PREPARATION OF A DRAFT NATIONAL CODE OF PRACTICE

RETROFITTING PASSENGER RESTRAINTS TO BUSES

NTC AUSTRALIA

National Transport Commission

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Prepared by

Vehicle Design and Research Pty Limited

National Transport Commission

Preparation of Draft National Code of Practice for Retrofitting Passenger Restraints to Buses

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REPORT OUTLINE

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Key Milestones:	This is a review of national guidelines that have been in operation since 1994.
Abstract:	A draft Code of Practice has been prepared to set out requirements for modification of existing buses with the intention of improving occupant protection in crashes.
Purpose:	To provide background information on the draft Code of Practice. This report is not intended to be a public document.
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FOREWORD

The National Transport Commission (NTC) is a statutory body established by an intergovernmental agreement to progress regulatory and operational reform for road, rail and inter-modal transport to deliver and sustain uniform or nationally consistent outcomes.

Following the research that was commissioned for the NSW RTA into the retrofitting of seatbelts for buses and coaches, as well as advice from the Bus Industry Confederation (BIC), it was concluded that the original guidelines ("Guidelines for the Voluntary Modification of Existing Buses and Coaches to Improve Occupant Protection") need to be revised. These guidelines were originally developed in 1994 by the National Transport Commission (NRTC), the Federal Office of Road Safety (FORS) and the Australian Bus and Coach Association (ABCA).

The NTC lead the review and a project steering committee provided key input and overall direction on the review. This review is an important strategic objective under the National Heavy Vehicle Safety Strategy (NHVSS) and the National Heavy Vehicle Safety Action Plan 2003 - 2005 (NHVSAP).

The NHVSS and Action Plan (NHVSAP) were originally adopted by the Australian Transport Council (ATC) in 2003, to complement the National Road Safety Strategy and Action Plan and to provide a focus for road trauma resulting from crashes involving heavy vehicles.

The ATC comprises Commonwealth, State, and Territory Ministers with transport responsibilities and includes an observer from local government. Both the NHVSS and the Action Plan are specifically targeted at reducing the number of road users killed or seriously injured in crashes involving a heavy vehicle. They were developed using the advice provided by the road transport industry, Commonwealth, State and Territory transport policy advisors, and road safety researchers. This revised Action Plan 2005/07 has been developed jointly by the Heavy Vehicle Safety Strategy Taskforce, which is comprised of a broad range of representatives from road safety organisations and the heavy vehicle industry.

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SUMMARY

A draft Code of Practice has been prepared to set out requirements for modification of existing buses with the intention of improving occupant protection in crashes. The Code is intended to replace national guidelines that were issued in 1994.

Based on:

- investigations of bus occupant safety research since the 1994 code was introduced, and
- commercial availability of Australian Design Rule 68/00 (ADR68) seats with integral lap/sash seatbelts from several local and overseas manufacturers,

it is now recommended that, where seatbelts are to be retrofitted, then only lap/sash seat belts incorporated in ADR68 certified seats and anchored to withstand a 20g crash pulse be permitted.

Whilst, in some cases, this places more stringent requirements on the vehicle than at original manufacture, it reflects practical application of available technology to ensure a uniform standard of protection for bus occupants choosing public vehicles with seatbelts fitted.

More than 10 years after the introduction of ADR68 there is considerable demand for large/small luxury/basic buses which have seatbelts fitted. This has resulted in continuing retrofit activity of vehicles which were exempted from ADR68 at the time of manufacture, either because of standee provision (route buses) or installation of low back seats. This results in an anomalous situation where a vehicle which has its usage changes after initial manufacture was not required to have occupant protection brought up to the appropriate level (ie ADR68).

An audit by the Roads and Traffic Authority in 2001 revealed a wide range in quality of seat belt installations on buses in NSW.

The intention is that the Guidelines become a National Code of Practice and that all States and Territories insist that retrofitted buses meet this Code.

The availability of consulting engineers who are competent to advise on and certify retrofits was one issue that was also identified.

It is proposed that :

- all seat belt retrofits be certified by an approved engineer
- retrofitted buses be fitted with a modification plate or similar for clear identification
- Further work be undertaken on a simplified seat anchorage test to facilitate certification of retrofitted vehicles to ADR68 performance levels.

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1. INTRODUCTION

1.1 Background

During the 1980s plans were made to introduce improved bus occupant protection based on the philosophy of providing seats that would withstand impacts by unrestrained occupants seated to the rear and only providing seat belts for occupants in the front row of seats. These requirements were incorporated in Australian Design Rule 66 (ADR66) which applies to coaches manufactured from July 1992. Route service buses are exempt from the ADR.

Two severe coach accidents in 1989 led to a change in philosophy and the development of lap/sash seat belts for coaches in Australia. ADR 68 "Occupant Protection in Buses" was introduced July 1994 and heavy coaches manufactured since then have had lap/sash seat belts in all seating positions.

Figure 1. Grafton and Kempsey bus crashes in 1989

Route service buses (ie buses with provision for standees), buses which have seats with seatbacks less than 1m high and buses with less than 16 passenger seats are exempt from ADR68. Most buses used for transport of school children are route service buses and the activity with coaches led to calls from parent groups for seat belts to be fitted to school buses. As a result, in 1992, Dr Michael Henderson and Michael Paine were contracted to conduct a review of school bus seat belts for the NSW Department of Transport. That study looked at the technical and operational issues associated with retrofitting seat belts, particularly to older large buses. The authors concluded that it was inadvisable to fit seat belts to these vehicles without substantial structural improvements to seats, seat anchorages and, in some cases, the bus structure.

The authors did note, however that most buses built since 1991 had seats that met the intent of ADR66 and that these buses required less upgrading than older buses (however, mandatory fitting of seat belts was still not justified). They also recommended that a national code of practice be developed for retrofitting seat belts to small buses.

Late in 1993 a national workshop concluded that a code a practice for fitting seat belts (and other occupant protection measures) to all sizes of buses should be developed. This became the Code that is the subject of this project report. The 1994 Guidelines were issued by the National Road Transport Commission, Federal Office of Road Safety and Australian Bus and Coach Association in 1994. The intention was that the measures should not be mandatory but where operators

chose to upgrade their vehicles the modifications should be carried out in accordance with the Guidelines.

In 1999 the Roads and Traffic Authority commenced an audit of buses retrofitted with seat belts. The results were reported in a paper published in the proceedings of a 2002 Australian road safety conference and were not encouraging. Out of 134 large buses inspected 32 (24%) required "significant modification or rectification". Of the 104 small buses inspected most did not strictly meet the requirements of the guidelines but they were found to provide similar levels of protection.

Dynamic testing using actual bus seats and mock-ups of bus floors and sides were conducted to assess the ability of the installations to withstand ADR66 loads (in effect 10g peak deceleration), but with the seat under test having occupants wearing seat belts. These tests generally confirmed concerns about seat belt installations and the need for significant improvements. They also confirmed the inherent difficulties where seatbelts are retrofitted to non-ADR68 seats

The RTA research also revealed misunderstandings about the wording and intent of the Guidelines amongst the retrofitting industry and consulting engineers and it was recommended that the Guidelines be reviewed.

The National Code of Practice for Heavy Vehicle Modifications (VSB 6) were published several years after the Guidelines. They contain checklists for assessing modifications. This approach is also appropriate for checking retrofitted seat belts in buses. VSB6 does not contain specific requirements for bus seat or seat belt upgrades.

2. DEVELOPMENTS SINCE THE ORIGINAL GUIDELINES WERE PREPARED

The guidelines were first issued in 1994. Since then there have been several developments which need to be taken into consideration in the review of the guidelines.

2.1 Availability of ADR 68 bus seats

Considerable design effort has gone into the development of bus seats that meet the stringent requirements of ADR 68 (3 point seat belts, 20g dynamic loads with restrained occupants plus impact by unrestrained occupant to the rear). Specifications indicate current models are typically lighter than early seats which did not have seatbelts.

Figure 2. Wall/floor mounted bus seat with integral three point seat belts (Styleride)

Advice from seat manufacturers is that there are more than four thousand Australian coaches fitted with ADR 68 seats. Based on the data supplied, it appears about half of these are retrofitted vehicles.

Figure 3 Bus seats with integral three points seat belts – McConnell on left and Transport Seating Technology on right

2.2 Buses complying with ADR 59

Buses designed for route service are not required to have ADR 68 seats. However, nearly all heavy buses (coaches and route service buses, other than "low floor buses") manufactured since July 1992 have been required to comply with ADR 59 for rollover strength. Our initial investigations indicate that the stronger structure resulting from ADR 59 makes the retrofitting of ADR 68 seats much easier. In many cases the same seat anchorage systems are used for ADR 68 coaches and route service buses and so the "metro" seats can be replaced with ADR 68 with minimal modification. These should make a good "source" of used buses for the retrofit industry. ADR59 is discussed further under "Additional Issues".

2.3 Audit by Roads and Traffic Authority of NSW

In 1999 the Road and Traffic Authority of NSW (RTA) became aware of some questionable installations of retrofitted seat belts. Subsequent inspection of 134 large coaches and 926 small buses revealed that most retrofits used methods that were different to those specified in the guidelines. Sled tests to ascertain whether the installations could withstand a 10g dynamic test were conducted for several representative installations. Results are described by McGuire and others (2002): "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 RTA found that there were basically three different types of retrofit installations of concern: one type involved lap belts being attached by brackets to the floor and two different types of installation that involved seat belts being directly fixed to the seat assembly. In one of the sled tests a new seat assembly with integral lap/sash seat belts was used. In the others, lap only belts were added to unmodified existing seats. All of the tested installations failed to demonstrate an adequate level of protection in the 10g tests. Sled testing of the

the new seat resulted in a failure of the seat pedestal (Figure 4a). An improved model of this seat, with stonger support legs was also tested and found to withstand the 10g dynamic loads (it was subsequently found that the seat was not certified to comply with ADR68, however the RTA advises that the distributor arranged for the pedestals on existing retro-fitted buses to be replaced).

Figure 4a. Pedestal failure during Crashlab sled test (10g)

Dynamic testing of all of the installations observed in the smaller unitary construction buses demonstrated that all currently employed installation methods (even those that departed from the existing guidelines) did provide an adequate level of protection, when subjected to the 10g test.

