Retrofitting Seat Belts in Buses and Coaches

Justin McGuire#, Greg Dirkranian#, Ross Dal Nevo* & Julie Brown+

#Heavy Vehicle Safety & Standards; *Crashlab; +Consultant
NSW Roads and Traffic Authority
260 Elizabeth St, Surry Hills 2010

Abstract

This paper presents the development and findings of a program addressing retrofitted seatbelt installations in small unitary construction buses and larger coach like buses.

A procedure for inspecting retrofitted installations and dynamically assessing installations of concern has been developed. This paper details these procedures as well as the results of both the visual inspections and dynamic tests. In summary, 134 large coaches and 926 small buses were identified as being pre ADR vehicles that had been retrofitted with seat belts. Most of these retrofits were found to have been installed using methods that were different to those specified by available technical guidelines.

Detailed inspections of a sample consisting of almost all large buses and approximately 10% of all of the smaller buses retrofitted (134 coaches and 104 small buses) were conducted.

For the large buses, the inspections issues were raised in 32 of the 134 installations. When assessed dynamically, all of the 32 installations required rectification. However dynamic assessment of installations observed in all of the smaller unitary construction buses demonstrated that all currently employed installation methods (even those that depart of the guidelines) do provide an adequate level of protection.

Both the technical and policy aspects of this project and future initiatives for maintaining and enhancing occupant protection in retrofitted vehicles are addressed in this paper.

Introduction

In response to a number of bus crashes in NSW in the late 1980's the NSW Roads and Traffic Authority (RTA) through its Crashlab facility, in conjunction with the Federal Government, undertook a program to develop an occupant protection package that would address deficiencies in crash protection in long distance coaches (Dal Nevo et al, 1991). The package eventually put forward and included in a series of new and revised Australian Design Rules (ADRs) comprised of:

- Lap sash seatbelts integrated into each seating position,
- Adequate structural integrity to withstand roll-over without intrusion into the occupants space,
- An appropriate number of strategically positioned emergency exits to provide access when the bus is on it's side or roof,
- Emergency exits large enough to allow the passage of a rescue stretcher
- Emergency exits that were conspicuous to both trapped occupants and external rescuers, and
- Provision of child restraint anchorages in a small number of seats.

Of interest here are the ADRs specifically related to improved occupant protection and the installation of seat belts in coaches, i.e. ADR 66/00 and ADR 68/00. Both of these standards provide testing procedures and engineering standards in relation to seat strength and the installation of seat belts. Besides the type of vehicle to which they apply, one of the major differences between the two is that ADR 66/00 requires a vehicle to pass a nominal 10g static or dynamic test, ADR 68/00 requires vehicles to pass a nominal 20g static or dynamic test.

For the majority of light and heavy omnibuses (or unitary construction buses and larger coach like buses) the ADRs covering these improvements were introduced for vehicles manufactured from 1994 and 1995. Since there is generally a slow turnover in the fleet of buses, by the end of the 1990s only a relatively small number of omnibuses in operation actually had these improved occupant protection features as standard. For example as of December 2001, there were 41,650 buses under 5 tonnes and 8,549 buses over 5 tonnes registered in NSW, but approximately 80% of buses under 5 tonnes and 60% of buses over 5 tonnes on NSW roads at this time were manufactured before 1994. Therefore the majority of buses in NSW are pre occupant protection ADRs ('pre ADR 66 and 68') vehicles and would not have come from the manufacturer with seat belts, or in many cases with provisions for seat belts.

With the introduction of the new ADRs, it was widely recognised by all parties involved in the bus industry, including regulatory bodies, that it would not be feasible to require all pre ADR 66 and 68 vehicles to be retrospectively upgraded to meet the new requirements. It was however, deemed feasible to improve occupant protection in pre ADR vehicles to some extent. A Federal Office of Road Safety (FORS), National Road Transport Commission (NRTC) and Australian Bus and Coach Association (ABCA) joint workshop held in late 1993 explored the options for making such modifications to existing buses on a voluntary basis. The outcome of this workshop was the agreement between industry representatives that; such modifications were feasible, they should remain voluntary (ie not be required by law), and guidance should be provided as to what would be accepted as the best technical practice for modifying existing vehicles to improve occupant protection (NRTC et al, 1994).

