BENCHMARKING CANADIAN, AMERICAN AND AUSTRALIAN BUS SAFETY

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Abstract

This paper summarizes the results of a study that compared the road safety record of the Canadian, Australian, and American bus industries. Bus accident rates have been benchmarked against other modes and countries to help highlight areas of concern. The primary objectives of the study were to identify critical safety-related bus issues, further refine information requirements, explore possible countermeasures, and to provide a basis for consultation with stakeholders.

Canada was shown to have comparatively high bus fatality rates, particularly among school and intercity buses. Fatal school bus accidents in Australia were three times more likely to involve a pedestrian compared to Canada or the United States.

All three countries were found to lack data concerning details of bus type and function at the time of the accident, passenger loads, and non-collision injuries. Finally, recent safety initiatives were identified both domestically and abroad and their relevance explored.

Résumé

Ce document résume les résultats d'une étude qui comparait la fiche de sécurité routière des industries d'autobus au Canada, en Australie et aux États-Unis. Les taux d'accident d'autobus au Canada ont été comparés à ceux d'autres modes de transport et d'autres pays pour aider à cerner les problèmes. L'étude visait principalement à identifier les enjeux de sécurité pour l'industrie du transport par autobus, à définir plus clairement les besoins en information, à explorer différentes contre-mesures possibles et, enfin, à fournir un document de fond pour la consultation des intervenants.

Au Canada, le taux d'accidents mortels est relativement élevé dans l'industrie du transport par autobus, particulièrement dans les secteurs scolaire et interurbain. En Australie, les accidents mortels d'autobus scolaires risquent d'impliquer des piétons trois fois plus souvent qu'au Canada ou aux États-Unis.

Les trois pays à l'étude manquent de données détaillées sur le type et la fonction des autobus au moment d'un accident, sur leur capacité en passagers et sur les blessures découlant d'accidents sans collision. Enfin, l'étude fait mention des dernières initiatives de sécurité entreprises au Canada et à l'étranger, et elle évalue l'utilité de chacune.

1.0 Introduction

This study was originally undertaken to help develop a better understanding of the safety issues and where opportunities for improvement lie within the Australian bus industry. However, this paper presents the Canadian perspective in comparison to Australian and U.S. experiences. It was hoped that safety differences in the domestic bus industry could be highlighted by contrasting accident rates with similar countries.

Bus safety typically receives little attention from policymakers except in the wake of high profile accidents. Although collisions involving buses represent a relatively small proportion of all Canadian motor vehicle accidents, there are a number of opportunities to reduce the casualties associated with this class of motor vehicle. The linkages between the identification of safety-related issues, developing countermeasures or strategies, adopting policies/regulations, and expending resources need to be better understood to ensure more consistent processes are followed in the future. It is hoped that a

more objective perspective can be gained through a retrospective analysis of crash statistics and rates. In turn, safety programs and policies can be developed with an optimal return on investment.

1.1 Objectives

The study serves to identify Canadian safety issues for all bus types, further refine information requirements, explore possible countermeasures, and to provide a basis for consultation with stakeholders.

1.2 Method

A review of previous safety-related bus studies was undertaken to provide background to the current work. Detailed analyses of bus collision data were conducted and compared with similar analyses of data from Australia and the United States. By benchmarking Canadian bus collision rates and patterns, problematic areas could be identified and possible countermeasures explored.

1.3 Data Sources and References

Most of the Tables and Figures that follow were developed using information from numerous sources. *While space restrictions do not permit disclosure of complete references for figures and tables in this paper, detailed information is available in the recent study by Hildebrand and Rose (2001).*

It is important to note that since the frequency of serious bus collisions is relatively low, there is often a significant variance in the data from year to year. It was therefore important to try to generate collision rates by using averages spanning multiple years. For this reason, wherever possible the information presented in this paper is derived from averaged data from the mid and late 1990s. The disadvantage of this approach is that any strides achieved through recent changes in policy or standards becomes diluted.

The Canadian Traffic Accident Information Database (TRAID) is a national resource that combines all provincial road collision reports for all severities (property damage, injury, and fatality). Bus accidents within the dataset were analyzed for a ten-year period ending 1998 to provide comparative rates. It should be noted that there are many similarities between Canada and Australia that make a comparison between bus fleet safety appropriate (including geography, demographic distributions and regulatory environment). A recent report published by Transport Canada (1998) entitled *Review of Bus Safety Issues* also provided a very good overview of the bus issues receiving most of the attention at the federal level in Canada.