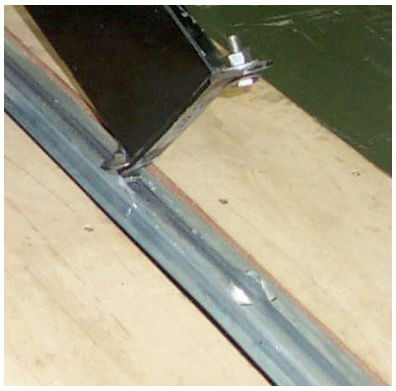

Figure 4b. Floor anchorage failure during Crashlab sled test (10g)

The RTA issued two Vehicle Inspectors Bulletins (No. 49 and 50) that addressed many of the problems encountered during the audit. These include, for MD buses:

- Methods for reinforcing seat legs
- Methods of anchoring seat belts to the floor
- Loading spreading plates for under-floor anchorages
- Anchorages to have a nut and washer or self-locking nut (tapped hole not acceptable)
- Lap seat belts not permitted to be attached to original seats
- Additional frames that might increase hazard of injury to occupants not permitted

ME requirements include:

- Minimum longitudinal bolt spacing for seat mounts 300mm
- Strengthened wall and floor seat mounts
- Tapped holes not permitted for seat belt anchorages
- Cast aluminium legs not permitted
- Additional frames that might increase hazard of injury to occupants not permitted

VIB 50 for large buses (May 2003) states that seat belts capable of withstanding a 10g deceleration are acceptable to the RTA. However, there is no reference to ADR 68 seats (with integrated 3 point seat belts) in this document, which appears to be primarily concerned with the fitting of seat belts to existing seats. Note that ADR 68 requires the seat belt be anchored to the seat rather than the vehicle

structure. ADR 66 has the same requirement in cases where a seat belt is fitted, unless there is no seat immediately to the rear.

In 2001 the RTA issued Vehicle Standards Information 44 "Retro-fitting seat belts to buses and coaches". That document requires that installations be certified to either the relevant ADRs or the Guidelines (the document also makes mention of Vehicle Standards Bulletin 5A "National Code of Practice - Commercial Manufacture and Installation of Additional Seats"). The document reproduces the table from Appendix 5 of the Guidelines and states that the loads (for Level 4 protection - lap seat belts) should be used when designing alternative mounting systems.

The new information gathered for the current review indicates that this advice should now be revised and withdrawn in its current form. The loads provided in Appendix 5 were derived from a dynamic test of a particular seat . It is understood that, in the absence of better data, Appendix 5 was intended to be indicative of the typical loads that might be experienced for other configurations but it was never intended to "set the standard". In particular, we are concerned that the dynamic loads depend crucially on the dynamic performance of the seat. A very rigid seat can be expected to produce high peak loads whereas a more flexible seat will reduce the peak loads - perhaps by a half.

Mr Bleakly's background report also provides the results of ADR68 (20g) tests. The most important outcome from this work is that the anchorage loads for Level 4 (lap belts, 10g) can be expected to be about double those for Level 2 protection (no belts, 10g) and that Level 5 (ADR68) anchorage loads can be expected to be about double those for Level 4 protection. In other words, the loads are roughly proportional to the number of dummies that need to be restrained (by seat belts or cushioned impact) and the peak deceleration (10g or 20g).

In summary, the current position has developed in an environment where buses are covered in sections of three ADRs, where ADR 5 (seat belt anchorages), ADR 66 (10g bus occupant protection) and ADR 68 (20g bus occupant protection) can essentially provide competing requirements for the same vehicle – depending upon usage and the seat type fitted by the manufacturer.

2.4 Queensland Transport

The Queensland Government has established operational and technical requirements for buses, in essence depending on their radius of operation (Information Bulletin VSA.1.2/05). Padding is required on handrails, seats and partitions of "local" and "school" buses which entered service from January 1997 and all "regional buses". All "heavy school buses" will require padding from 5 July 2005, unless they are older than 23 years on that date. The padding requirements are set out in Information Bulletin VSA.12.2/05, which is based on the existing Guidelines.

On 9 February 2005 the Queensland Transport Minister announced that lap/sash seat belts would be progressively installed on all school buses that operate in steep and hazardous areas. These vehicles would also be required to comply with ADR 59 (rollover strength). About 100 buses are affected by the announcement.

2.5 United Kingdom

2.5.1 Tests of seats in large buses

In the mid 1990s legislation was introduced in the UK that required coaches and buses to be equipped with seat belts when carrying children on excursions. This led to a demand for retrofitting seat belts to existing vehicles. In 1997 the Transport Research Laboratory (TRL) carried out a research project that tested examples of retrofitted seat belts and developed technical guidelines for these installations. Seats with seat belts and typical mountings were tested according to ECE Regulation 14. This defines a static pull test that is equivalent to a 10g dynamic test for "minibuses" and 6.6g for large buses (Figures 3 & 4). There is no provision for seat impact by rearward occupants in this test. EEC Directive 76/115/EEC contains equivalent requirements.

Figure 5. Lap belt test to ECE 14.

(Credit: TRL/MIRA)

Figure 6. Lap/sash belt test to ECE 14

The output from the TRL project was used for the development of a "Guide to the changes to seat belt installations" issued by the UK Department for Transport. Use of the static pull test is encouraged to verify the design but, as an interim measure, individual vehicles can be approved on the basis of a "enhanced visual check" that applies where seat belts (usually lap belts) are retrofitted to a seat. They do not apply to seats manufactured with seat belts or to seat belts anchorage to the vehicle instead of the seat. In brief, the requirements for unitary minibuses ("M2") are:

- Where seats are attached to tracking, certification for the track and lockable fittings is required.
- Unless indicated otherwise (e.g. on a test certificate), all holes in the seat leg must be fitted with appropriate size bolts.

- Vehicles fitted with over-floor (plinth) style reinforcements may need to be inspected during construction.

- Double seats bolted to the (original) floor must have reinforcing channels under the floor. Channels should be at least 76x38x5mm and run longitudinally between structural cross-members. Box sections must have crush tubes. In addition flat reinforcing plates at least 100x100x4mm must be fitted between each front leg and the floor.

The visual inspection requirements for chassis based buses are similar except that the channel size depends on the spacing between cross-bearers. For example, in the case of a double seat with two legs and a cross-bearer spacing between 400 and 600mm, the minimum channel size is 50x40x4mm. The cross bearers are required to be stronger (through gauge or second moment of area) than the reinforcing channels.

Special mention is made of bench style seats at the back of the bus. Difficulties with finding suitable structure are noted. Substantial steel box sections are specified for cross-bearer in these cases.

Diagrams for assessing the energy absorbing characteristics of seat backs are provided in the UK document.

2.5.2 Small bus crash tests

Kecman (1998) reports on a comprehensive investigation into the deceleration pulses occurring in minibus crashes. They analysed 25 real world crashes and conducted eleven full scale crash tests. Computer simulations were also undertaken. From this work the authors recommended a dynamic test that is very similar to ADR 68, with a nominal peak of 20g and combined loading from restrained occupants in the seat and unrestrained passengers to the rear. They note that:

> "Provided a satisfactory restraint system is fitted to these [rear] seats, the passengers [in these seats] have the opportunity to survive exceedingly severe impacts...The primary requirement is that the restraint system does not fail, including no separation of the seat and belt anchorages from the floorpan...Seat belts and anchorages in minibuses [should] aim to provide protection similar to that of back seat passengers in cars."

The authors caution that the introduction of stronger seats should not unduly increase the hazard to unrestrained occupants and they set injury criteria (similar to ADR 68) for unrestrained

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Figure 8. NHTSA Full Frontal Crash Test of a School Bus (50km/h)

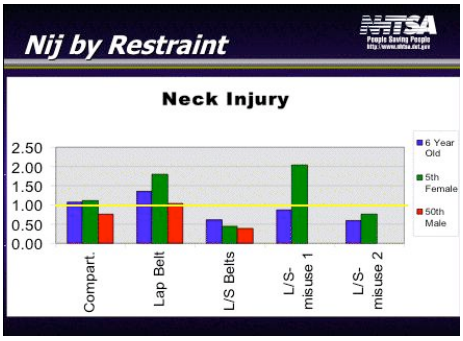

Figure 9. NHTSA Neck Injury Risk (Nij is derived from combined loads on the dummy neck)

dummies striking the seat in front during the recommended dynamic test.

2.6 USA - National Highway Traffic Safety Administration (NHTSA)

The NHTSA website provides advice on retrofitting lap seat belts to a school bus. This states that only "lap belt ready" seats can be used and that not all buses can be fitted with these seats. NHTSA suggests that bus operators approach the vehicle manufacturer for advice. Where seat belts are fitted NHTSA recommends that the anchorages meet the requirements of FMVSS 210 "Seat belt assembly anchorages" and that seat belts meet FMVSS 209 "Seat belt assemblies".

FMVSS 222 "School bus passenger seating and crash protection" is similar to ADR 66 in that it relies on occupants being restrained by the seat in front. The Standard does, however, set performance requirements for seat belts used in association with wheelchairs (13.3kN per anchorage). Otherwise lap/sash seat belts are not mentioned in relation to school bus occupants.

A researcher from NHTSA confirmed that the Administration does not issue any practical guidelines or alternative tests for retrofitting seat belts to buses in the USA and recommends that bus operators seek advice from the bus manufacturer. It is possible that some States or School Districts in the USA have unpublished guidelines but we were unable to locate any.

Full scale crash tests of school buses (April 2002) revealed high risk of serious neck injury with lap only belts. There was a slight risk with no belts and good protection with lap/sash belts. These full-frontal crashes were conducted at 50km/h and are equivalent to a head-on collision between similar vehicles, each travelling at 60km/h. This crash produced a peak deceleration of about 12g in the vehicle body. This supports the Australian conclusion that 20g restraint systems are needed for 100km/h head-on crashes between heavy vehicles.

2.7 Proceedings of 19th ESV

In mid-June 2005 the proceedings of the 19th International Conference on the enhanced safety of vehicles became available. The conference was held earlier in June in the USA. Four papers in the proceedings of that conference deal with issues that are relevant to the current project:

"COACH PASSENGER INJURY RISK DURING ROLLOVER: INFLUENCE OF THE SEAT AND THE RESTRAINT SYSTEM " (Belingardi 2005) considers the effect of restrained passengers on the dynamics of the rollover test specified in ECE Regulation 66. Some improvements to the regulation were recommended.

"ENHANCED COACH AND BUS OCCUPANT SAFETY" (Mayrhofer 2005) looks at occupant protection in small and large buses, including route service buses. The authors recommend that research be undertaken to introduce regulations to minimise the risk of injury to occupants of route service buses in low-severity collisions (or sudden braking). This proposal should be monitored for possible future inclusion in the ADRs or NCOP. Computer modelling of frontal and rollover crashes with restrained and unrestrained occupants is described.

"CHILD SAFETY RESEARCH IN SCHOOL BUSES" (McCray 2005) describes NHTSA's further research into the crashworthiness of school buses in the USA.

One crash of a "small bus" resulted in four passenger fatalities, all of whom were ejected from the school bus. In the investigation the National Transportation Safety Board noted that the children were not instructed to wear the required lap belts due to the potential risk of injuries from use of lap belts in frontal impacts. NTSB evaluated six selected school bus crashes for a 1999 study. Based on that analysis, the Safety Board came to the conclusion that the current "compartmentalization" is incomplete in that it does not adequately provide protection in all crash scenarios. After conducting further research on frontal crashes, NHTSA is considering the following changes to existing federal safety regulations:

1) increased seat back height to reduce the potential for passenger override in the event of a crash;

2) require lap/shoulder belt restraints in buses under 4536 kg ; and

3) require standardized test procedures for voluntarily installed lap/shoulder belts (it is noted that this was not mentioned when a NHTSA representative was contacted on the retrofit issue early in the project).