With the approval of the Ministerial Council for Road Transport (Feb 1994), a voluntary code of practice, or technical guidelines, were developed cooperatively by FORS, NRTC & ABCA and issued in 1994. The intent of the guidelines, as set out in the document "is to define procedures acceptable to State and Territory registering authorities". And further since it is "not practical for many existing vehicles to meet the latest safety levels applying to new vehicles" the guidelines "supply details of modifications which may be possible within the constraints of the original vehicle construction" (NRTC et al, 1994).

The guidelines also describe five "levels" of safety improvement, which are ranked in ascending order of the safety provided and modification expense. A summary of the safety levels described in the guidelines is reproduced below.

Summary of Safety levels as Published in Available Guidelines

Level 1	Implementation of recommendations of Section 1 only, with improved exit conspicuity and tested exit function, and with structural integrity verified by inspection. This is a necessary prerequisite for further safety level modifications. Unless the vehicle structure has been verified as adequate, it would be potentially dangerous to improve occupant retention in the seating positions.
Level 2	Strengthened vehicle seat mounting structure, including replacement of aluminium legs. This level relies on the existing seatback to retain the passenger to the rear. It must be recognised that collapse of the seatback may occur at high deceleration rates.
Level 2a	As for Level 2 but with the addition of padding to the seatback to reduce head injury potential.
Level 3	Strengthened vehicle seat mounting structure and replacement of seats with ADR 66/00 conforming seats.
Level 4	Fitting of lap belts to existing seats, with replacement seat leg systems incorporating seat belt anchorage beam and strengthened vehicle seat mounting structure.
Level 4a	As for Level 4 but with the addition of padding to the seat back to reduce impact injury.
Level 5	Strengthened vehicle seat mounting structure and replacement of existing seats with ADR 68/00 conforming seats with lap sash belts.

The guidelines set out, in significant detail, methods for installing upgraded occupant protection features. This includes designs for modified and strengthened legs, seat anchorage beams and seat wall mounts. By following the recommended modifications in the Guidelines, engineers and bus owners are provided with a cost-effective way of implementing various levels of improved occupant protection that are acceptable to registration authorities, without having to undertake further validation or dynamic testing. (ref guidelines)

It has always been in the interest of authorities accountable for road safety, as a policy matter, to encourage bus owners to upgrade pre ADR 66 and 68 buses by strengthening seating and installing seat belts. More recently, in NSW, commercial pressure has increased bus operator motivation to upgrade the safety provided in their buses. Specifically, this appears to have come about by the introduction of a regulation (ie a legally binding rule) by the Department of Community Services (DOCs) that requires a child to be restrained in an appropriate restraint when being transported on an excursion. This in turn has led to schools in NSW wanting to hire buses with seat belts.

In NSW, modifications that have the potential to impact ADR compliance carried out on vehicles must be certified by an Engineering Signatory recognised by the RTA. Additionally the modifications must, by law, be reported to the RTA by the vehicle owner. With respect to the upgrading of occupant protection in buses , the RTA generally accepts certification of compliance with either; (i) the Voluntary Guidelines discussed above, (ii) the intent of the relevant ADRs or (iii) Federal Vehicle Standards Bulletin No 6: Heavy Vehicle Modifications (VSB 6).

In the late 1990s the RTA became aware of issues with a number of seat belt installations in some pre ADR buses and coaches. These issues included concerns about a possible lack of complete or appropriate certification of the seatbelt installations. The newly formed Heavy Vehicle Safety and Standards Section of the NSW RTA undertook a process to investigate and address issues and ambiguities with the upgrading of occupant protection in pre ADR buses. The nature of this process, findings of these investigations, and recommended future actions are discussed in detail in this paper.

