Analysis of Improving Occupant Protection in Existing Coaches

Prepared by:

Andreassen, D

Cusack, S

ARRB Transport Research Ltd

MR13

1996

Federal Office of Road Safety

Analysis of Improving Occupant Protection in Existing Coaches

Project Officer(s)
David Andreassen
Simon Cusack

January 1996
C5 510

FEDERAL OFFICE OF ROAD SAFETY
DOCUMENT RETRIEVAL INFORMATION

Report No.	Date	Pages	ISBN	ISSN
MR13	January 1996	22	0 642 51325 2	0810 770X

Title and Subtitle

Analysis of Improving Occupant Protection in Existing Buses

Author(s)

D Andreassen
S Cusack

Performing Organisation (Name and Address)

ARRB Transport Research Ltd
500 Burwood Highway
VERMONT SOUTH VIC 3133

Sponsor

Federal Office of Road Safety
GPO Box 594
CANBERRA ACT 2601

Project Officer: K B Smith

Available from

Federal Office of Road Safety
GPO Box 594
CANBERRA ACT 2601

Abstract

This study was initiated to undertake a cost benefit analysis of equipping the coaches in the Australian fleet, as at 30 June 1994, with a range of occupant protection measures as outlined in the Code of Practice (Bleakly 1994).

The amount of data on bus crashes in Australia is limited. There is no data readily available on coach crashes. For this reason it was assumed that the coach crash number was in the same proportion as the number of coaches in the bus fleet.

A range of occupant protection packages and scrappage rates were applied. The Level 4 occupant protection with low (current level) scrappage would give a positive net present value over a 15 year period and the fitting would appear to be justified.

The Level 5 occupant protection, while it gives 15 per cent more annual benefit costs almost twice that of Level 4 to fit to coaches. A clear case cannot be made for fitting Level 5 alone.

It would appear that the cut off for fitting of Level 4 occupant protection would be coaches up to 10 years for low (current level) scrappage and coaches up to 6 years for high (previous level) scrappage.

Keywords

Retrofit, Scrappage, Coach, Occupant Protection, Accident Cost, Cost-Benefit Analysis.

NOTES:

(1) FORS Research reports are disseminated in the interests of information exchange.

(2) The views expressed are those of the author(s) and do not necessarily represent those of the Commonwealth Government.

(3) The Federal Office of Road Safety publishes four series of research report
- (a) reports generated as a result of research done within the FORS are published in the OR series
- (b) reports of research conducted by other organisations on behalf of the FORS are published in the CR series.
- (c) reports based on analyses of FORS' statistical data bases are published in the SR series.
- (d) minor reports of research conducted by other organisations on behalf of the FORS are published in the MR series.

arrb Transport Research

Contents

1. Background

In 1993 the Federal Office of Road Safety (FORS), the National Road Transport Commission (NRTC) and the Australian Bus and Coach Association (ABCA) began examining the feasibility of retrofitting buses with additional safety equipment. Following a workshop in November 1993 FORS funded the development of a Code of Practice for Improving Occupant Protection in Existing Buses (Bleakly 1994). This Code provided engineering and cost data on a range of 'packages' of occupant protection measures from seatback padding through 10 g seats, to seat belts, and finally to ADR 68 standard seat and seat belt systems.

In November 1994 a further workshop was held to examine casualty crashes over a prior six year period. This workshop brought together a range of experts and sought to estimate the occupant protection or injury reduction benefits that might have resulted had the coaches concerned been equipped with each of the packages specified in the Code of Practice.

The result of this work was expressed in terms of percentage reductions in 'fatalities', 'serious injury' (hospital admission) and 'other injuries' (untreated or treated) for each of the 'levels' or packages outlined in the Code of Practice, and was summarised for the major types of bus crash (FORS 1995).

The next stage which needed to be taken, using this information, was to conduct a cost benefit analysis of retrofitting coaches with each of the 'packages' outlined in the Code of Practice.

2. Objective

The objective of this report was to undertake a cost benefit analysis of equipping coaches already in service with a range of occupant protection measures. The analysis was to cover long distance or touring type coaches in the Australian fleet as at 30 June 1994. Standard cost benefit analysis methodology was to be adopted. The cost data on the various occupant protection 'packages' came from the Code of Practice (Bleakly 1994). The cost data on casualty classes of the occupants came from Andreassen (1992a).

3. Bus Fleet Considerations

The split of the coach fleet, between 'new' vehicles that are being fitted with occupant protection during construction, and 'old' vehicles that could be retrofitted with appropriate protection packages, throws up some interesting questions. For example, will 'old' vehicles be used on the same routes and to the same extent as 'new' vehicles. The service life left in individual 'old' vehicles and across the 'old' fleet is an important consideration in the analysis. The 'old' vehicles have a distribution of ages from near-new to those close to the end of their service life.

The availability of good information on coach fleet size, use, and service life is essential for a full analysis. Coaches close to the end of their life do not demonstrate any positive value for the fitting of devices, given the likely lower profile of operation they will be engaged in. The present value of benefits over a number of years minus the cost of fitting should preferably be stratified into a range of age groups (bus life) and solved for each.

Again, if routes/usage changes with age of coaches within the old fleet, then exposure to crashes will not remain constant across all age groups. Any differences may affect the exposure and likelihood of crashes.