"REAL AND SIMULATED CRASHWORTHINESS TESTS ON BUSES" (Vincze-Pap 2005) conducted computer simulations of a series of full-frontal crashes of a large metro bus (test carried out in Hungary in the 1980s). Test speeds were 4, 7 and 30km/h. The 30km/h crash produced a peak deceleration of the passenger compartment (centre of floor) of about 12g (Figure 10). This is further confirmation that a 10g crash pulse is too low for severe bus crashes.

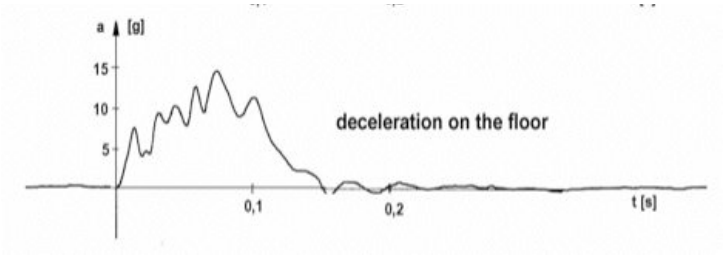

Figure 10. Crash pulse for metro bus full frontal crash test at 30km/h (Vincze-Pap 2005)

"THREE POINT SEAT BELTS ON COACHES - THE FIRST DECADE IN AUSTRALIA" (Griffiths 2005) gives background on the development of ADR68 and points out the innovative seat designs that have been developed in Australia. The authors express concern about possible low wearing rates for seat belts in Australian coaches.

2.8 Economic and regulatory incentives in Australia

The change from sales tax (22% for automotive parts) to GST (10%) has reduced the price of new seats but increased the cost of labour. As a result there is now greater commercial incentive to replace old seats rather than modify them to take seat belts.

Deregulation in the bus industry (at least in NSW) has led to many small companies setting up charter operations and there is continuing demand for older buses and coaches to be converted for charter work (there being no age limit for charter buses in NSW). where there is substantial market demand for seat belts.

This creates the anomalous situation where a lower cost bus can be effectively introduced into the charter industry and typically operated in a high speed road environment where the bus might not be suitable for protecting occupants in a severe crash.

This route to increasing the charter fleet acts against the intent of ADR59 and ADR68 and indicates the need to provide strong incentive for

a. retrofitted vehicles to be brought up to current standards and

b. compliance clearly communicated to the travelling public. (eg using the recognition scheme covered in Section 5.1)

In understanding the bus and coach market, it is important to recognize that these vehicles have much longer lifetimes than private passenger vehicles and large buses have a somewhat indefinite life, due to opportunities for comprehensive refurbishment of power trains and upgrades of interiors and paintwork.

2.9 Biomechanical research

In September 1994 a Sydney conference was devoted to the issue of the safety of lap seat belts. At the conference the RTA and other road safety professionals encouraged the retrofitting of lap/sash seat belts to the centre rear seat in cars. One major supplier of vehicles to Australia (Toyota) announced that they were phasing out centre rear lap seat belts in light vehicles. Consumer programs like NCAP have also encouraged lap/sash seat belts in all seating positions of light vehicles.

Subsequent international conferences have confirmed concerns about the inferior protection provided by lap only seat belts compared with lap/sash belts. Overall lap seat belts are more effective at preventing serious injuries than unrestrained occupants but some serious injuries can be caused by the lap belt:

- Poorly adjusted lap belts can cause abdominal injuries (twice the risk of lap/sash seat belts - Lane 1994)
- Lower spine injuries can result from the extreme flexing of the torso around the lap belt (Middleton 1994)
- If a head contact occurs then severe cervical spine injuries can result from the combination of tension and shear forces in the neck (Henderson 1994). Padding may not reduce the risk of such injuries because it takes only a mild shear force to cause life-threatening injury when a child's neck is under extreme tension in a frontal crash.

It is acknowledged that lap belts can provide a convenient solution to occupant restraint against forward and upward ejection (from the seat) where adjacent structure is not available for upper torso anchorages (eg aisle seat on MD buses) but the balance of more recent research now indicates that it is better to upgrade the seat ahead to provide compartementalised ‘restraint’. In reality if the seat is to be changed, then a better solution is an ADR68 seat with integral lap/sash seat belt. This is to be supported by introduction of the simplified test to assess the strength of retrofits of ADR68 seats. (Refer Section 4.5)

3. CONSULTATIONS

We have met with several stakeholders and some feedback has been received from the preliminary advice circulated late in March. Appendix A summarises these consultations. Key additional points arising from our research are.

a. There are a wide range of buses being retrofitted with seat belts and substantial variations in the quality of these installations are likely to be associated with inadequate protection in a severe crash. For example, it would be quite misleading for bus occupants to assume that all current installations of lap/sash seat belts would protect them in a severe crash. This situation has resulted from:

   - misunderstandings about the existing guidelines
   - failure to ensure that retrofitting was completed to a consistent standard throughout the vehicle
   - competing requirements for similar vehicle types arising from ADRs 5, 66 and 68

b. There is widespread support for the principle that ADR68 seats (with lap/sash seat belts) only be installed where the anchorages are strong enough for 20g dynamic loads. Differences of opinion occur over how this might be demonstrated but there was strong support for a practical field test of anchorage strength.

c. Recent work in the USA and Canada has confirmed the unsuitability of lap seat belts for bus passengers. There is a high risk of serious neck injury with lap seat belts where the head is able to contact an object - padding makes little difference to this risk and may exacerbate neck injury by increasing sliding resistance on head contact areas during impact

d. There is a strong market for retrofitting lap/sash seat belts to buses which do not comply with ADR59 (rollover protection). Given the concerns about the risk of injury to restrained occupants in the event of a rollover crash, it is considered appropriate to continue to allow lap/sash seat belts on these vehicles provided that bus passengers are made aware of the reduced occupant protection, compared with a bus that complies with ADR59. However, the guidelines should provide for cases where a pre-ADR59 bus can be shown to have the same structure (or is upgraded) as a bus that complies with the ADR.

e. There is a need for identifying buses that have undergone approved modification - a modifier plate is one suggestion. In any case all seat belt installations should be certified by an approved engineer.

f. There is support for the assessment of vehicle mass if the upgrade results in a significant change to tare mass or seating capacity.

4. DISCUSSION

4.1 ADR59 Rollover Protection

Nearly all heavy buses (GVM >5t) built from July 1992 and other buses with 12 or more seats built from July 1993 are required to comply with this ADR so there should be a good "supply" of suitable buses (unlike the situation when the 1994 guidelines were prepared). In addition it is likely that bus manufacturers built complying buses prior to the ADR implementation date and these manufacturers may be prepared to certify that particular buses have identical structure to buses which comply with ADR59 (or at least provide technical drawings that enable this to be checked). Similarly, newer models of "low floor" buses that are exempt from ADR 59 are likely to be much stronger than previous designs (in any case, it seems unlikely that there will be a demand for retrofitting seat belts to these buses, which are specially designed for route service).

In the early stages of this project it was proposed that ADR68 seats should only be fitted to buses that comply with ADR59 (rollover protection) or have equivalent structure. That proposal caused concern amongst stakeholders. Clearly there is a strong demand for retrofitting ADR 68 seats to buses that were built well before ADR 59 came into force. It is also evident that, with some models of older bus, these installations can be done in a way that provides occupant protection in a severe (20g) frontal crash.

Figure 11a. Roof sway resulting from rollover crash

Our concern is that about one third of serious coach crashes involve the vehicle tipping onto its side or further (Paine 1993 - review of Australian coach crashes for NRTC). In these cases an occupant who is effectively restrained by an ADR68 seat belt may be exposed to intruding side components during the rollover event (Figure 11). In other words, a bus that complies with both ADR59 and ADR68 provides superior occupant protection to one which only complies with ADR68. Under the current guidelines there is no way to inform bus users about the difference in protection between these buses.

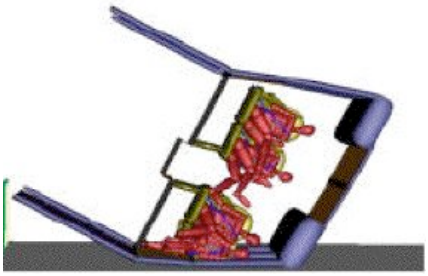

Figure 11b. Computer model showing risk to restrained occupants (Belingardi 2005).

It was therefore recommended that ADR68 seats be permitted for older (pre ADR59) buses but that ways of informing bus users about the extra protection provided by ADR59 be explored.

4.2 10g anchorages and lap/sash seat belts

The concept of ADR66/68 seats with integral 3-point seat belts designed to withstand 10g loads was considered.

Potential benefits of this approach could be:

- 3-point seat belts with 10g anchorages would provide better occupant protection than either no seat belts or lap-only seat belts.
- it would allow a larger range of buses to be fitted with 3-point seat belts since some current buses are excluded due to inadequate structure (they could withstand 10g but not 20g loads).
- European Directive for static testing 3-point seat belt systems to 10g (nominal) loads could be used in Australia for this purpose.

We strongly recommend that this concept be rejected in the Australian context where ADR 68 complying vehicles have been available for over 10 years, It would introduce a class of vehicles offering inferior occupant protection which appeared essentially identical to both occupants and registration authorities.

At a technical level, 10g anchorages are likely to fail catastrophically in a severe crash, resulting in severe/fatal injuries to occupants that would not have happened with 20g anchorages. This could be exacerbated by the use of ECE Regulation 14 as the performance requirement since this regulation does not allow for the loading of the back of the seat by unrestrained occupants. Compared with Europe, Australian bus operations involve a relatively high exposure to head-on crashes with other heavy vehicles. Although such crashes are extremely rare, a multiple fatality crash that was exacerbated by inferior seat anchorages would cause a public outcry.

Other issues include:

- With increasing demand for buses with 3-point seat belts (for school excursions and the like), there is pressure on bus operators to acquire buses with this feature. Currently this effectively means acquiring a bus with 20g anchorages - a good long term outcome for road safety. Retrofitted buses that were only required to have 10g anchorages would be much cheaper to buy and it is likely that this would severely affect the market and delay the changeover of the fleet to ADR68 complying buses. It would also be unfair to operators who acquire ADR68 buses.
- There would be no incentive to retrofit suitable buses with AR68 seats and 20g anchorages - a viable option for many recent buses that comply with the rollover strength requirements of ADR59. At present the dynamic testing of a specific combination of seat and anchorage can be economically justified if there are several buses to be fitted out. Less demand would mean fewer cases where the ADR68 test was worth doing.
- There would be pressure to allow European seats with 3 point seat belts (designed for 10g) instead of ADR68 seats. This would undermine the high standards of Australian seats and be unfair to current suppliers.