A Process for Ensuring Acceptability of Existing Retrofits

The primary motivation for initiating a process to investigate and rectify any problems with retrofitted seat belts in pre ADR 66 and 68 buses is that incorrectly installed seat belts can lead to seat and seat belt failure. In addition, experience from the investigation of real world crashes indicated that in some instances restraining an occupant to a seat of poor structural integrity could increase the risk of injury.

In general terms the process involved establishing a system to identify buses that had been retrofitted together with development of material to assist the implementation of the process. This material included information bulletins for the RTA's vehicle inspectors and Engineering Signatories. Consideration was also given to the political, legal and financial implications of the project.

The potential impact of rectifying a large number of vehicles on bus operators was also examined. It was concluded that while the RTA acknowledged that such actions to modify, repair or remove the seat belt installations could cause both an inconvenience and a business operational constraint to the owner, the RTA considered that such implications were necessary for passenger safety.

Once the magnitude of the issue was established an independent inspection and testing regime was established to verify that the modifications had been carried out in accordance with the guidelines, or if not, that the seat belt installations provided the same level of protection as they would if the installation had been carried out in accordance with the guidelines.

The Inspections

As discussed above, the primary aim of the inspection program was to ensure that retrofitted seatbelt installations provide adequate occupant protection and do not in themselves present a hazard to occupants.

Buses that had been retrofitted with seat belts were identified through engineering certificates where these were available. Reports and calculations were obtained from engineering signatories for retrofits that they had certified. In addition, as part of the HVIS arrangements, heavy vehicle inspectors were asked to inspect all buses retrofitted with seatbelt installations at the time of periodic inspection and then send a report on the nature and condition of the retrofitting to the RTA's Heavy Vehicle Safety and Standards Section. (Note: The NSW HVIS requires that vehicles used as public vehicles, such as buses and small buses 2.5 tonne tare or more, undergo regular inspections for registration purposes.

Vehicles used as public vehicles require inspections every six months and small buses require annual inspection in line with registration renewal.) This report was in the form of a survey sheet and was used to determine the number of buses that had been retrofitted and their level of compliance.

From this process, 134 large coaches and 926 small buses were identified as being retrofitted with seat belts in NSW as of February 2001. Most of these retrofit installations were reported to fit into the category ‘fitting arrangement other than specified in the Guidelines”. This means that the installations meet performance standards and are certified by an Engineer.

To ensure that these vehicles did indeed provide an adequate level of protection, a panel of three engineers, expert in bus design and modification, were contracted to the RTA to undertake detailed inspections of a sample of the retrofitted vehicles. The sample was designed to demonstrate whether further investigations were required while at the same time prioritising long distance coaches and school buses, particularly in rural areas. The sample consisted of almost all large buses identified as being retrofitted and approximately 10% of the smaller buses. In all, inspections were conducted on 131 coaches and 104 small buses. All inspections were conducted by a team consisting of one of the contracted independent expert engineers and an officer from RTA’s Heavy Vehicle Safety and Standards Sections.

The inspection procedure involved the following: -

- Identification of the vehicle
  Details such as vehicle owner, vehicle make and model, date of manufacturer, compliance plate details, registration number and VIN were recorded
- Determination of what standard etc the retrofit had been installed under
  Had the retrofit been installed with the intention of meeting the relevant ADR, or in line with the Voluntary Guidelines or some other code of practice. What standard had the engineer certified the modification to?
- Inspection of the structural integrity of the installation
  How were the seats and seat belts anchored to the vehicle. What was the integrity of the anchorages in respect to their mounting positions on the floor and walls. What method was used for anchorage, eg what type of mounting method, what was the material used and what were the dimensions of this material. What was the general condition of the vehicle in regard to the installation eg was there significant rust present?
- Description of the retrofit installation
  What type of seat belts was installed. Where were the belts anchored. Any other general features of the installation.
- Identification and inspection of any other safety upgrades
  Was there any indication that frame inspections had been carried out. Was there any upgrade of emergency exits. Had padding being fitted to the back of seats.