In essence it is a question as to whether the benefits experienced, i.e. persons injured x injury level changes over a period of time after the devices have been fitted to the coaches, for the crash involvement of 'old' coaches, will equal or exceed the cost of fitting devices to ALL 'old' coaches, whatever their likely service life.

While this project is similar to retrofitting of seatbelts in cars, there are also differences. For cars, the use of a comprehensive database enabled a large sample of crashes to be analysed to estimate the likely benefits. In the present case, 19 crashes over 8 years does not offer the same confidence in the averaging of effects that is possible with a large data set.

4. Costs for Providing Protection

The information supplied (Bleakly 1994) was on materials and labour to modify a 53 seat coach (labour was costed at $35 per hour).

	Level 2	Level 3	Level 4	Level 5
Cost	$9,455	$23,775	$15,480	$30,675

5. Summary of Protection Levels

Level 1 — Exit labelling is improved, function of emergency exits is tested and structural integrity inspection is conducted as described in Section 1, Part B of Bleakly (1994), with no other structural modifications.

Level 1 is a prerequisite for all further safety level modifications.

Level 2 — Existing seats are used to retain occupants, with strengthened seat mountings and with cast alloy legs replaced where necessary.

Level 3 — Seats are replaced with ADR 66/00 seats fitted to strengthened body seat mounts.

Level 4 — Existing seats are fitted with lap belts, requiring replacement seat legs which include a transverse beam with lap retractors mounted under the seat. Floor mountings are modified to a greater strength than levels 2 & 3 to accommodate unrestrained rear occupant and restrained front occupant loading on the seat.

Level 5 — Seats are replaced with ADR 68/00 seats with lap/sash belts. This level is recommended only for ADR 59/00 conforming bodies with strengthened body seat mounts.

ADR 59/00 (related to rollover strength) was introduced on 1 July 1992 and ADR 68/00 on 1 July 1994.

ADR 66/00 related to seat energy absorption was introduced on 1 July 1993.

6. Estimates of Injury Reduction

The information on injury reduction for various levels of protection was supplied by FORS (1995) and relates to 19 specific crashes over the period 1987-94 (8 years) involving long distance buses (coaches). These crashes were a mix of 14 fatal crashes, two 'serious' injury crashes and three 'other' injury crashes.

In three crashes only did Level 2 or 3 protection have any estimated effect. The certainty/reliability of the estimates is unknown and while a narrative accompanied each of the crashes for which an estimate had been made each crash was very case specific. Generalising to the total population of coach crashes in Australia obviously has limitations.

The injury reduction estimate as supplied appear in Table 1. The crashes are subdivided into coach only, coach/car, and coach/heavy vehicle.

The narratives were analysed and an ARRB Model Guideline accident-type determined for each. The percentage changes in Table I were converted to numerical changes and these appear in Table 2.

Table 1
Injury Reduction for Retrofit Additional Safety Equipment

Crash	Casualties	Level 2	Level 3	Level 4	Level 5
1. Coach only					
1a	K 12; H 39; O 00	0	0	K-H 80%; H-O 80%	K-H 80%; H-O 90%
1b	K 00; H 00; O 12	0	0	O 50%	O 50%
1c	K 01; H 06; O 10	0	0	K-H 100; H-O 50; O 80%	K-H 100; H-O 50; O 80%
1d	K 00; H 00; O 11	0	0	O 50%	O 100%
1e	K 00; H 00; O 06	0	0	O 50%	O 50%
1f	K 05; H 00?; O 40?	0	0	K + 20%; H, O 90-100%	K + 20%; H, O 90-100%
1g	K 00; H 02?; O 23?	0	0	K + 50%	K + 25-100%
1h	K 11; H 38?; O 00?	0	0	K-H 40%; H 40%	K 70%; H 80%
1j	K 05; H 17?; O 00?	0	0	0	K-H 20%; H-O 80%
2. Coach/car					
2a	K 00; H 01; O 14	0	0	H-O 100%; O 100%	H-O 100%; O 100%
2b	K 01; H 00?; O 18?	0	0	K 100%; H, O 100%	K 100%; H, O 100%
3. Coach/heavy vehicle					
3a	K 10; H 35?; O 00?	0	0	K 10%; H 50%; O 50%	K 10%; H 50%; O 50%
3b	K 01; H 34?; O 00	H 15%	H 20%	H 50%	H 80%
3c	K 01; H 40?; O 00?	H-O 50%; 0 50%	H-O 50%; 0 50%	K-H 100%; H-O 50%	K, H, O 100%
3d	K 01; H 06; O 11	0	0	K-H 100%; H-O 50%	K-H 100%; H, O 80%
3e	K 01; H 10	cannot estimate	cannot estimate	K, H, O 100%	K, H, O 100%
3f	K 35; H 39	cannot estimate	cannot estimate	cannot estimate	K 75%, H-O 100%
3g	K 20; H ??; O ??	0	H-O 50%	K 55%, H-O 50%	K 55%; H-O 75%
3h	K 04; H 35?; O ??				