It is noted that this policy was also recommended by Kit Bleakly in his background report for the original guidelines:

> "As a matter of policy, it was decided that the lap/sash belted seats would only be permitted in vehicles with sufficient mounting strength to meet the full ADR68/00 20g acceleration pulse, even though the terms of reference for the Code required only the ADR 66/00 10g pulse. It was considered to

be highly undesirable to allow vehicles to be modified to physically resemble the latest ADR 68/00 coaches, without offering the same level of protection." (Bleakly 1994)

4.3 Mass li*m*its

Many buses operate at close to the regulated mass limits. The modifications for retrofitting seat belts to buses may increase the tare mass and this will have an effect on carrying capacity. Consideration should therefore be given to requiring a laden mass assessment of the bus in association with the retrofitting of seat belts.

4.4 Lap/sash seat belts in unitary construction buses

Under the ADRs, smaller buses (GVM 3.5t or less) are required to have upper seat belt anchorages and lap/sash seat belts for all outboard seating positions. Inboard seats can have lap belts.

We have observed several examples of small buses being successfully fitted with ADR68 seats with integrated lap/sash seat belts. These provide superior protection compared with the basic ADR5 systems and they should be encouraged. However, axle capacities will need to be checked as the conversion may increase laden mass beyond the manufacturer's limits.

Figure 12. Coaster bus fitted with ADR68 seats

A critical difference between ADR5 and ADR 68 requirements is that ADR5 was evolved from sedan requirements where there were typically only two rows of seating, seating positions to the rear had lap/sash seatbelts and wearing rates are high. This is quite different to an MD class vehicle where there are several rows of seat and high speed crash experience in Australia indicates the occupants and seats are displaced forward causing progressive failure and increasing injuries to passengers closer to the front of the bus.

Photos below show a mid-size bus which sustained a heavy frontal impact with a tree and interior damage with most seats occupied at the time of the crash. Unlike ADR 5, ADR 68 was developed specifically to deal with the restraint of occupants and seat wearability/convenience in a bus and provides substantially better protection than ADR 5 requirements for a similar vehicle.

Figure 13. Severe frontal crash of a mid-size bus, showing displaced seats

In the USA, NHTSA has effectively banned the use of small buses (known as "passenger vans") for school bus work. NHTSA found that the rollover risk with these vehicles is three higher with a laden small bus, compared with an unladen small bus. As a recent small bus crash in Australia demonstrated, the structure of these vehicle usually adequate to withstand a rollover so that seat belts can be highly effective in such crashes.

Figure 14a. ADR68 dynamic test by Crashlab

Further discussion of issues with small buses is provided in Appendix B.

4.5 Static test as an alternative to ADR68 dynamic test

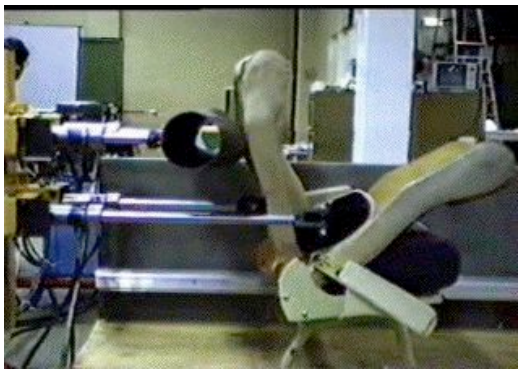

Figure 14b. Crashlab experiment with ECE80 static test procedure

There is a need for a simple static test in the guidelines as an alternative to the ADR68 20g dynamic test. The static test prescribed in ADR68 is much more demanding than the dynamic test and would result in much stronger anchorages and heavier structures than are necessary to withstand 20g dynamic loads. Although we did not come across any test comparisons, it seems likely that many current installations that comply with the ADR68 dynamic test would not be able to meet the ADR68 static test. It is therefore considered impractical to require that older vehicles meet the AR68 static test. This is particularly the case where ADR68 seats are used and the only purpose of the static test is to check the strength of the seat anchorages.

Our review of other anchorage tests (see next section) has not revealed a suitable method for direct use in the guidelines. We have proposed a specification for a simplified static test which will be an essential component of the implementation of the revised guidelines.

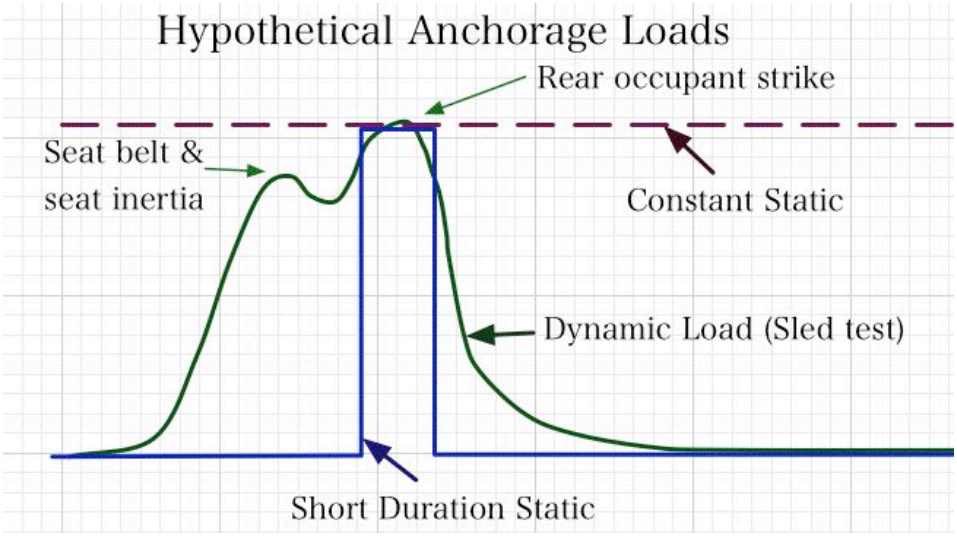

Figure 15. Graph of hypothetical anchorage loads during a ADR68 dynamic test and the potential for a short duration static test.

Such a test could then be an acceptable alternative to evidence by engineering comparison with systems that comply with ADR68.

4.6 Published test procedures for seat belt anchorages

The following table compares the dynamic and static test procedures that have been published as regulations or recommended practices.

None is considered suitable for testing ADR68 seat anchorages. The main problems are:

- Test too complex to perform in a workshop or too severe
- Test not severe enough (much less than 20g protection)
- Test does not simulate a strike by an unrestrained occupant to the rear
- Test does not simulate seat mass (many seat belt anchorage tests assume the seat belt is directly attached to the vehicle structure)

Table 1. Summary of Seat Belt Anchorage Strength Tests

Test	Type	Effective g	Occupant to rear?	Comments
ADR68	Dynamic. Three rows of seats on platform. Restrained Hybrid IIIs in middle row. Unrestrained dummies in rear row. Injury criteria set for restrained occupants.	20g	Yes	"Expensive" and destructive. Not suitable for one-off retrofits. Sometimes conducted in two stages with two rows of seats. See Figure 14a

Test	Type	Effective g	Occupant to rear?	Comments
ADR68	Static. Cylinders simultaneously pushed against seat back at two heights and for each seating position. Simultaneously a load is applied to two body blocks that represent a restrained adult and a further load representing the inertia of the seat (may be added to the lap belt body block). Limits are set for the horizontal displacement of the loading systems.	>20g?	Yes	See Figure 14b. Likely to be much more severe than a 20g dynamic test. Likely to be destructive. Technically difficult to apply four separate loads to each seating position (two cylinders and two body blocks). A seat back energy dissipating test is also conducted with a limit on headform deceleration. Not suitable.
ADR66 (ECE R80)	Dynamic. Two rows of seats. Unrestrained Hybrid IIs in rear row. " If a seat belt is used then the strength of the 'Seat' shall be such that it is capable of withstanding the seat belt load and the load [from the unrestrained dummy to the rear]". Injury criteria set for unrestrained occupants.	10g	Yes	The seat belt load is not specified in ADR66. The method of simulating the seat belt load during the dynamic test is not covered in ECE Reg 80 (Reg 14 is used). Required strength is too low.

ADR66 (ECE R80)	Static. Cylinders simultaneously pushed against seat back at two heights and for each seating position. If a seat belt is used then the strength of the 'Seat' shall be such that it is capable of withstanding the seat belt load and the load [from the unrestrained dummy to the rear]". Limits are set for the horizontal displacement of the loading systems.	>10g?	Yes	Difficult to apply simultaneous loads. The seat belt load is not specified in ADR66 (ADR5 used - see below). No provision for seat mass. Required strength is too low. A seat back energy dissipating test is also conducted with a limit on headform deceleration. See Figure 14
ECE R14	Static. Simultaneous loads applied to two body blocks that represent a restrained adult. Limits apply to the displacement of the anchorages.	6.6g for large buses	No	No provision for seat mass or seat being struck from behind. Very low crash severity for a heavy bus (6.6g). See Figures 5 & 6
ADR5/04	Static. Simultaneous loads applied to two body blocks that represent a restrained adult. Anchorages must be "capable of supporting" the applied loads.	9g?	No	For buses, 9kN is applied to the body block, compared with 22kN for light vehicles. No reference to displacement of the anchorages under load. Bus seat belt anchorages may be "proved by design". Required strength is too low. No provision for seat mass or seat being struck from behind.

ADR4/03	Dynamic. Sled test with seat rig.	23g	No	Intended to test the seat belt components under dynamic conditions.
FMVSS 210 (USA)	Static. Simultaneous loads applied to two body blocks that represent a restrained adult. Components may deform and fail provided that the load is held for 10s.	>20g	No	A 13kN load is applied to each body block (pelvic and upper torso). Maximum rate of increase of load 133kN per second. Prescribed load to be reached within 30s and held for at least 10s. Severe - likely to be destructive. A seating position is exempt from the static test if the FMVSS 208 crash test is conducted with a dummy in the seat. No provision for being struck from behind.
SAE J383, J384 and J385 (USA)	Similar to FMVSS 210. J384 describes a static test rig for testing seat belt anchorage strength.	>20g	No	As for FMVSS 210. No provision for seat being struck from behind.

4.7 Seat anchorages for route service (metro) bus seats

Our investigations revealed no standards or regulations relating to occupant protection in the design of seats for route service buses. The 1992 review of school bus seat belts (Henderson and Paine 1992) noted concerns about the seat anchorages of many route service buses being used in school transport work in NSW (some seat legs were simply screwed to timber floors). However the authors noted that it was inadvisable to strengthen seat anchorages without considering the failure modes of the seat since a broken seat frame might present more of a hazard to unrestrained occupants than a seat which became detached from the floor. Since the early 1980s Victoria has required seat anchored to timber to have 50x50x3mm steel reinforcing plates.