Following inspection of the seat belt installation a rating on the over all structural integrity of the installation was recorded, and all information collected entered into a database.

Inspection Results

Overall, the inspections revealed that most modifications could be slotted into one of four categories. These were: -

1 Installations that were installed as per the voluntary guidelines
2. Installations that departed from the guidelines but were considered acceptable
3. Installations that required minor modifications to be considered acceptable
4. Installations that required significant modification or rectification.

Specifically, the investigations revealed that 32 of the 134 large coach installations were found to be in the fourth category described above. To ensure the adequacy of the installations in these 32 large coaches it was deemed necessary to obtain more information from the company that carried out the modification and/or to conduct simulated crash tests using these installations to demonstrate the level of protection being offered.

For the smaller buses, the majority of seat belt installations fell into two generic types. These were

- Seatbelts attached directly to the floor of the vehicle using an ‘L’ shaped bracket with a mild steel spreader plate underneath the floor; and
- A modified seat and leg assembly that incorporates seat belts

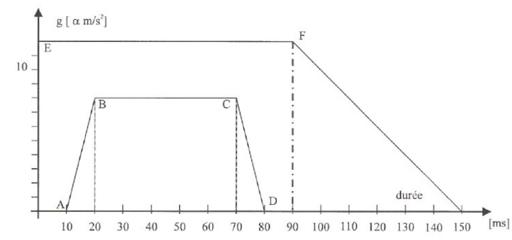
While neither of these installations strictly met the requirements set out in the Guidelines, it was not possible to ascertain, by visual inspection alone whether the installation would provide the same level of protection as an installation that had been done strictly in accordance with the guidelines. Therefore, the majority of the 104 vehicles inspected fell into category 4 discussed above.

Dynamic Testing

It is important to note that the review of pre ADR 66 and 68 bus retrofits included large coach like vehicles and smaller unitary construction buses like the Toyota Coaster, Nissan Civilian or Mazda T3500. The smaller unitary construction buses have a GVM of approximately 4500kg and a seating capacity of up to 22 passengers. The larger coach like buses have significantly greater GVM’s and seating capacities. Because of the differences in typical construction between these two vehicle types, the guidelines stipulate different types of modification methods for these vehicles.

Both vehicle types were assessed dynamically to ascertain whether the installation would survive a 10g crash. This test severity relates to an impact condition where the vehicle is subjected to a deceleration 10 times the force of gravity. The ability to withstand a 10g impact is also the basic occupant protection requirement of ADR 66/00. Although this level of protection is less then that required by ADR 68/00, it has been set as an acceptable level of performance that can be achieved within reasonable cost boundaries. In terms of real world performance, a vehicle that can meet such a requirement should provide more effective occupant protection then one that has not been upgraded. But will not provide the same level of protection in higher severity crashes as one that has been manufactured to meet ADR 68/00.

The dynamic test method used here was therefore based on the requirements of ADR 66/00. The basic test requirements of this design rule specify the severity of the test impact in terms of the magnitude of the change in velocity, the magnitude of the deceleration and the time over which the deceleration is applied. In other words, the design rule specifies a test ‘crash pulse’. In summary, this pulse requires that the velocity change of the test impact be between 30 and 32 km/hr. In addition the applied deceleration must be between 8 and 12g for a period of not less than 50ms. How the acceleration is applied with respect to time is also stipulated and the average deceleration for the entire test must be between 6.4 and 8.5g. This requirement is graphically illustrated in the crash profile reproduced from ADR 66/00 and shown in Figure 1.



	t(ms)	g
A	10	0
B	20	8
C	70	8
D	80	0
E	0	12
F	90	12
G	150	0

Figure 1: Dynamic Test Pulse Reproduced from ADR 66/00

In ADR 66/00 tests, the performance of bus seats is assessed in terms of their ability to withstand the severity of the impact in conjunction with the loads produced by an unbelted occupant striking the rear of the seat assembly. The test seat itself is not occupied during testing. This scenario represents what may happen in a 10g real world impact where the occupants seated behind any particular row of seats were not wearing their restraints. In effect this test assesses the seats ability to remain structurally intact while containing the forward excursion of unbelted 'rear seated' occupants in a biomechanically acceptable manner. It does not attempt to assess the level of protection provided to a restrained occupant in that seat.