The study draws heavily on the 'Fatality File' developed by the Australian Transport Safety Bureau (ATSB) (formerly the Federal Office of Road Safety, FORS). This dataset is a composite of State/Territory monthly traffic collision records, coronial reports, and medical records. Most Sate/Territory jurisdictions do not delineate bus type (motor coach, transit, school, etc.) with their accident records, but the 'Fatality File' uses other sources to supplement the mass data. Changes in the coding framework and compilation process have restricted the number of years' worth of available data to 1994, 1996, and 1997. While the 'Fatality File' contains extensive information regarding the more serious collisions, it should be noted that a so-called *safety* study must also consider those collisions involving injuries (of all severities) and non-collision events resulting in injuries. This level of information is not currently available in Australia.

Although the United States Department of Transportation has produced a number of focused bus safety reports, their Fatal Accident Reporting System (FARS) database had to be analyzed to provide a full overview of American bus accident rates.

2.0 The Canadian Experience

Table 1 presents a composite ten-year average of fatalities involving a bus while delineating by type of bus involved.

Table 1: Canadian Fatalities Involving Buses (10-year average; 1989-1998)

Type of Bus Involved	Category of Road User			
	Ped.	Occup. of Other Veh.	Bus Occupants	**Total**
School	5	13	1	**19**
Urban Transit	4	6	0	**10**
Intercity	1	4	5 [1]	**11**
Unspecified	4	9	5	**21**
Total	**14**	**32**	**11**	**57**

1. Includes 1997 Quebec tour bus accident which claimed 43 lives.

Source: Transport Canada, requested query of national Traffic Accident Information Database (TRAID) prepared Nov. 2000.

As shown, over a ten-year period, Canada averaged nearly 57 fatalities per year related to bus collisions. **This equates to nearly one bus related fatality every 6 days.** It is noteworthy that over 80 percent of the fatalities were non-occupants of the bus. Given the relative mass of buses, it is not surprising that occupants of other vehicles represent the largest proportion of fatalities for each bus category.

Using information form the same source, Table 2 was prepared which summarizes the number of bus collisions by severity.

Table 2: Canadian Collisions Involving Buses (10-year average; 1989-1998)

Type of Bus Involved	Collision Severity			
	Fatal	Injury	Property Damage	**Total**
School	16	550	2281	**2847**
Urban Transit	9	732	1771	**2513**
Intercity	5	193	484	**682**
Unspecified	13	595	1872	**2479**
Total	**43**	**2065**	**6392**	**8501**

While the total figures presented in Table 1 only represent approximately 1.42 percent of all Canadian road fatalities, a much more detailed review was needed to identify specific areas that are over represented and therefore candidates for some form of countermeasure.

Important factors that must be considered include estimates of *exposure*. Proxies for exposure to the risk of an accident commonly include number of vehicles in each category, vehicle-kilometres driven, and passenger-kilometres. Although relevant, factors such as traffic volumes, conflict points (intersections, lane changes, etc.), operating speeds, geometric characteristics of the road, time of day/night all play a role in relative levels of exposure they are seldom included in comparative measures due to lack of data.

3.0 Modal Comparisons

To better understand whether the accident experience of Canadian buses presented in Tables 1 and 2 is relatively high or low, it was necessary to benchmark collision rates against comparable countries. As a first step, collision rates were contrasted against other transportation modes. Many of the comparisons that follow include the U.S.A. and Australia because of the availability of appropriate data and given the similarities that exist between these countries as noted earlier.

Figure 1 presents a comparison of the proportion of transportation fatalities by mode. Those killed on the highways consistently represent the vast majority of fatalities, ranging from 92 to 95 percent among the three countries. As noted, total transportation fatalities in Canada were nearly 3,300 in 1997.