Given the lack of regulation in this area, the potential for introducing injury-causing mechanisms and the small number of cases that are likely to be encountered it was decided that the Code should not include requirements for anchoring route service bus seats. However, we recommend that consideration be given to an occupant protection ADR for seats on route service buses. Once an ADR is developed then the issue of older buses could be addressed.

4.8 Certification of bus seats and other components

As noted in Section 2.3, for the purpose of sled testing, the RTA acquired a new bus seat with integrated lap/sash seat belts and this seat pedestal failed during a 10g sled test. This seat was marketed for bus retrofits and it was reasonable to assume that it complied with ADR68 (eg 20g dynamic test) but clearly it would not have withstood 20g dynamic loads. This case highlights the difficulty that bus modifiers may have in establishing that seats comply with ADR68. One method is to check that the seat supplier has a "Component Registration Number" issued by the Road Vehicle Certification Scheme. The Scheme is operated by the Depatment of Transport and Regional Services. This can be checked online at http://rvcs-prodweb.dot.gov.au/.

5. PRINCIPLES FOR PREPARATION OF THE CODE

After considering the information gathered for this project, we developed a set of draft principles for preparation of the Code. These were discussed during a meeting of the Project Steering Committee on 31 May 2005. Key issues and the final principles are set out below.

The Principles need to take account of:

- commercial availability of ‘ADR68’ seats
- increasing evidence of detrimental effects of lap seat belts
- pre-ADR59 buses/coaches now at least 12 years old & large number of newer buses that are exempt from ADR59 and ADR68
- strong consumer demand for 3 point seat belts in buses, including smaller buses.
- potential availability seats to ECE R80 with 3 point seat belts tested to 10g or less
- Limited consumer understanding of occupant protection issues (eg seat anchorage strength, rollover strength)

5.1 Principle 1 - Recognition of ADR68+59 Buses

- There should be active recognition of buses that fully comply with ADR68 (seats and seat belts) and ADR59 (rollover protection) i.e. “GOLD” recognition
- Recognition relates to technical issues - promotion and marketing are outside scope

5.2 Principle 2 - Do not undermine ADRs 68 & 59

- Code should not introduce or facilitate practices that would significantly undermine or reduce progressive coverage of ADR68 and ADR59 to all applicable buses, as the fleet is gradually replaced.
- Code should encourage/facilitate availability of vehicles with ADR68 and ADR59 occupant protection.
- Avoid loopholes that allow inferior seat belt installations to look like ADR68

5.3 Principle 3 - No new lap-only seat belts

- US NHTSA research has confirmed earlier concerns about the injuries caused by lap-only seat belts on buses - serious neck injuries from head contacts, even with padding
- RTA audit of retrofits found numerous examples of poor lap belt installations
- When done properly, there is little different in cost between rebuilding an existing seat tocarry the 20g loads of a lap belt and replacing it with an ADR68 seat with 3 point seat belts
- original-equipment lap belts continue to be acceptable because the manufacturer takes reponsibililty for the complete vehicle package including occupant protection – existence of the retrofit code may influence availab ility of lap only seatbelts from manufacturers as has already occurred with Australian sedans and derivatives
- Retain provision for lap seat belts on side facing seats

5.4 Principle 4 - Encourage ADR68 seats in older buses but introduce a surrogate test for anchorage strength (based on 20g dynamic test loads)

- If ADR68 certified seats are used then demonstration of “compliance” should be simplified (e.g. static pull test, able to be conducted in a workshop)
- ADR68 dynamic test too onerous for one-off retrofits
- ADR68 static test impractical and too demanding (c.f. dynamic test)
- If non-ADR68 seats (with 3 point belts) are used then evidence of ADR68 testing should be required
- Buses that are shown to meet seat anchorage strength requirements by the surrogate test should be identified by an appropriate recognition level:
- SILVER if the bus meets ADR 59
- BRONZE if there is no evidence that the bus meets ADR 59

5.5 Principle 5 - Requirements for high-back seats without belts should be based on ADR 66

- The ADR66 (ECE R80) principle of “compartmentisation” should apply to high-back seats not fitted with seat belts
- Seats should withstand loads equivalent to the 10g dynamic test in ADR66 (unrestrained occupant to the rear)

- Energy dissipation requirements of ADR66 apply
- No explicit “recognition” of these buses (incentive for full ADR68 upgrade)
- Little market demand for this upgrade

5.6 Principle 6 - Encourage the replacement of vehicles not meeting recognised levels

- There are few limitations on vehicle age or safety level in the de-regulated charter industry
- Arrangements should be made to discourage the long term commercial use of charter/touring buses that do not meet the Gold, Silver or Bronze levels

5.7 Other Decisions Taken by Steering Committee

This section describes related matters that were discussed by the Steering Committee .

5.7.1 Certification by Qualified Engineers

- The RTA audit, and our discussions with stakeholders, reveal that seat belt installations that are not conducted under the supervision of a qualified engineer are likely to be unsatisfactory
- A “cookbook” approach to seat belt installations is no longer appropriate. There are too many variations among vehicles and too many structural variations for seat anchorages within a vehicle.
- An engineer needs to assess the complete vehicle and identify modifications and reinforcements that are needed for each seat anchorage.
- Most states/territories have schemes for recognising qualified engineers
- Arrangements for fitting “Modification Plates” to heavy vehicles are under consideration
- Reputable retrofitters already obtain professional engineering advice for all buses upgraded with 3 point seat belts
- The Code should set out performance requirements for use by these engineers and not be too prescriptive
- The engineer should certify all steps in the upgrade process (preferably on one form) & keep photographs of details

It was agreed that all bus seat belt upgrades be certified by a qualified engineer and that modification plates be required to identify these buses

5.7.2 Recognition of Safety Levels

Beneficial upgrading which would not meet minimum recognition level includes:

- All upgraded buses must meet emergency exit and structural inspection requirements
- Original low-back seats may be fitted with padding
- Original (pre ADR 66) high-back seats may be fitted with padding. Structural upgrades should be to ADR66.

- Where ADR 66 seats (without seat belts) are retrofitted the mounts should withstand the equivalent of the ADR 66 dynamic test

Upgrades which meet recognition levels:

- Any seat fitted with lap/sash seat belts must be shown to comply with ADR 68
- Where anchorage strength is demonstrated by surrogate means a BRONZE or SILVER recognition applies (depending on ADR 59 status)
- Where seats & anchorages are demonstrated to comply with ADR 68 and bus complies with ADR 59 then GOLD recognition applies

It was agreed that the proposed Recognition Levels be incorporated in the Code, as set out in the following diagram. However further consideration needs to be given to implementation issues.

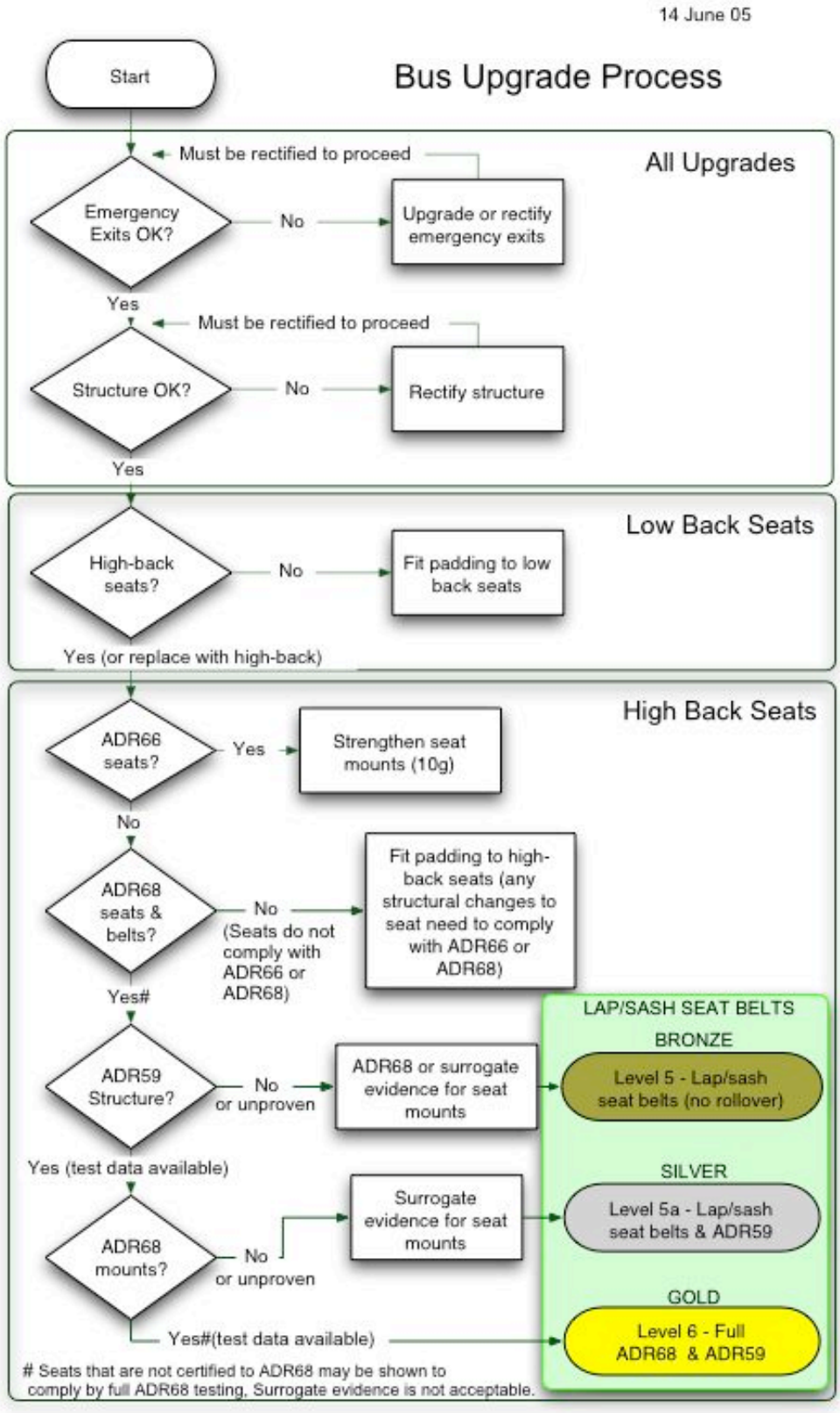

Figure 16. Proposed recognition levels arising from the Principles

5.7.3 Practices that are no longer acceptable due to risk of occupant injury

- "Level 2" (old Guidelines): Existing seats should not be modified unless ADR 66 compliance is demonstrated (an exception is the replacement cast aluminium components)
- "Level 4" (old Guidelines): Lap seat belts should not be installed in any future retrofit

As a consequence, many of the methods of construction in Appendices 1 & 2 of the 1994 Guidelines no longer apply.