Occupant protection provided by ADR 66/00 is equivalent to Level 3 of the Voluntary Guidelines, that is, occupant protection is provided by ensuring the structural integrity of the seat mountings. Any pre ADR 66 and 68 vehicle modified by the installation of seat belts effectively has been modified to the Safety Level 4 (as described in the Voluntary Guidelines), and represent modifications that are required to meet a more demanding level of loading. In other words, Level 4 modifications represents a more demanding level of structural integrity than that required by ADR 66/00 in that the test seat must provide lap belt restraint to its occupants as well as providing containment for the unrestrained occupants seated behind it. In terms of dynamic testing, this means that assessing the performance of Level 4 installations requires a more demanding test than ADR 66/00. This was achieved by conducting the tests with surrogate lap belted occupant in the test seat, as well as including surrogate unrestrained occupants in a row of seats behind the test seat as required in the ADR 66/00 test. By including restrained occupants in the test seat the structural integrity of the seat is subjected to a more rigorous test than that required by a normal ADR 66/00 test.

In terms of assessing what constitutes good or bad performance in these tests, the relevant ADR 66/00 criteria that can be used for guidance on a Safety Level 4 test are the strength of the seat and the seat mounts and the strength of the vehicle anchorages. The containment requirements for the unrestrained rear occupants and the biomechanical injury criteria included in ADR 66/00 criteria are not strictly appropriate given that the stipulated level of modification for Safety Level 4 does not require strengthening of the seat back or the fitting of energy absorbing padding.

The actual criteria used in all dynamic assessments was therefore adopted directly from those ADR 66/00 requirements related to seat, seat mount and anchorage integrity. (See Section 5.2.3 of Appendix A, ADR 66/00).

Since the test method required the use of surrogate rear seat occupants that would load the test seat in a realistic manner, Hybrid III dummies were used. These dummies allow measurement of the biomechanical criteria required by ADR 66/00 and although these measurements were not required for this assessment, measurements were taken and reported for indicative purposes. However since these measurements were used for indicative purposes only, the Hybrid III dummies were used in a non-calibrated (response not validated) condition to simplify the test procedure and reduce the likelihood of damaging expensive in-calibration dummy components.

For the installations found in unitary construction buses, the dynamic test method used here were similar to that described above. Except that since the unitary construction buses (because of their inherent light construction) would have difficulty in meeting the safety levels stipulated in the Voluntary Guidelines for the larger coach like vehicles, different safety levels are prescribed for these vehicles. Basically, the Guidelines do not consider the structural strength of the standard floors in unitary construction vehicles (like the majority of small buses investigated) to be adequate to accommodate any of the occupant protection improvements from levels 2 to 5. The standard vehicle is only considered suitable for the Level 1 improvements of emergency exit and signage. The Guidelines state that level 2, 3 and 4 can only be achieved by the design and installation of a raised false floor (plinth) fitted over the existing floor. Acknowledging the limitations associated with the installation of a plinth floor, the Guidelines describe another alternative upgrade method which involves lap only belts and the lap portion of lap & sash seat belts anchoring directly to the vehicle's floor. This alternative method is achieved by the use of an additional under floor structure, bonded to the floor and welded to the cross-bearers at the ends, to provide secure anchorage(s) for the centre portion of the seat belts on dual occupant seats. Bridging bars, vertically spaning the side windows, are specified as the method of providing the anchorage for the sash portion of any outboard seating positions retrofitted with lap & sash seat belts.