Source: Federal Office of Road Safety

Table 2
Accident-types and number of injured persons

Coach only - Single vehicle

	Chosen Cell	Subsequent Event	Supplementary Code	Existing situation					Situation - Package 4					Situation - Package 5				
				K	H	O	Uninjured	Total	K	H	O	Uninjured	Total	K	H	O	Uninjured	Total
1a	704		2.IX, 1.01, 1.18, 1.02, OT	12	39	0	0	51	2	17.8	31.2	0	51	2	13.9	35.1	0	51
1b	803L		1.15, 1.02, OT, GS	0	0	12	0	12	0	0	6	6	12	0	0	6	6	12
1c	805		OT	1	6	10	29	46	0	4	5	37	46	0	4	5	37	46
1e	704		1.14, OT	0	0	6	0	6	0	0	3	3	6	0	0	3	3	6
1f	605		1.13	5	0	19	0	24	6	0	0.9	17.1	24	6	0	0.9	17.1	24
1g (average)	803L		1.10, OT	0	2	23	0	25	12.5	1	11.5	0	25	15.625	0.75	8.625	0	25
1h	703		1.18, 1.02, OT, 1.21	11	38	0	0	49	6.6	27.2	0	15.2	49	2.2	7.6	0	39.2	49
Total	*** Using 1g (average) (n=7)			29	85	70	29	213	27.1	50	57.6	78.3	213	25.825	26.25	58.625	102.3	213
	703 & 704 (n=3)			23	77	6	0	106	8.6	45	34.2	18.2	106	4.2	21.5	38.1	42.2	106
** Using 1g (average)	803 & 804 (n=2)													15.625	0.75	14.625	6	37
** Using 1g (average)	703, 704, 803 & 804 (n=5)													19.825	22.25	52.725	48.2	143

Coach/Car accidents - Multiple vehicles

	Chosen Cell	Subsequent Event	Supplementary Code	Existing situation					Situation - Package 4					Situation - Package 5				
				K	H	O	Uninjured	Total	K	H	O	Uninjured	Total	K	H	O	Uninjured	Total
2a	201	703	1.18, OT	0	1	14	0	15	0	0	1	14	15	0	0	1	14	15
2b	201	704	1.18, OT	1	0	18	0	19	0	0	0	19	19	0	0	0	19	19
1d	301	703	1.14, OT, 1.15	0	0	11	0	11	0	0	5.5	5.5	11	0	0	0	11	11
1i	306	704	1.18, 1.02	5	17	0	0	22						4	0	15	3	22
	703 & 704 (n=4)			6	18	43	0	67	5	17	6.5	38.5	67	4	0	16	47	67
Total	(n=4)			6	18	43	0	67	5	17	6.5	38.5	67	4	0	16	47	67

Coach/Heavy vehicle accidents - Multiple vehicles

	Chosen Cell	Subsequent Event	Supplementary Code	Existing situation					Situation - Package 4					Situation - Package 5				
				K	H	O	Uninjured	Total	K	H	O	Uninjured	Total	K	H	O	Uninjured	Total
3a	201C	803L	1.18, 1.20	10	35	0	0	45	9	17.5	0	18.5	45	9	17.5	0	18.5	45
3b	201			1	34	0	0	35	1	17	0	17	35	1	6.8	0	27.2	35
3c	201C	803L	1.10	1	0	40	0	41	0	1	6	34	41	0	0	0	41	41
3d	104		OT	1	6	11	0	18	0	4	8.5	5.5	18	0	2.2	2.2	13.6	18
3e	301			1	10	0	0	11	0	0	0	11	11	0	0	0	11	11
3f	201C			35	39	0	0	74						9	0	65	0	74
3g	201	701	OT	20	15	0	0	35	9	18.5	7.5	0	35	9	10	11.25	4.75	35
	201 (n=1)			1	34	0	0	35	1	17	0	17	35	1	6.8	0	27.2	35
	201 (n=2)			36	73	0	0	109						10	6.8	65	27.2	109
	201 + (803) (n=2)			1	0	40	0	41	0	1	6	34	41	0	0	0	41	41
	201, 201(+803), 201(+701) (n=4)			22	49	40	0	111	10	36.5	13.5	51	111	10	16.8	11.25	72.95	111
	201, 201(+803), 201(+701) (n=5)			57	88	40	0	185						19	16.8	76.25	72.95	185
Total	(n=6) -PACKAGE 4 & 5			34	100	51	0	185	19	58	22	86	185	19	36.5	13.45	116.05	185
Total	(n=7) -PACKAGE 5 ONLY			69	139	51	0	259						28	36.5	78.45	116.05	259

	Existing situation					Situation - Package 2					Situation - Package 3				
	K	H	O	Uninjured	Total	K	H	O	Uninjured	Total	K	H	O	Uninjured	Total
3b	1	34	0	0	35	1	28.9	0	5.1	35	1	27.2	0	6.8	35
3c	1	0	40	0	41	1	0	20	20	41	1	0	20	20	41
3g	20	15	0	0	35	20	15	0	0	35	20	8.25	6.75	0	35

As can be seen in Table 1, the crash labelled '3 h' has no estimate for reductions for any of the levels. Only two crashes have any effect estimated for Level 2 and only three have estimates for Level 3. Estimates for Level 4 and Level 5 appear together for 17 crashes and for Level 5 and not Level 4 for one crash.

Where reductions such as 90-100 per cent were shown in Table 1, they were taken as 95 per cent for the purposes of calculating the change in numbers. One wide ranging estimate might be noted for Level 5 for crash '1 g' which shows an increase in those killed of between 25 and 100 per cent.