5.7.4 Small buses

- ADR 68 only applies where GVM>3.5t
- ADRs 4 & 5 apply where seat belts are fitted to lighter buses. These provide inferior protection for bus occupants, compared with ADR 68:
    - Lap-only belts permitted for inboard seats
    - No requirement for seat belt to be attached to seat
    - No provision for strike by unrestrained occupant to rear
    - MD3, MD4 & ME buses built before ADR68 need only meet the equivalent of 10g dynamic test loads
- RTA audit found problems with retrofits
- Where seat belts were not provided to all seats as part of the original equipment there is a strong case for requiring that these buses only retrofit seats and seat belts complying with ADR 68 requirements.
- In effect, this involves the application of stricter standards than those applying when the vehicle was first registered. This could be justified on the basis that the vehicle is to be used for hire and reward and therefore any modifications from original specifications that affect occupant safety should be to the latest safety standards (an implementation of Principle 2)

It was agreed that upgrades to small buses (MD) be treated the same as large buses (ME) - that is ADR68 seats be installed with 20g anchorages. Exceptions are where seat belts and anchorages are the same as ones provided for that model by the vehicle manufacturer in accordance with ADRs and side-facing seats.

5.7.5 Content of the Code

- The Bus Retrofit Code is being developed along the same lines as VSB6 "National Code of Practice for Heavy Vehicle Modifications"
- However, it is proposed that a separate Certification Form be used by the qualified engineer (i.e. do not embed questions and checklists in the body of the Code)

- Form goes step by step through the assessment process, using questions and answers to cover key items
- Form covers emergency exits, structural inspection, rollover strength and seat/seat belt installation

5.7.6 Proposed layout of Code

- Part A - General. Introduction, Background, Legal issues, Principles, Recognition levels
- Part B - Technical Requirements. Introduction, philosophy, engineering evidence, responsibilities of certifying engineers, emergency exits, structural inspection, seat padding, ADR 66 seating, ADR 68 seating, rollover strength
- Part C - Examples of Modifications. Pictures and drawings of acceptable and unacceptable practices

5.7.7 Sources of advice

- Understandably, companies are reluctant to provide details of technical solutions to retrofitting ADR 68 seats.
- Few, if any, examples will be available for use in the new Code
- Many examples in the old Guidelines are no longer applicable
- One proposal was to compile a public list of engineers/companies who can provide engineering advice on the retrofitting of ADR 68 seats to specific models of bus (Steering Committee did not agree with this proposal)

It was agreed that the content be as described. The proposal for a public list of advisors would not proceed.

5.8 Additional technical requirements

We support the following suggestions for additional requirements in the Guidelines:

a. All retrofitted seat belts in large buses to be retractable

b. Padding should be applied to seat backs for all upgrades to existing (pre ADR68) seats. Modesty panel grab rails should also have padding.

c. Drivers seat belt must be present and in good order

d. With large buses, the exterior side panels must be removed if there are structural changes to be made to wall mounts or the progressive inspection protocol followed per Section xx of the draft Code.. They must be removed during the structural integrity check if the structural components cannot be observed from inside or underneath the vehicle.

e. A prominent sign about the wearing of seat belts must be fitted inside the bus.

f. emergency exit signs should not be positioned where they might be covered by curtains.

g. *Self-tapping* bolts are not acceptable for seat anchorages.

h. Where access to install nuts is not available, drilled and tapped holes for high-tensile bolts without nuts are acceptable, subject to normal engineering practices and careful supervision (refer to draft Code for fastener torquing recommendation).

5.9 Australian Motor Vehicle Certification Board

Early in May the NTC circulated a letter to members of the Australian Motor Vehicle Certification Board seeking advice about several aspects of the proposals. The Board deals with vehicle construction standards in Australia. The main content of the letter is set out below.

> ...The purpose of this letter is to outline the preliminary advice and seek your feedback on particular elements of the proposal.
>
> Although the review is primarily concerned with technical issues it is important to consider the implementation of any new arrangements. The preliminary advice from Michael Paine recommends that, from a specified date, only lap/sash seat belts incorporated in ADR 68 certified seats and anchored to withstand a 20g crash pulse be permitted for retrofits. In other words, lap seat belts and lap/sash seat belts attached to existing (pre ADR 68) seats would not be permitted.
>
> This recommendation goes beyond the requirements applying at the time of first registration of these vehicles. However, it is important that high standards be demanded for retrofitted vehicles that will be used as public passenger vehicles, particularly so that ADR 68 is not under-mined. For example, there is a strong demand for buses with lap/sash seat belts in the deregulated charter industry. An audit by the Roads and Traffic Authority in 2001 revealed a wide range in quality of seat belt installations on buses in NSW.
>
> The intention is that the Guidelines become a National Code of Practice and that all States and Territories insist that retrofitted buses meet this Code. Your advice on whether this approach could be achieved through legislation (such as public transport regulations) is sought. If not, do you have any alternative suggestions for enforcing the Code?
>
> The availability of consulting engineers who are competent to advise on and certify retrofits was one issue that was also identified. It is proposed that all seat belt retrofits be certified by an approved engineer and that the bus is fitted with a modification plate or similar for future reference. Your advice on whether your State/Territory has an appropriate system in place to support this approach is sought?

Only one response had been received at the time of preparation of this report. That response was generally supportive but expressed concern about any proposals for sunset clauses to gradually remove buses with inferior occupant protection from "hire and reward" service. The administrative resources and costs associated with promoting the Gold/Silver/Bronze recognition also need careful consideration.

A similar letter was widely circulated to the bus construction industry (more than 90 organisations involved with bus manufacture, bus modification and certification of modifications). Only a few responses were received by the deadline of 15 June 2005. These are covered in Appendix A.

We were invited to address a meeting of AMVCB on 28 November and Mr Paine attended that meeting (airline disruption on the day prevented Mr Bailey from attending and Mr Griffiths was overseas when the meeting was arranged). During that meeting some concerns were expressed about the Gold/Silver/Bronze recognition system and its appropriateness for a Vehicle Standards Bulletin. A board member also pointed out that the SDS test was crucial for allowing older buses and some small buses to be retrofitted with seat belts, since other means of proving anchorage strength were costly and impractical.

An important outcome from that meeting was confirmation that each State and Territory would be able to require retrofitted buses to comply with the technical requirements of the Code, if it was published as a Vehicle Standards Bulletin (VSB).

After considering the comments raised at the AMVCB meeting, we feel the key issue revolves on the facts that:

a) There is already a large (and increasing number) of buses in the marketplace which have been built since 1994 to comply with both ADR 68 and ADR 59 (i.e. buses which would by definition meet the "Gold" recognition level)

b) Owners of these vehicles would be commercially disadvantaged if consumers were unable to differentiate between their vehicles (with 3 point ADR 68 seat belts and ADR 59 rollover protection) and vehicle retrofitted for ADR 68 seat belts only.

c) Legal action could result from a crash involving rollover where consumers had not been informed of real differences in the crash protection between POST 1994 BUSES (ie ADR 68 and ADR 59) and RETROFITTED BUSES (ADR 68 only).

Our previous recommendation envisaged a composite regulatory and consumer strategy, where the consumer labelling (Gold/Silver/Bronze):

- provided incentives and rewards to vehicle suppliers/operators to provide the best levels of protection and
- informed consumers what they were getting and not getting in crash protection.

Without a star or equivalent rating system, the consumer part of the strategy will be absent and only a regulatory strategy requiring a minimum standard will remain. This would prolong the refurbishment of buses with inferior rollover protection.

In the current environment of: --

- the need to recognise and reward operators who voluntarily retrofit to the higher standards.
- the need to inform consumers of what they are and are not getting with retrofit buses,

we developed the concept of an alternative strategy so that consumers could make an informed choice. We proposed that the identification issue could be addressed by requiring signage of appropriate format adjacent to the main passenger entry door (see figure 17).

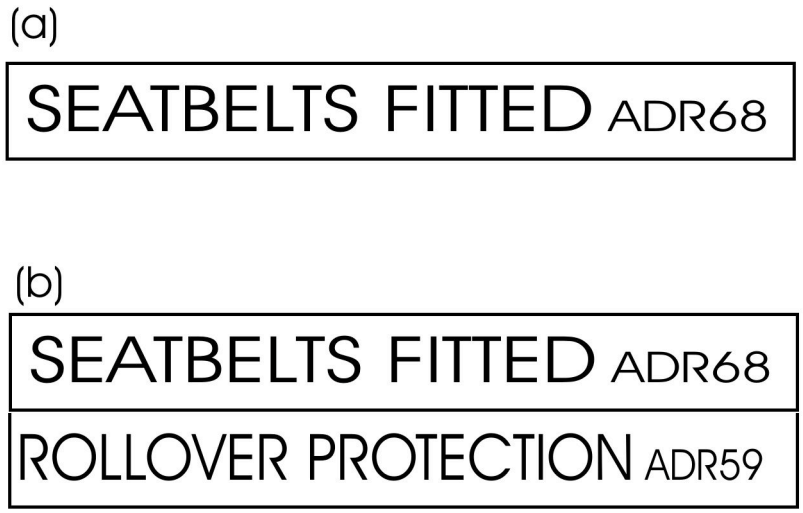

Figure 17: Possible alternative to Gold/Silver/Bornze recognition - permanent sign to be fitted adjacent to the main passenger entry , type (a) for retrofitted vehicles complying with ADR68 only (including the Code provisions for seat belts) and type (b) for vehicles complying with ADR68 and ADR59

Reference to the specific ADRs would assist enforcement of the requirements, which would be set out in the Code. The Code, and vehicle standards legislation, should also prohibit reference to seat belts and rollover protection in the case of buses that do not comply with the relevant ADRs or VSB.

5.9.1 Expediting development of the short duration static test

On 1 July we submitted to the NTC a draft brief for an extension to the project to develop a "short duration static test" to represent the magnitude *and timing* of loads that occur during the full ADR68 dynamic test. Our initial investigations had determined that such a test was technically feasible. We suggested a budget of around $120,000 for this project but noted that a substantial proportion could be covered by "in kind" contributions (i.e. test facilities and seats). We also suggested that the test equipment resulting from the project could be hired out to certifying engineers once the Code was implemented.

It will take several months to develop and verify a suitable alternative test method for seat anchorage strength. If the VSB is published before the test is available, then many older buses and small buses will be precluded from fitting seat belts because there will be no practical means of demonstrating compliance with the VSB.

To expedite the task, it is recommended that a small working group be formed from NTC, Steering Committee and AMVCB members to:

a) review the project brief that we have prepared,
b) establish a budget for the project
c) explore sources of funding - including "in kind" contributions
d) monitor the progress of the project and
e) arrange for the resulting test protocol to be incorporated into the Code/VSB (as an appendix).
f) determine ways in which certifying engineers can gain access to the test equipment (or manufacture their own).