In terms of performance, this type of modification is required to simply restrain the seated occupants during a 10g-deceleration. The seat is not expected or required to provide containment of unrestrained rear occupants, and therefore, the tests are conducted with a single row of seats only (and therefore the potential loading due to unrestrained surrogate rear seat occupants is not included in the assessment process).

Dynamic Test Method

The dynamic test pulse and criteria used to assess the adequacy of installations are based on ADR 66/00 as discussed above.

Applying the pulse to the installations was achieved by mounting an actual bus seat to a structural representation of the bus ('test module') on a dynamic crash simulator (sled). The sled and the test module were then subjected the required impact conditions. The mounting of the seat and its attachments were designed to replicate that used in the actual vehicle. A number of different installation methods for both large coach like vehicle and the smaller unitary construction buses were tested. Details of the dynamic tests undertaken are given in Appendix 1.

Dynamic Test Results

For the unitary construction vehicles, examinations of vehicles in the field demonstrated that three tests and one control test would be adequate to cover the entire range of installation observed. The methods of installation tested included:

- Installations using Lap Belts mounted to the floor via metal anchor straps,
- Installations conducted as per guidelines, and
- Installations using modified seats with seat mounted belt systems

All of the seat belt installations used in unitary construction buses assessed dynamically demonstrated the ability to provide a level of protection equal to that required by the Guidelines.

In addition, the testing demonstrated that modifications incorporating smaller under floor load spreading plates for lap belt anchorages than that suggested by the guidelines still provide sufficient strength. That is the guidelines suggest the use of a load spreading plate of approximately 100x50x3mm, however a test of floor mounted lap belts conducted here (S020019) used significantly smaller plates (50mm x 25mm x 3mm) on the inner lap belt anchorage, and this mode of anchorage still demonstrated an ability to meet the performance requirements of the Guidelines.

Possibly one of the most significant observations made from this series of tests was that the ultimate performance of the seat and lap belt assembly in each test appears to have been limited by the structural performance of the seat anchorage wall fixture and not the seat assembly itself.

For the larger coach like buses field investigations revealed 32 of the 134 coaches to be rated as category 4. All required significant modification or rectification to provide an adequate level of protection. Of the 32, 12 installations were of a similar type involving modified seat floor mounts and lap belts systems fitted to the seats. This method involved the existing seats being mounted to the floor via an aluminium tracking system and was assessed by the conduct of two dynamic tests.

This system failed to demonstrate the ability to meet safety Level 4 of the *Guidelines*. Crashlab engineers reported that the way the aisle side or pedestal anchorage failed in this method of retrofit installation is a "well recognised" phenomenon. And in fact the guidelines address the potential of such anchorages to fail in this manner by explaining that "all seats with an anchor bolt pitch of less than 300mm are likely to suffer structural failure with the combined load of the lap belted and rear occupants." The engineers also reported that this problem was compounded in the seat arrangement tested by the choice of attachment bolts.

Two other types of installations were identified among the other 10 cases that were of concern. Both installations involved different types of modified seat assemblies incorporating seat mounted belt systems. Assessment of these modified seat assemblies was achieved by three dynamic tests, and both of these systems also failed to demonstrate the ability to met safety Level 4 of the Guidelines. However, one type of modified system, the "Secure' seat was re tested after the manufacturers of this seat strengthened the pedestal support leg. In this condition, the "Secure" system was shown to retain structural integrity in the dynamic test, and could therefore (in the modified state) meet this level of safety. Examples of all methods of installation tested, both for unitary construction vehicles and the larger coach like vehicles, are given in Appendix 2.

Policy Implications

As discussed above it is in the interest of all road safety stakeholders to encourage upgrading the level of protection offered to small and large omnibuses. However, the NSW experience demonstrates that rigorous monitoring of the upgrade process is required to ensure after market modifications provide the desired protection and do not reduce the level of existing protection.