The problems with the lack of a record of the total occupancy of the coaches and the casualty classes of the occupants are problems in common with other vehicle types as shown by the question marks in the table. Many States do not record total occupancy, which makes it impossible to estimate the effects of any injury modifying device installed in vehicles.

There are five casualty classes that are meant to be in use throughout Australia the five classes range from killed to uninjured. The age, gender, and seating position of an occupant can influence the likely casualty class outcome in a particular crash-type for light vehicles and it is obviously the case for coaches too, with the added complication of a much larger number of seats to consider.

The information supplied was not in the amount of detail nor the volume that is desired to make a clear analysis of the effects of the protection afforded in a variety of accident-types and speed environments. The data is provided for three broad categories of accidents viz coach only, coach vs car, and coach vs heavy vehicle. The apparent benefit to bus occupants for retrofitting of Levels 4 or 5 is greatest in coach vs heavy vehicle, then coach only, then coach vs car.

7. Number of Coach Crashes in Australia

Such is the crash data recording that there is no distinction between "route buses" and "coaches". It may have been possible to match the registration plate numbers of the "buses" in crashes to registration databases to ascertain which were coaches. More fundamental data of this nature is required nationally at the reporting phase.

FORS supplied the number of bus crashes in 1992 which resulted in death or serious injury to at least one of the bus occupants. For Australia the number of such crashes was 78 (bus vs heavy 4; bus only 31; bus vs car 43).

As the number of bus crashes that in fact involved coaches was unknown, and so an assumption was made that the proportion of crashes involving coaches was in the same proportion as the number of coaches of the total bus fleet.

The need to have information in reasonable detail in relation to both the crashes and the number of coaches to carry out a cost benefit analysis necessitated the use of data at a State level and New South Wales was chosen. If the occupant protection proved to be effective for NSW then it might be assumed to be so for other States.

The crash numbers in 1992 involving buses and coaches were -

	Australia	NSW
bus vs heavy	4	3
bus vs car	43	11
bus only	31	15
	78	29

8. Number of Coaches in Australia

The number of coaches in Australia was obtained from the Australia Bus and Coach Association. As at January 1995 the number was 2,147 which included 106 coaches that were aged two years or less and likely to have been built to comply with ADR 59/00 and some to comply with ADR 59/00 and 68/00.

Between 1992 and 1995 the cost of a coach increased from \$379,000 to \$492,000 (almost 30 per cent) and resulted in a decrease in coach construction/supply from around 200 per year to 50 per year and a resultant increase in average age of coaches from six years to eight years.

The net effect is that to maintain/service the current demand the pre- 1992 ADR coaches will have to remain in service for longer periods than in the past. The general service life of a coach previously was taken as 10 years. This in itself makes the matter of retrofitting more critical to answer.

From the information supplied on the distribution of the ages of coaches (Figure 1) the scrappage rate was estimated by displacing the distribution. Figure 2 shows the current and displaced age distributions and from this the scrappage rate of 162 per year was determined.

A number of scenarios are possible with regard to the number of coaches in the future.

(1) new coaches are put into service at 50 per year and the total number held constant (i.e. scrappage is 50 per year);

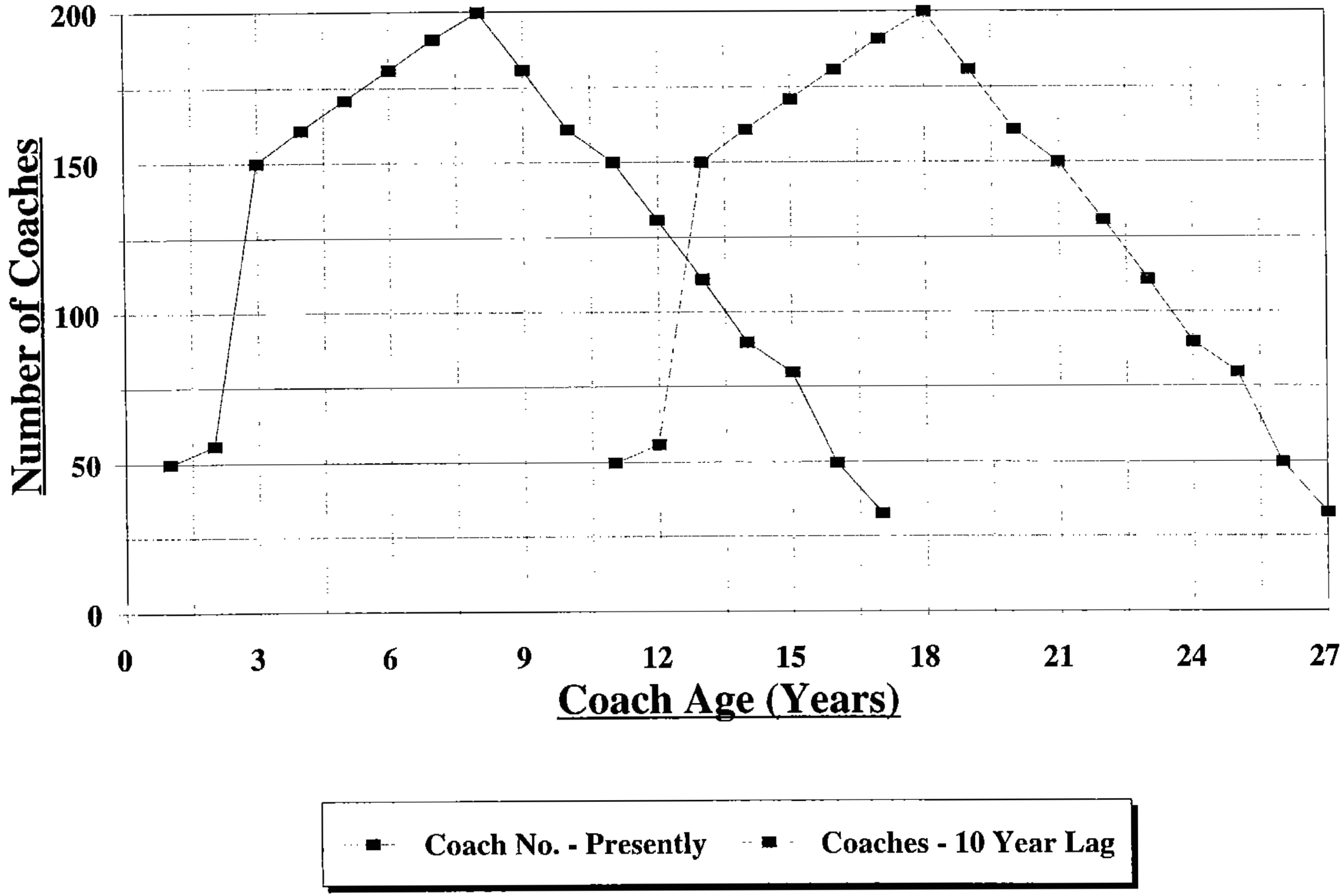
(2) new coaches at 50 per year and scrappage is at previous rate of 162 per year; or