A more appropriate way to contrast road safety among the countries is to normalize the number of fatalities. Table 3 presents fatality rates normalized on the basis of population, vehicle fleet size, and by vehicle kilometres of travel. As shown, all rates compare favourably and are generally below the median values for countries belonging to the Organization for Economic Cooperation and Development (OECD). It is noteworthy that the U.S. has a disproportionately high rate per population likely due to the comparatively high level of mobility that country enjoys. However, once car ownership and exposure (kilometres driven) are included the rate per 100 million vehicle-kilometres is the lowest among all three countries. The similarities of the rates strengthen the premise that Canada and Australia provide a good basis for comparison.

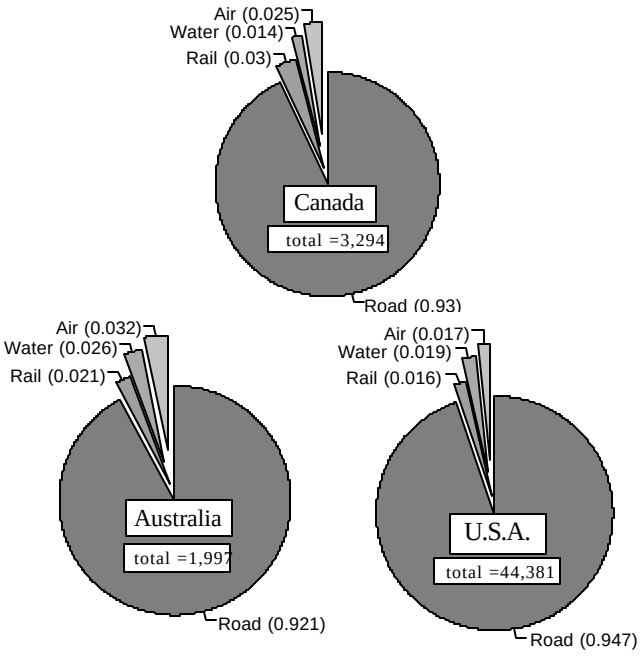

Figure 1: Transportation Fatalities by Mode (1997 data)

Table 3: Road Fatality Rates (average for 1994-96)

	Australia	U.S.A.	Canada	OECD Median
Per 10,000 capita	10.6	15.8	10.9	12.0
Per 10,000 reg. vehicles	1.82	2.02	1.90	2.23
Per 100 million veh.-km.	1.17	1.10	1.11	1.27

To further contrast road safety among the three subject countries, Figure 2 presents a comparison of highway fatalities delineated by different user groups. Of note are the apparent over representation of pedestrians and motorcyclists among Australia's fatalities. Given the snowbelt regions of Canada and the U.S. it is appropriate that the proportion of motorcyclist fatalities would be higher in Australia. The high proportion of pedestrian fatalities in Australia may be attributed, in part, to a higher concentration of the population in larger urban areas.

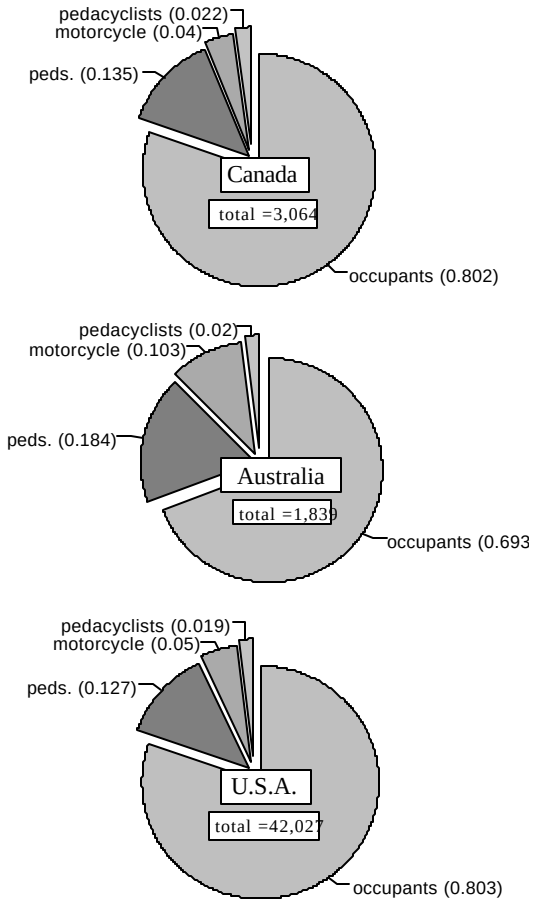

Figure 2: Fatalities by Road User Group (1997 Data)