It appears problems with retrofits identified in NSW (in particular in large coaches) occurred due to ambiguities in the status of the existing voluntary guidelines. This has been rectified in NSW through the education of engineering signatories and will be maintained through annual heavy vehicle inspection schemes. Vehicle inspectors will also be educated to ensure the inspection process picks up any future 'installation of concern'

Retrofit occupant protection upgrades in omnibuses should remain voluntary, but the NSW experience suggests there may be a need to review the voluntary status of the technical guidelines for methods by which such retrofits are achieved. While these guidelines remain voluntary, the NSW experience demonstrates that road safety stakeholders in other jurisdictions should be aware of the potential for similar road safety issues in vehicles registered in those jurisdictions.

Technical Implications

Through out the process of assessing the installations judged to be in category 4 a number of issues relevant to the current retrofit guidelines became apparent. These include a need to review some of the technical aspects of the existing guidelines.

In particular, it appears that some of the questions related to the performance requirements of the guidelines arose from the inclusion of the advisory document discussing the technical basis of the development of the guidelines. This discussion includes results obtained (in terms of measured loads) from the dynamic assessment of installation methods stipulated in the guidelines. It appears that in some cases this information was misunderstood as prescribing loads associated with a test procedure for ensuring the structural integrity of any retrofit installation. This section needs to be re written and clarified. To further improve the clarity of this issues, we would recommend inclusion of a test procedure for those installation that are not in strict accordance with the guidelines.

In addition, alternative methods of installation shown to provide adequate protection should be considered for inclusion in the guidelines. This relates particularly to installations for unitary construction vehicles.

Some observations made during this test series also demonstrated the need for the correct replication of the entire installation when dynamically assessing it in the laboratory. Prior to the testing carried out here, it was thought that the integrity of the floor mounts would be most critical in terms of a seat structures' ability to withstand dynamic loading. Therefore, true replication of the floor mounts in the laboratory was thought to be adequate in attempting to replicate the performance of an installation. However, in conducting tests of seat modifications for unitary construction buses, it became apparent that the accurate representation of the wall attachment was equally as important as correct replication of the floor mount. This observation should be kept in mind in the development of future test procedure and assessment processes.

Finally, one of the seats tested under this project is a seat sold without modification for installation in new coaches. On testing the seat achieved a poor result. After significant modification to the seat's leg assembly it was deemed suitable for retrofitting in terms of the voluntary code.

A broad issue that emerged was that of self-certification by component manufacturers under the ADR system. The RTA has referred this issue to DoTaRS as the agency responsible for the ADR system. The strengthening of this process will enhance the confidence of stakeholders in the road safety outcomes of the system as a whole.

Conclusions

- In 2001, 134 large coaches and 926 small buses were identified in NSW as being pre ADR vehicles that had been retrofitted with seat belts. Most of these retrofits were found to have been installed using methods that were different to those specified by the technical guidelines.
- Detailed inspections of a sample consisting of almost all large buses and approximately 10% of all of the smaller buses retrofitted were conducted.
- For the large buses, the inspections revealed 32 of the 134 installations required significant modification or rectification. This was confirmed when the installations were assessed dynamically.
- Dynamic assessment of installations observed in all of the smaller unitary construction buses demonstrated that all currently employed installation methods (even those that depart of the guidelines) do provide an adequate level of protection.
- A process for ensuring retrofitted occupant protection upgrades in omnibuses has been implemented in NSW.
- The NSW experience has demonstrated the potential need for similar rigorous maintenance of occupant protection standards in other jurisdictions.
- The review and dynamic assessment process carried out here has identified the desirability of the NRTC reviewing existing guidelines both in terms of their voluntary status and technical specifications.