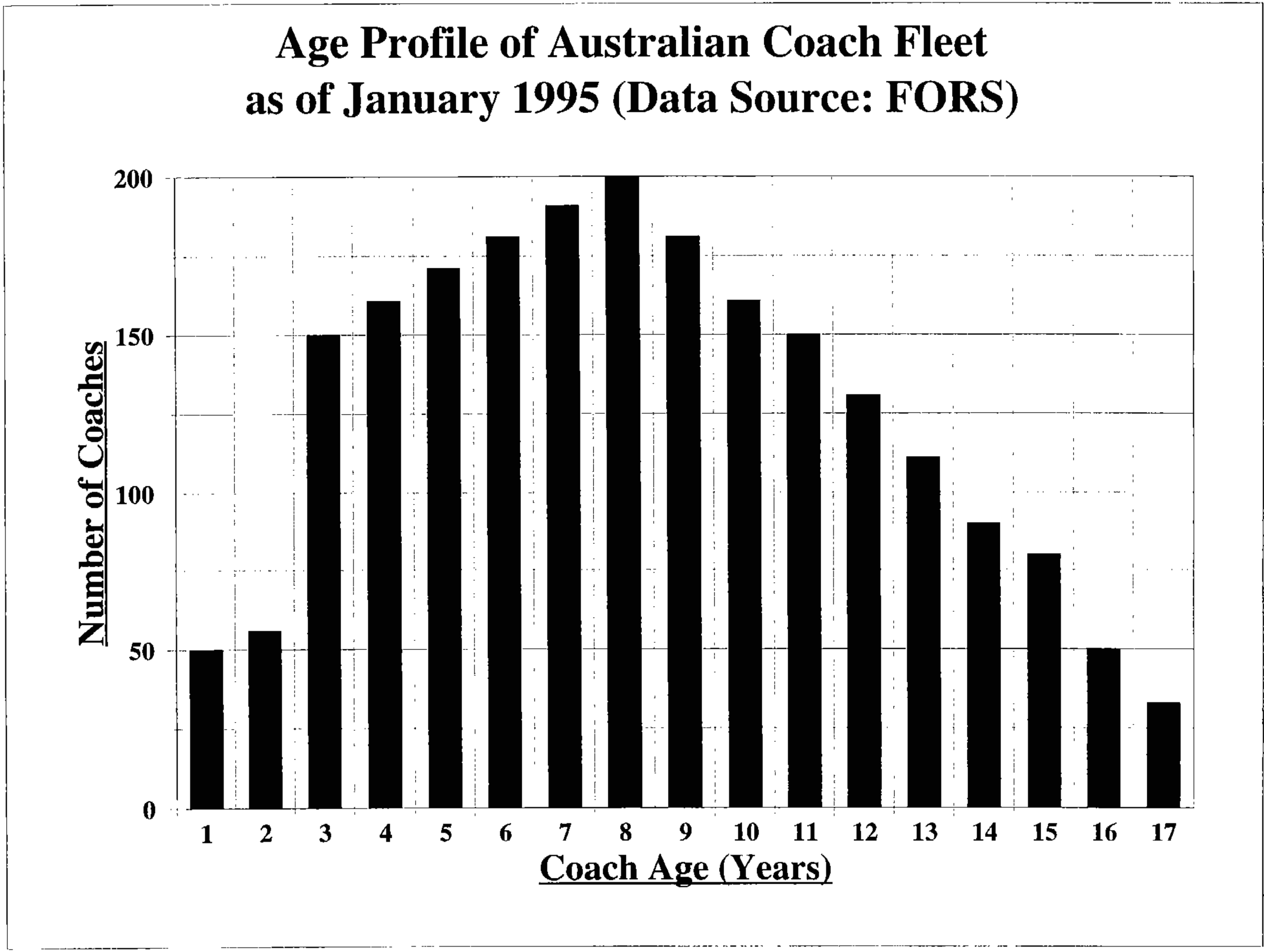
(3) new coaches returns to 200 per year and scrappage is at previous rate of 162 per year.