Finally, the percentage of road fatalities involving buses is presented in Figure 3. Plots for both total bus fatalities (including pedestrians and those in other vehicles) and only those on board a bus are depicted. Canadian figures indicate that 1.42 percent of road fatalities result from collisions involving a bus. This percentage is substantially higher than 0.81 percent experienced by the U.S. and slightly lower than the Australian proportion of 1.77 percent. Interestingly, the number of bus-kilometres relative to total vehicle-kilometres is only about 0.61 percent in Canada Transport Canada, 1999). This would suggest that buses are over represented in fatalities on a per kilometre basis. This is not completely unexpected given the relative mass of the vehicles. However, when considering the number of *passenger*-kilometres that buses provide (approximately 5.6%), the fatality rate is under-representative.

Interestingly, Figure 3 shows that the percentage of bus occupants killed in Australia is 5 and 8 times higher than either Canada or the U.S., respectively. Although these figures are not normalized for bus usage, they do suggest an over representation of bus fatalities within Australia.

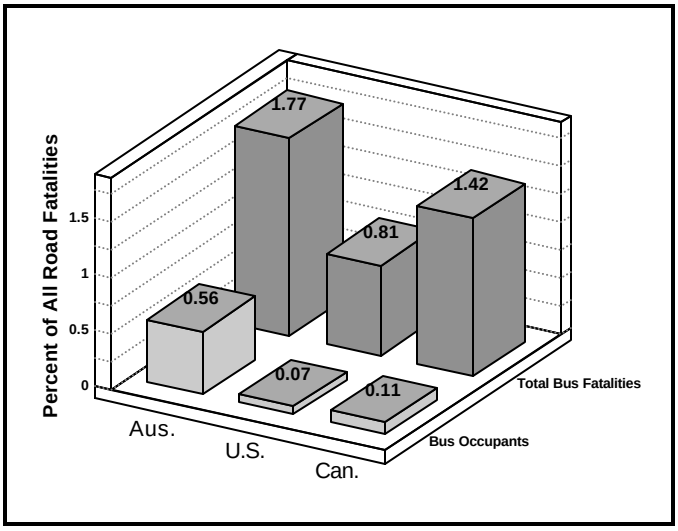

Figure 3: Bus Fatalities

4.0 Bus Collision Rates

Whenever bus accident data are analyzed, the results sometime need to be interpreted with caution given potentially small frequencies and high variances from year to year (particularly if dealing with fatality information). As noted previously, most analyses in this paper include several years of data to *smooth* the effect of outliers. Figure 4 illustrates how erratic bus fatality information can be for countries like Australia and Canada where totals are relatively low. Fatally injured bus occupants are shown to spike in 1997 as a result of a single accident involving a tour bus which claimed 43 lives in Quebec.

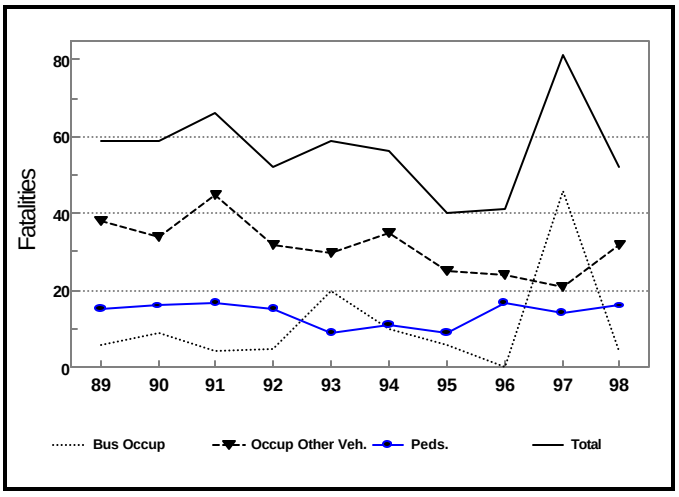

Figure 4: Canadian Trends in Bus Fatalities (1989 - 1998)

In an effort to provide a more normalized comparison of bus accident rates, the data presented in Table 4 were prepared through detailed analyses. Bus fatality rates were developed on a per capita, per vehicle, and per vehicle-kilometre basis. These rates were determined for both total fatalities resulting from a collision involving a bus and for bus occupants only. Note that total bus fatalities include those cases where individuals are killed within the bus (as passengers or the driver), or struck by the bus (as pedestrians, cyclists, or an occupant of another vehicle).

