capital Territory and the Northern Territory) have annual inspections of cars at registration renewal

- NSW has a system of inspections by private service stations
- ACT uses government operated inspection stations
- Northern Territory uses both government and private service stations
- Victoria and Queensland require inspections and a road worthiness certificate at time when a vehicle changes owner
- other jurisdictions do not require inspections after first registration, except if it is an out of State purchase.

COMMENT

In spite of many years experience there has been no correlation demonstrated between road safety and annual vehicle inspections.

A review of the Cost Effectiveness of Road Safety Measures (prepared by R J Nairne & Partners Pty Ltd in November 1987 on behalf of the SA Road Safety Division) concluded that compulsory vehicle inspection schemes were not cost effective. Other research carried out generally draws this same conclusion.

The costs of annual inspections do not warrant the benefits gained. However, while there is no road safety benefit for introducing annual inspections for private cars, there is a consensus among States and Territories that regular inspections are appropriate for public service and heavy commercial vehicles.

The use of licensed garages in NSW has led to problems due to inconsistent standards and possible self interest in rejecting vehicles to gain workshop trade. In addition there have been consumer complaints about the standard of work carried out by garages and the high cost of the work.

Comparison of State and Territory fatality rates do not assist in determining the effectiveness of the various State and Territory inspection schemes, particularly in view of the relatively small number of fatalities attributed to vehicle factors.

In a paper presented to the National Road Safety Symposium in Canberra 1984 Mr I J Lees said that in an in-depth study of 386 motor vehicles involved in accidents in Adelaide in 1975-79

- only 11 had defects which were considered to be a significant causal factor and another 3 had defects which were considered to be a major causal factor.

Of the three defects which were major causal factors one was a modified rear suspension, one was unmatched tyres without tread on the rear wheels and the third was also unmatched tyres

- tyre related defects were the most common of the significant causal factors.