Scenarios (2) and (3) will produce the same answer since the number of new coaches alone does not affect the number of old coaches.

The scrappage rate includes coaches written off in crashes and could include new coaches. As no information was supplied as to the age of coaches involved in crashes no adjustment was able to be made to the subsequent calculations. The crashes to coaches was assumed to be spread uniformly over the age distribution of crashes.

Age Profile of Australian Coach Fleet as of January 1995 (Source: FORS)




Age Profile of Australian Coach Fleet
as of January 1995 (Data Source: FORS)
Number of Coaches
0
50
100
150
200
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Coach Age (Years)

9. Coach Crashes, Costs of Fitting and Benefits

To make a cost benefit analysis (CBA) there is a comparison made between the costs of equipping the coaches (over a short time period) and the benefits from the reduced injuries of the occupants of the coaches involved in crashes over a long period of time. Obviously if coaches were involved in no crashes then the cost of equipping the coaches would be deemed not to be justified. To provide benefits the coaches have to be involved in crashes, since the devices fitted modify the severity of injury, they do not affect the occurrence of crashes.

The year 1992 on which this analysis has been based was not a year that had as many crashes as, say, 1989 as there has been a general drop in crash occurrence since 1989. The more crashes coaches are involved in the greater the amount of benefits in reduction in aggregate injury costs providing a counter to the expenditure on fitting.

The approach taken in this analysis was to determine the crash benefits for the three broad categories of crashes as an amount saved per crash per year and via time streams determine the Present Value (PV) of the benefits for 10 and 15 year periods these were then compared to the cost of equipping the coaches.

The injury reductions in terms of person per crash at each casualty class from Table 2 were applied to the NSW data in Table 3. Where the reductions from Table 2 exceeded the number of persons per crash in that casualty class in Table 3, the reduction was taken as 100 per cent of the number in Table 3.

The changes in injury outcome per crash by casualty class for the three broad categories are shown in Table 4.

The changes were converted to dollars using the casualty class costs of Andreassen (1992a). The values are shown in Table 5 along with the weighted mean value of the three broad categories. For Level 4 protection, for example, each crash a coach was involved in would on average save $362,081. A reduction in casualty costs due to the effect of the occupant protection. Obviously if the relativities of involvement in the three broad categories change then the weighted mean would change. The weighted mean is particularly sensitive to changes in 'bus vs heavy' crashes. If the number of such crashes increased from three to six per year while the others remained constant the weighted mean would increase from $362,081 to $479,025 (+ 32 per cent). Also if the total number of bus crashes increased with the relativities unaltered then the annual savings would increase in proportion.

Table 3
Injury Outcomes for Bus Occupants from FORS Fatal & Serious Injury Crash Files for NSW only for 1992

	Bus vs Heavy NSW	Bus vs Car NSW	Bus Only NSW
Killed	4	0	5
Hospitalised	28	5	23
Other Injury	24	39	31
Uninjured	8	140	114
Total	64	184	173
Crashes	3	11	15

Table 4
Injury Outcome Change per Crash by Applying Retrofit Package 4 or 5 for Bus Occupants

	Bus vs Heavy		Bus vs Car		Bus Only	
	Package 4	Package 5	Package 4	Package 5	Package 4	Package 5
Killed	1.333	1.333	0.000	0.000	0.271	0.333
Hospitalised	7.000	9.333	0.250	0.455	1.533	1.533
Other Injury	4.833	6.258	3.545	3.545	1.771	1.625
Uninjured	-13.167	-16.925	-3.795	-4.000	-3.576	-3.492
Total Change	0	0	0	0	0	0

Table 5
Cost Saving of Injury Outcome Change per Crash

	Bus vs Heavy		Bus vs Car		Bus Only		Weighted mean of three types	
	Package 4	Package 5	Package 4	Package 5	Package 4	Package 5	Package 4	Package 5
Killed	$833,467	$833,467	$0	$0	$169,670	$208,367		
Hospitalised	$751,100	$1,001,467	$26.825	$48,773	$164,527	$164,527		
Other Injury	$29,000	$37,550	$21,273	$21,273	$10,629	$9,750		
Uninjured	($4,082)	($5.247)	($1,177)	($1,240)	($1,109)	($1,082)		
Total Saving Crash/Year	$1,609,485	$1,867,237	$46,921	$68.805	$343,717	$381,561	$362,081	$416.620
Crashes/Year	3	3	11	11	15	15	29	29
Total Saving Year							$10,500,337	$12,081,984

From Table 5 the expected saving in injury costs when a bus crash occurs relates to all the bus crashes in NSW in 1992. As stated earlier the number of crashes to coaches was assumed to be in the same proportion as the number of coaches is to the total number of buses. As at January 1995 the total number of buses and coaches in NSW was 5,500 and the number of coaches was 850. Thence *percentage coaches* = 15.45 *per cent* (or 1 in 6.47).

Applying this proportion to crashes gives 29/6.47 = 4.48. [Note these are crashes where injury to bus occupants was at least one person killed or admitted to hospital], i.e. Estimated number of (F & HA) coach crashes in NSW = 4.48.