5.10 Public Comment

Early in September the NTC placed the draft Code on its website for public comment. The following table sets out the key issues raised and the manner in which they were resolved. A revised the draft Code was submitted to NTC in mid-November 2005.

Issue	**Comment and *response***
Concern that the Code will take precedence over the ADRs	The ADRs set minimum standards at the time to vehicle was built. The Code aims to set best practice for retrofits in recognition of the higher standards set in the latest ADRs. *Wording clarified*.
Gold/Bronze/Silver recognition system not supported because older buses will not be able to achieve better than bronze recognition.	These older buses are likely to have significantly inferior rollover protection and it is considered that there is a duty of care to inform consumers about this. *Retain recognition system*.
Voluntary nature of the Code may cause confusion	Although the Code is not mandatory for upgraded buses under the federal system, state jusrisdictions may decide to require compliance with the Code for buses to be used for public passenger operations. Similar arrangements apply for modified trucks in the application of VSB6. *Wording clarified*.
Retrofits of older buses are less likely to be commercially viable	It is untenable to continue to allow inferior seat belt installations that look like ADR68 systems but are likely to fail in a severe crash. Newer buses that have been designed with ADRs 68 and 59 in mind are becoming available for retrofitting and these are preferred to older buses. *Maintain high standards for all retrofits*.
Requirement for 20g anchorages too severe for older buses	Examples of successful 20g installations in older buses are available. 10g systems are likely to fail in a severe crash. ADR5 was developed well before research into severe bus crashes revealed that nothing less than 20g anchorages would provide adequate

	protection and that such anchorages were feasible . *Maintain high standards for all retrofits*.
Need for a short-duration static test questioned.	Our review of the range of test methods available revealed none that would give a satisfactory assurance that the installation would withstand the equivalent of ADR68 dynamic loads. Constant loads at appropriate levels resulted in excessive demands of the structure. The ADR68 static test is impractical. *Develop the SDS test.*
Driver mass omitted from laden mass calculation	*Driver mass now included.*
Concern about certifying that a bus continues to comply with ADR59	*Wording clarified.*

6. IMPLEMENTATION ISSUES

6.1 Administrative systems

The main purpose was to review the technical content of the guidelines. However, our discussions have revealed the need to look at the administrative systems that are associated with retrofitting seat belts to buses. In our opinion these systems need to ensure that:

a. all retrofitted buses are certified by a qualified engineer.

b. all retrofitted buses have a plate or similar method of identifying the organisation that carried out the retrofit.

c. completed forms associated with the retrofit are reliably archived (preferably by a registering authority).

d. a simple set of inspection checks are conducted when buses are subjected to roadworthiness inspections (e.g. UK Department for Transport and RTA NSW publications).

e. a program for progressively reviewing all previous retrofits and ensuring that they meet the above requirements - particularly the engineering certification - is implemented. It is our understanding that all reputable retrofitters have suitable records to facilitate such a program. Non-complying installations would have the option of removing the seat belts or upgrading the installation.

f. operators be banned/discouraged from advertising the availability of lap/sash seat belts unless they meet the Gold, Silver or Bronze requirements and these grades are included in the advertisement.

6.2 Legislation and publications

6.2.1 States and territories

As indicated in the section concerning the AMVCB, it is recommended that each state/territory give consideration to requiring "hire & reward" buses that are retrofitted with seat belts to meet the requirements of the NCOP. This may be possible through public transport regulations rather than vehicle registration regulations.

Existing state/territory publications such as the NSW RTA Vehicle Inspectors Bulletins 49 & 50 and Vehicle Standards Information 44 need to be reviewed to align with the NCOP.

6.2.2 Australian Design Rules

The Australian Design Rules should be reviewed to ensure consistency of application of the most appropriate regulations for vehicle types and ensure that current exemptions from ADR68 do not result in a retrofitting loophole which result vehicles with inferior occupant protection levels entering inappropriate service areas.. In particular, there appears to be no reason to continue the exemption for buses with less than 17 seats (MD3, MD4 & ME vehicles). Exemptions for "route service" buses and seats with a reference height less than 1m should remain for these categories. The Toyota Coaster is the largest selling model in the non-ME categories. It is not currently available with ADR68 seats from Toyota but, as indicated previously, there are several retrofit solutions for ADR68 seating. There is evidently a strong market demand for lap/sash seat belts in the Coaster. The retrofitting industry has shown the feasibility of ADR 68 seating systems in Coasters. There do not appear to be any ongoing technical obstructions to requiring ADR 68 on these buses. It is understood that Toyota has considered producing a variant that complies with ADR68 (as Mitsubishi have done with the Rosa), however it appears Toyota Japan will require a mandatory rule before making it available to the Australian market..

In the case of MD1 and MD2 vehicles, the Toyota Commuter is currently the only production bus certified to the ADRs in these categories. ADR68 does not apply to these vehicles. ADR5/04 requires seat belts for all seating positions but allows lap belts for inboard seats. The ADR also exempts "route service" MD1 & MD2 buses. The Commuter now comes with retractable lap/sash seat belts as standard (a commendable voluntary measure by Toyota). Given the results of research on small bus crashworthiness and concerns about lap belts, there is now a strong case for swiftly amending ADR5/02 to require retractable lap/sash belts for all seats in MD1/MD2 buses and to remove the route bus exemption for these categories.

In the longer term it would be preferable for these small buses to meet the superior occupant protection requirements of ADR68 (improved injury prevention and ability to withstand the forces from an unrestrained occupant to the rear).

Consideration should be given to the development of an ADR to cover occupant protection with route service (“metro”) bus seats on larger buses.

6.2.3 Vehicle Standards Bulletins

The proposed NCOP is a stand-alone document that could be published as a new Vehicle Standards Bulletin by DOTARS. In this case it would be necessary to amend Vehicle Standards Bulletins 5A, 5B and 6 to make it clear that seat belt retrofits to buses must be done in accordance with the new NCOP. Otherwise there could be confusion over which standards should apply to this type of modification.

6.3 Publicity

The existence of the Guidelines and the levels of protection are unknown to most (if not all) bus users. At present consumers simply ask for a "bus with seat belts" or a "bus with lap/sash seat belts" when enquiring about a hiring.

Consideration should be given to publicising the levels of protection and encouraging consumers to seek the highest protection available. Such an approach is incorporated in the principles of Section 5. However the marketing aspects of this proposal are beyond our brief.

7. RECOMMENDATIONS

A draft Code of Practice and a draft Certification Form (for use by certifying engineers) have been prepared in accordance with the findings set out in this report. It is recommended that these documents be issued by the federal Department of Transport and Regional Services as a National Code of Practice.

It is also recommended that development of a short-duration static test be expedited so that there is an economically viable means of demonstrating that the seat anchorages of older buses can withstand loads that are similar to those experienced in the ADR68 dynamic test.

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APPENDIX A - CONSULTATIONS

Note that this table summarises key points raised during discussions or in correspondence. It does not necessarily represent the views of any person or organisation.

Organisation	Business	Key Points
Custom Coaches John Boon 15/3/05	Bus manufacturer	The illustrations from the current guidelines that mention Custom Coaches have not been used for at least 20 years. Many recent (eg post 1993) buses already have suitable structure for mounting ADR68 seats and can be readily identified by the 65x65x6 angle under the floor. Relatively simple reinforcement can be added to upgrade other recent models. A minimum height for wall mounts and maximum wall to pedestal distance apply. Recommends that ADR68 seats only be fitted to buses that comply with ADR59 or have equivalent structure. Is able to provide information to assist in determining whether a pre ADR59 bus has equivalent structure.
RTA NSW Greg Dikranian, Steve Williams (Craig D'Souza) 21/3/05	Regulator	Discussed the RTA's audit of seat belt installations. Will obtain papers and go through details. Issued VIB 49 & 50 to address some of the unsatisfactory installations. Prefer 20g anchorages for ADR68 seats. Ban self-tapping bolts - too much variation in quality of installation. Prefer all bolts to have nuts. Extensive checklists for all steps in process are needed. Possibly each seat should be covered by the checklist.
BCA NSW Technical Committee 24/3/05	Industry assoc.	The charter bus industry is buying older buses and adding seat belts to satisfy market demands. No age limit on these buses and questionable quality of some installations. Need a level playing field with all operators meeting the same (high) safety standards. Operators providing school services have

Organisation	Business	Key Points
		a capacity problem if seat belts are fitted (eg 3 for 2 rule). Also a maintenance/vandalism problem.
Manly Coaches Geoff Harper, Bob Stephens, Peter Weatherby 7/4/05  Self-illuminated sign  Location of "break glass" sign	Charter operator, retrofitter and engineer	Strong market demand for 3 point seat belts. Using design recommendations from ADR68 seat manufacturer and results of previous static pull tests on a similar model to establish satisfactory installation. Always use nuts on seat anchorage bolts (wall and floor) even though access is difficult at times. Hardened washers also used. To simplify installation they usually drill and tap from above, fit bolts and then fit nuts. Rear row of seats needs careful design - usually structure needs to be added in a confined space. Have sourced a self illuminated (chemical) "Emergency Exit" sign that makes installation much simpler (no wiring). Needs to be located where it cannot be covered by curtains. Disagree with proposal to restrict ADR68 installations to ADR59 vehicles. Many older vehicles can be retrofitted to withstand a severe frontal crash. Rollover protection is an added benefit. Consider there is no longer a case for allowing lap only belts.
Volgren Australia (Grenda Corp) Geoff Grenda, Michael Kearney (Craig D'Souza) 14/4/05	Bus manufacturer	Volgren use a unique modular aluminium construction for their buses. All current models are certified to ADR68 but most production is for metro buses. Upgrades to fit ADR68 seats needs to use Volgren parts. Operators usually find it is most economical having Volgren do the retrofits. Vogren uses a channel for the wall mount. The channel insert is specially designed and has been tested to ADR68. Therefore

Organisation	Business	Key Points
		page 48 of the current guidelines is incorrect (says aluminium channel should not be used for level 5). Also Volgren Australia have never used the system illustrated on page 68. Volgren also has concerns about items in the RTA's VIBs. Consider there is no longer a case for allowing lap only belts. There is a need for a retrofit plate to identify the modifier. ADR58 seating capacity values of 65kg for passenger and 15kg for luggage are too low for coaches with overseas travellers (airlines use 77kg + 20kg?). The separate company Volgren *Queensland* is no longer in business. They produced some buses that are not covered by Volgren Australia's certifications.
Geelong Coachworks Jim Mifsud 15/4/05  Wall mount section  Floor mount section (welded to chassis flange)	Retrofitter	All conversions are covered by engineering certificates issued by Andrew Enkelman & Assoc. Geelong Coachworks maintains detailed records and photographs of all conversions. Have developed a method of welding a thick steel strip to the top of the chassis rail. This is then drilled and tapped to anchor the pedestals. The bolts do not go through the chassis (avoiding stress concentrations) and nuts are not used. The HT bolts are supplied by McConnell. They have also developed a steel rolled section for use in wall mounts. Again these are drilled and tapped. Noted that VSB6 provides for engineer's plate to be fitted to modified trucks. A similar arrangement should apply to bus seat belts. Geelong Coachworks could retrofit plates to all buses it has upgraded. Concerned about some bus operators fitting "lap seat belt kits" to buses. Highly