References

NRTC, FORS & ABCA (1994)
"Guidelines for the Voluntary Modification of Existing Buses and Coaches To Improve Occupant Protection"

Crashlab, RTA (2001)
SPECIAL REPORTS: SR2001/011 & SR2001/012

Crashlab, RTA (2002)
SPECIAL REPORTS: SR2002/001, SR2002/002, SR2002/005, SR2002/007 & SR2002/008

Dal Nevo R, Duignan P & Griffiths M (1991)
Occupant Protection in Omnibuses
Paper 91-S9-O-14
International Conference on Enhanced Safety Vehicles
November, 1991

ISBN 1-876346-46-9 © RS2002 Conference

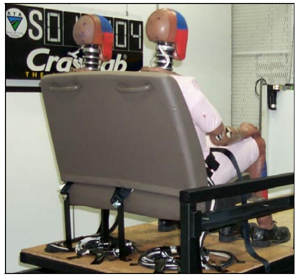
Appendix 1: Dynamic Test Schedule

Test No	Vehicle Type	Seat Description	Mount/Anchorage Description
S010404	Unitary construction	Standard Seats	Lap belts with standard wall mount & floor anchorage via metal strap with larger 50x50x3mm underfloor spreader plate
S010405	Unitary construction	Modified seat with seat belt mounted to seat	Seat mounted to wall using pressed metal top hat type section and to floor via reinforced leg with standard seat anchorage bolt
S010406	Unitary construction	Standard Seats	Lap belts bolted directly to floor as per guidelines (ie had pressed metal section under floor)
S020019	Unitary construction	Standard Seats	Lap belts with standard wall mount & floor anchorage via metal strap with 50x25x2mm underfloor spreader plate
S020020	Unitary construction	Modified seat with seat belt mounted to seat	Seat mounted to wall using same pressed metal top hat type section but with metal gusset reinforced anchorage point and to floor via reinforced leg with standard seat anchorage bolt
S010403	Large Coach Like Bus	Reclining bus seats retrofitted with lap seat belts	Seat mounted in same way as observed in actual vehicle with pedestal legs on aisle side and wall mounts on window side. The fastening of the floor and wall tracks to the module also replicated the method and spacings observed in an actual bus. [Distance between front and rear seats was 90cm. Seat mounted to aluminium tracks via anchorage bolts. Seat belt also mounted to tracks via anchorage bolt. All anchorage bolts and aluminium tracks supplied with seats].
S020022	Large Coach Like Bus	Reclining bus seats retrofitted with lap seat belts	Seat mounted in same way as observed in actual vehicle with pedestal legs on aisle side and wall mounts on window side. The fastening of the floor and wall tracks to the module also replicated the method and spacings observed in an actual bus. [Distance between front and rear seats was 90cm. Seat mounted to aluminium tracks via anchorage bolts. Seat belt also mounted to tracks via anchorage bolt. All anchorage bolts and aluminium tracks supplied with seats]. Same as S010403 but with altered pulse
S020122	Large coach like bus	Reclining bus seat with lap belts fitted to seat	Test set up replicated set up observed in field. Involves pedestal leg anchorage on aisle side mounted via drill and tap into the chassis or some major structural element. Wall mount in test set up used a mild steel bolt effectively replicating "worst case" wall anchorage.
S020088	Large coach like bus	'New" seats claiming compliance to ADR 68/00 (have fixed squabs and integrated retractable lap and sash seat belts).	The seat was mounted to the test module in the same way the seat is mounted to an actual vehicle. This involves an aisle pedestal support leg constructed of pressed metal attaching to a floor mounting plate via front and rear attachment bolts. The seat is also mounted to the wall.
S020108	Large coach like bus	Modified version of above	Mounting method the same as above but the support leg was modified by (i) being constructed from a wider gauge material (ii) having the front and back edge reinforced with a heavy gauge section

ISBN 1-876346-46-9 © RS2002 Conference

Appendix 2: Photographs

Small (Unitary Construction) Buses

Installations using Lap Belts mounted to the floor via metal anchor straps		**Installations conducted as per guidelines**		**Installations using modified seats with seat mounted belt systems**	
Pre Test	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**
					

Large (Coach Like) Buses

Installations without modified seats existing			Installations using modified seats		
Pedestal leg & floor Pre Test	**Post Test**		**Pre Test**	**Post Test**