There would, of course, have been a whole number of crashes in 1992 but for a long term average over a number of years for performing a CBA the decimal value is appropriate.

Thence the estimated injury saving per year if all coaches had Level 4 protection

= 4.48 x $362,081 (from Table 5)

= $1.623 Million

The scrappage has been assumed to take effect at the <u>end</u> of each year in the analyses that follow.

As discussed under Section 7 a number of different assumptions are possible in regard to the number of 'old' coaches in future years and these need to be considered in the CBA. The various aspects considered are -

1. All the coaches as at 1 January 1995 to be fitted with Level 4 protection

2. Coaches more than two years old, as at January 1995 to be fitted with Level 4.

3. Coaches two years and under, as at January 1995 to be fitted with Level 5 protection and the remainder with Level 4. [Note: see Section 5; Level 5 is recommended only for ADR 59/00 confirming bodies (1 July 1992)].

4. Two scrappage rates to be considered -

   (a) Scrappage of "old" coaches at the same rate that "new" coaches come into service (i.e. 50 per year for Australia, 20 per year for NSW).

   (b) Scrappage of "old" coaches at a rate approaching the rate estimated from the age profile (i.e. 150 per year for Australia, 60 per year for NSW).

5. What is the effect of coaches being involved in more (F & HA) crashes than their proportion of the total bus fleet alone would suggest. That is, it is assumed that as coaches are 15.45 per cent of bus fleet in NSW that they are involved in 15.45 per cent of bus crashes. What if their involvement is, say, fifty per cent more than the assumed proportion.

9.1 Base calculation for Level 4 Protection (low scrappage)

(a) The number of coaches starts at 850 in the first year and at the end of that year the number drops to 830 due to a scrappage of 20 and so on for each subsequent year.

(b) The benefit from injury reduction starts at $1.623 Million in the first year and is smaller in the second year, $1.585 Million, due to the reduction in the number of coaches available to give a benefit. The benefit each further year becomes progressively smaller.

(c) The benefits from injury reduction in future years are further diminished by the discounting factor (taken as 7 per cent) when they are brought back to Present Value (PV). For example, the benefit in year two reduces from $1.585 M to $1.481 M when made a PV.

(d)	The PV of benefits for 10 years	=	$11.063 M
	The PV of benefits for 15 years	=	$13.672 M
(e)	The cost of fitting all the 850 coaches in year 1	=	$13.158 M
(f)	The BCR for 10 years	=	0.84
	BCR for 15 years	=	1.04

(g) If the number of (F & HA) crashes that coaches are involved is higher than that assumed, say 50 per cent increase from 4.48 to 6.72 crashes per year then -

The PV benefits for 10 years	=	$16.594 M
The PV benefits for 15 years	=	$20.508 M

and

The BCR for 10 years	=	1.26
BCR for 15 years	=	1.56

9.1.1 (ii) First Option

If some of the 850 coaches as at January 1995 are assumed to be already complying with the latest standards, then a reduced number of coaches would be available to be fitted with Level 4 protection. The reduced number was taken to be 810 coaches in the first year and the benefit in the first year therefore $1.546 M. The same scrappage rate of 20 per year was used.

(a)	The PV of benefits over 10 years	=	$10.489 M
and	The PV of benefits over 15 years	=	$12.928 M
(b)	The cost of fitting 810 coaches in year 1	=	$12.539 M
(c)	The BCR for 10 years	=	0.836
	BCR for 15 years	=	1.03

(d) If coach crashes are a higher percentage of bus crashes than assumed (50%) then -

The BCR for 10 years	=	1.25
BCR for 15 years	=	1.54

9.1.2 (iii) Second Option

If some of the 850 coaches comply with ADR 59/00 and can use Level 5 protection, while the remainder use Level 4. For the calculation if a 40/810 split was assumed.

The Level 5 alone does not provide sufficient benefit to cover the costs of installation but taking 4 and 5 together -

	The PV of benefit over 10 years	=	$11.08 M
	The PV of benefit over 15 years	=	$13.66 M
	The cost of fitting	=	$13.766 M
Thence	The BCR for 10 years	=	0.805
and	BCR for 15 years	=	0.990

If coach involvement was 50 per cent higher -

	The BCR for 10 years	=	1.21
and	BCR for 15 years	=	1.49

9.2 Higher Scrappage Rate

Instead of scrappage of 20 per year a rate of 60 was taken, being closer to that experienced in the past.

The corresponding results were -

- Base 850 coaches [*Note* that all the 'old' coaches would be gone in just over 14 years at this scrappage rate].

	The PV of benefit 10 years	=	$8.798 M
	The PV of benefit 15 years	=	$9.387 M
	The cost of fitting 850 coaches	=	$13.158 M
Thence	The BCR for 10 years	=	0.67
	BCR for 15 years	=	0.71

If coach crash involvement is 50 per cent higher -

	The BCR for 10 years	=	1.005
	BCR for 15 years	=	1.065

9.2.1 First Option

810 coaches [*Note* all "old" coaches are gone in 13.5 years]

	The PV of benefit 10 years	=	$8.225 M
	The PV of benefit 15 years	=	$8.642 M
	The PV of benefit 14 years	=	$8.664 M
Thence	The BCR for 10 years	=	0.656
	BCR for 15 years	=	0.689
	BCR for 14 years	=	0.691

If coach crash involvement is 50 per cent higher -

The BCR for 10 years	=	0.984
BCR for 15 years	=	1.03
BCR for 14 years	=	1.04

9.1.2 Second Option

40 coaches Level 5, and 810 coaches Level 4.