Organisation	Business	Key Points
		questionable strength.
Email and phone feedback		
DPI WA John Dombrose	Regulator	Agrees with proposal to check laden mass based on passenger capacity. Possibly require a detailed (but simple) calculation if the tare mass increases beyond a set amount. Clarification needed with the draft flowchart regarding replacement of seats.
Vicroads Ross McArthur	Regulator	Concern about dropping Appendix 5 as this would reduce custom bus solutions. Otherwise generally agrees with earlier recommendations.
McConnell Seats Denis McConnell	Seat manufacturer	ADR68 seats are generally heavier than their predecessors. ADR68 certified seats have 213mm bolt spacing (cf 300mm in NSW document) and use tapped holes with no nuts (cf NSW requirements for nuts). Improved design and tooling has helped to reduce costs. Isle width is not a problem with MD vehicles where 2+1 seats are fitted (double on one side, single on other) Considers that pre ADR59 buses should be allowed to fit ADR68 seats since the floor structure can be upgraded to take 20g loads. Agrees with recommendation that all ADR68 seats should have 20g mounts. (meeting on 4 May 05) Drawings and advice are available for retrofitting many older buses to ADR68 requirements using McConnell seats. These could be reproduced in the Code, if appropriate. Dynamic tests for ADR68 compliance did not have strain gauged seat anchorages so McConnell has no data to assist with the development of an equivalent static

Organisation	Business	Key Points
		test. They do have experience with the difference in performance arising from anchorage stiffness (compliant floor versus rigid floor) that may assist. The transverse distance between the seat leg and the wall must not exceed the seat manufacturer's recommendations. This can cause difficulties for some retrofits. Wall anchorage height also needs to be within limits. Limits on seat to seat pitch and offset apply.
RTA NSW Greg Dikranian 8/4/05	Regulator	Considers that ADR68 seats with 20g mounts should be allowed on pre ADR59 buses. New guidelines should give advice on how to achieve compliance with 20g requirement.
Curratech Pty Ltd Peter Weatherby (in advice to BIC) 19/4/05	Engineer	Important that retrofitting (and guidelines) do not result in non-compliance with applicable ADRs. Considers that ADR68 seats should be allowed on pre ADR59 buses. All retrofitted seat belts (lap and lap/sash) in large buses should have retractors. Static belts are too easily damaged and might trip passengers. Where lap seat belts are fitted the top and back of the seat in front must be padded. Modesty panels should also be padded. The ADR68 static test is much more demanding than the dynamic test. A simplified static test of anchorages is needed that is less demanding (and less destructive) than the ADR68 static test. With sound anchorages a 10g static test is unlikely to produce significant structural damage and appears to be equivalent to a dynamic test in the range 10g to 20g (this claim agrees with comments by Ross Dal Nevo regarding tests conducted by Crashlab). However, there is unlikely to be a viable field (workshop) test that will

Organisation	Business	Key Points
		unequivocally demonstrate that a system withstands 20g dynamic loads. There needs to be a check that a drivers seat belt is available and in good order. With unitary construction buses the option of anchoring seat belts to wall and floor or a separate frame should be retained. What about large buses? There is merit in requiring laden mass to be assessed. Some small buses are very close to the limits. During the structural integrity check of large buses exterior side panels should be removed except where the side frame components can be readily inspected from inside or underneath the vehicle. In any case exterior side panels should be removed whenever structural improvements are made to the wall mounts to ensure adequate access to components. The rear row of seats often presents problems for retrofitting seat belts - this should be noted in the guidelines. A sign should be installed in a prominent location to advise passengers to wear seat belts.
Queensland Transport Ian Matthews 11/4/05	Regulator	Queensland is implementing a program to upgrade buses used for steep school bus routes. It will requite the buses to comply with ADR59. have ADR68 seats and seat belts and be fitted with an approved powertrain retarder (auxiliary brake). The revised guidelines will be useful for this program. Unless users can somehow be fully informed about lesser standard (10g) seat belt installations then 20g installations should be required.

Mitsubishi Fuso Truck & Bus Australia Mr G Oxton 10/6/05	Bus manufacturer	Two variants of the Rosa comply with ADR68. Concern that retrofitting ADR68 seats may invalidate ADR59 compliance due to change in mass distribution and seat reference position.
Bus & RV Modifications, Caloundra 13/7/05	Bus modifier	Mainly deal with motorhome conversions but supports the principles for seat belt retrofits to coaches. Demonstrated a bus undergoing a detailed structural inspection.
Road Safety Inspections P/L Port Melbourne 21/7/05		Conducts routine roadworthiness inspections of buses in Victoria. Discussed inspection requirements for seats, seat belts, emergency exits and structure. Confirmed that different terms are used for the same bus components throughout the bus industry, making consistent descriptions of defects and modifications difficult (hence importance of photographs).

APPENDIX B – SEAT BELTS IN SMALL BUSES

The two very severe full size coach crashes in 1989 focused pubic and political attention on bus crashes and led to a comprehensive regulation package for bus occupant protection in Australia.

During early State and Federal organisation discussions the initial focus was on full size buses/coaches since these were the type involved in the 1989 crashes. However it was recognised that occupants of smaller buses were more vulnerable in these severe crashes due to mass and size disadvantages.

Nevertheless, industry representations at the time suggested that mid-size buses in the range of 10 to 30 seats (which were production buses, exported to many other countries) were simply not capable of having seats with seat belts fitted.

As the commitment of the State and Federal authorities at the time was to get the package into full size buses, the mid size buses were exempted (if less than 17 seats or the seat back is no higher than 1m from the floor), on the understanding that, once the package was in place for the full size buses, the situation for smaller buses would be revisited. It was anticipated that in the early 1990s the small bus industry would voluntarily do the necessary development work in readiness for compliance with ADR68 and that the ADR would be amended to cover these vehicles.

In 2005 the situation is that, in effect, ADR68 still exempts these buses from fitting seat belts to all seats. Most mid-size buses do not come standard with seat belts. In particular, the popular Toyota Coaster series is not available from the manufacturer with seat belts.

This means that the availability of seat belts on mid size buses is dependent upon retrofitting, rather than original equipment.

Since 1994 the market conditions have changed. It has become evident during the course of the current review that there is a large demand for retrofitting by consumers and fleet operators. As a consequence a significant retrofitting industry has developed and has become more sophisticated. Indeed, a rough analysis of the number of ADR68 compliant seats sold, and the number of new coaches supplied in Australia since 1994, indicates that for every new coach with ADR68 compliant seats and seatbelts, there is the equivalent of at least one full size retrofitted coach.

During the course of the review, it was found that there are a number of converters providing apparently satisfactory retrofits of mid size buses including the Toyota Coasters. A difficulty is that there is currently no practical test that can be undertaken to demonstrate the protection is equivalent to the ADR68 dynamic test.

Subject to this uncertainty, the Queensland company Coachworks has a package where they overlay a plinth on the floor structure, then mount commercial ADR68 seats on this structural plinth. Vehicles modified in this way were inspected, and appeared to both look good, and be structurally satisfactory, although no test evidence was sighted.

Enquiries with Coachworks revealed that they also carry out this type of conversion to the Mitsubishi Rosa (clients apparently prefer the retrofitted ADR68

seats to those supplied by Mitsubishi and certified to ADR68) and Mercedes Benz Sprinter. Coachworks has also retrofitted ADR 68 seats to smaller buses. These are illustrated in the following photographs.

Photograph 1

Photograph 2

Photograph 3

Photograph 4

Photograph 5

This is sound evidence that the perceived problems with the installation of ADR68 seats to mid size buses have now been overcome and there are a number of economical commercial solutions available for several models of small bus.

It should be remembered that when doing such conversions:-

- Many small buses operate at close to their permitted axle loads when fully laden and the plinth installation might take the axle loads over the limits, this could mean that passenger capacity needs to be reduced. To deal with this concern, a calculation to estimate laden mass is now included in the form to be completed by the certifying engineer.
- The change in mass distribution and seat height might affect compliance with ADR59 (rollover protection). In this case our review of research into rollovers of small buses suggests that these vehicles have good rollover strength, compared with large buses, and it is unlikely that the observed modifications would compromise rollover protection, provided permitted axle loads are not exceeded.

Crashes of mid-size buses

Figure 13 in the main part of the report illustrates a severe crash of a mid-size bus that occurred a few years ago.

During the course of the review, a 22 seat Toyota Coaster crash occurred in New South Wales. In that crash, there were two people ejected who received fatal injuries, and a further two people who reportedly received severe life threatening injury. The bus had lost control on a 110 km/hr designated freeway in wet conditions. The bus then rolled over, slid on its side, struck a guardrail, and rolled back up onto its wheels.

One of our team inspected the bus and observed that there was good preservation of its occupant space and overall good preservation of its structure. Inspection indicated that if the bus had been fitted with ADR68 seats (in the manner of conversion done by Coachworks or others), there would not have been any ejection, and there should not have been any serious injury to occupants restrained within the bus.

Photograph 6

Photograph 7

Our inspection was conducted in conjunction with New South Wales Vehicle Examination Police. The Police are also in the process of preparing a report for the Coroner on a 2003 Coaster crash which had resulted in serious injury. Seat belts were a likely recommendation in their report.

The police and Coroner interest motivated us to obtain NSW records of crashes where an occupant of a Toyota Coaster was injured.

The following table shows that in a nine year period from 1996 to 2004 in NSW there were 102 crashes of Toyota Coasters resulting in injury to their occupants. Overall there were 311 injured people requiring treatment, a further 96 with injuries requiring admission to hospital, and nine fatalities.

Toyota Coaster Crashes in NSW 1996-2004

Year	Injury crashes	Crashes with fatality	Fatalities	Injury requiring hospital admissions	Other injury requiring treatment
1996	6	0	0	6	19
1997	10	3	3	7	49
1998	10	1	1	9	40
1999	11	0	0	11	35

2000	10	0	0	10	16
2001	9	0	0	9	29
2002	16	1	4	15	62
2003	14	1	1	13	28
2004	16	0	0	16	33
TOTAL	**102**	**6**	**9**	**96**	**311**

Nationally this extraplotes to approximately 30 fatalities, 290 injured persons requiring hospital admission and a further 900 injured persons requiring treatment for the nine year period.

Cranfield Imapct Centre research shows that many of these casualties could have been prevented through ADR68-style occupant protection. However, in rare cases of very severe crashes the occupant survival space is compromised and mutliple fatalities can be expected. Such a crash occurred in New Zealand during the course of the project.

Photograph 8 – New Zealand Crash

Recommendations for small and mid-size buses are contained in the main part of the report.