	The PV of benefit 10 years	=	$8.69 M
	The PV of benefit 15 years	=	$9.13 M
	The cost of fitting 850 coaches	=	$13.766 M
Thence	The BCR for 10 years	=	0.63
	BCR for 15 years	=	0.66

If coach crash involvement is 50 per cent higher -

The BCR for 10 years	=	0.95
BCR for 15 years	=	0.99

9.3 Consideration of Age Profile and Scrappage

With some coaches being 17 years old at present, a 15 year period to collect benefits would result in some 32 year-old coaches at the end of the period. While one cannot generalise and say that all the older coaches should be scrapped when there might be some younger coaches in a worse condition, it seems reasonable for the purposes of the analyses to scrap the oldest coaches first. Because of the shape of the age distribution (Figure 1) some statistics on the ages are -

17 per cent are older than 12 years

38 per cent are between 8 and 12 years

40 per cent are between 3 and 7 years

5 per cent are under 3 years

The 13 coaches that are 17 years old would have only one year's exposure before being scrapped and would be expected to be involved in a total of .07 crashes (proportional to the number of coaches). The expected benefit from this would only be sufficient to equip 1.6 coaches.

Extending this argument it would appear that there should be a cut off for the fitting program so that the oldest coaches are not treated.

From calculation and interpolation it would appear that the cut off would be around the present age of 10 years (i.e. vehicles aged up to 10 years). Thus 600 coaches in service over a 13 year period would give a BCR just over 1.0. The oldest group of coaches would then be 23 years old vis a vis 32 years with non selective retro-fitting.

With the higher scrappage rate of 60 per year the group to be considered for fitting would be coaches up to 6 years old which over a 10 year period would give a BCR of 0.865 (with 50 per cent greater involvement BCR of 1.3).

The oldest group would then be 17 years old. About 22 coaches would be in this group at the end of 10 years and that can be compared with the 13 coaches presently that age.

10. Conclusions

The amount of data on bus crashes in Australia is limited in content. There is no data readily available specific to coach crashes. To carry out a CBA, it was assumed that the coach crash number was in the same proportion as the number of coaches in the bus fleet.

Information on the coach fleet was obtained, and this showed a drop in recent years in new coaches being produced from 200 per year to 50 per year. This is an important factor in assessing the value of fitting devices to the "old" coaches. The average age of the coach fleet has increased as a result of the slow down in new coach production. The slow down being due it appears from the increased cost of coaches complying with new standards.

While the previous scrappage rate was one of those used in the CBA, the rate of 162 per year over the next 10 years would result in a net drop in the number of coaches in the fleet. So for the CBA several scenarios were considered the first being the rate of new coach construction (50 per year) assumed as the scrappage rate, thus keeping the fleet at its present size.

The supplied estimates for injury reduction from a sample of 19 crashes over 8 years were applied to the recorded Fatal and Hospital Admission bus crashes for NSW 1992 as the best set of data was that available for NSW. Only three broad types (bus vs heavy vehicle, bus vs car, and bus only) were able to be used to derive the benefits in injury reduction from the fitting of occupant protection devices. The savings for these bus crashes was assumed to apply to coach crashes. A weighted mean benefit per bus crash was used.

For the given assumptions and a 7 per cent discount for future benefits, the Level 4 occupant protection would give a positive net present value over a 15 year period and the fitting would appear to be justified.

The Level 5 occupant protection, while it gives 15 per cent more annual benefit costs almost twice that of Level 4 to fit to coaches. A clear case cannot be made for fitting Level 5 alone.

If the number of new coaches being constructed reverted to 200 per year (for Australia) and the scrappage rate returned to that of the recent past, say, 150 per year then a different result emerges. With the scrappage rate three times the previous example the benefits will drop.

Only if the coach crash involvement increases does Level 4 become justified over a 10 year period. A 50 per cent increase in coach accidents will give a BCR of just over 1.0. The assumption that crashes are proportional to numbers of coaches could give an underestimate. It would require only a small increase in the absolute numbers of crashes to coaches to increase them by 50 per cent (4.48 to 6.72).

The current age distribution of coaches needs to be considered as to the likely exposure to crashes of the oldest and hence the likely benefits. It would appear that the cut off for the fitting of Level 4 protection would be coaches older than 10 years for low scrappage and coaches older than 6 years for high scrappage.

References

ANDREASSEN, D. (1992a). Costs for accident-types and casualty classes. ARRB Research Report ARR 227, July 1992.

--------------- (1992). A guide to the use of road accident cost data in project evaluation and planning. ARRB Research Report ARR 226.

--------------- (1994). Model Guidelines for accident data and accident-types. ARRB ATM 29 version 2.1

BLEAKLY, K. (1994). Improved occupant protection in existing buses, prepared for NRTC, FORS and ABCA by Commercial Vehicle Design Services Pty Ltd.

FORS (Federal Office of Road Safety). (1995). Analysis of certain long distance bus crashes 1987-1994 and estimates of injury reduction. FORS March 1995.