As shown, over an 11-year period, Canada averaged 50 fatalities per year related to bus collisions. On a per capita basis Australia was shown to have the highest rate among the three countries, however, when normalized on a per bus and per bus-kilometre basis the fatality rate was the lowest. This trend is indicative of a comparatively more extensive bus service as evidenced by greater exposure per bus (34,000 kilometres in Australia).

The number of bus occupants killed averaged 5 per year, or approximately one-tenth of the total bus fatalities. This proportion is substantially lower than that in Australia and in line with the U.S. proportion. When normalized for population, bus fleet size, and bus exposure, the Australian rate of fatalities among bus occupants remains relatively high. Canadian rates are consistently higher than those in the United States.

Table 4: Bus Fatality Rates

	Australia	U.S.A.	Canada
Number of Buses (x1,000)	65.7	669.9	64.3
Exposure (x 1,000 km./bus/year)	34.0	15.0	24.8
Population (x 1,000,000)	18.3	265.5	30.0
Bus Fatalities -fatalities (avg. per year) -bus occupants (avg. per year)	 34 11	 340 28	 50 5
Fatality Rates:			
-fatalities (/mill.people) -bus occupants (/mill. people)	1.84 0.58	1.28 0.11	1.65 0.18
-fatalities (/1,000 buses) -bus occupants (/1,000 buses)	0.51 0.16	0.51 0.04	0.77 0.08
-fatalities (/100 million bus-km.) -bus occupants (/100 million bus-km.)	1.49 0.47	3.35 0.28	3.10 0.34

To better illustrate the rates presented in Table 4, the data were plotted in Figure 5 and contrasted against rates that include all classes of road vehicles. The figure clearly shows how buses are over represented in fatal accidents (on a per vehicle-kilometre basis). Given that the fatality rates for bus occupants are generally so much lower, it can be inferred that the casualties are largely non-occupants of the bus.

Some previous bus safety studies have advocated that rates be normalized on the basis of passenger-kilometres of travel. Although this would indeed reflect the relative risk for bus occupants, it would misrepresent the casualties (to both occupants and those outside the bus)

generated by a bus given the relatively high passenger loads.

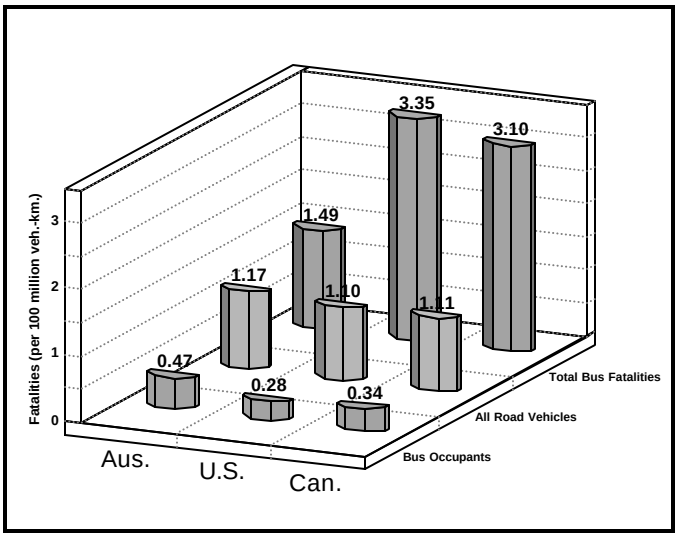

Figure 5: Comparative Fatality Rates

As the data suggest in Figure 5, the majority of fatalities occur to individuals outside the bus (i.e., pedestrians or occupants of other vehicles). Figure 6 depicts bus fatalities by user group for each of the three countries being compared. Canadian proportions are shown to be consistent with those in America except for pedestrians who only account for 11 percent of bus fatalities compared to29 percent in the U.S.. It is noteworthy that bus occupants are over represented among the Australian data with nearly one-third of the fatalities belonging to this group compared to only 13 and 11 percent for Canada and the U.S., respectively. Upon closer examination of the data it was found that half of the bus passenger fatalities occurred on long distance coaches in Australia.

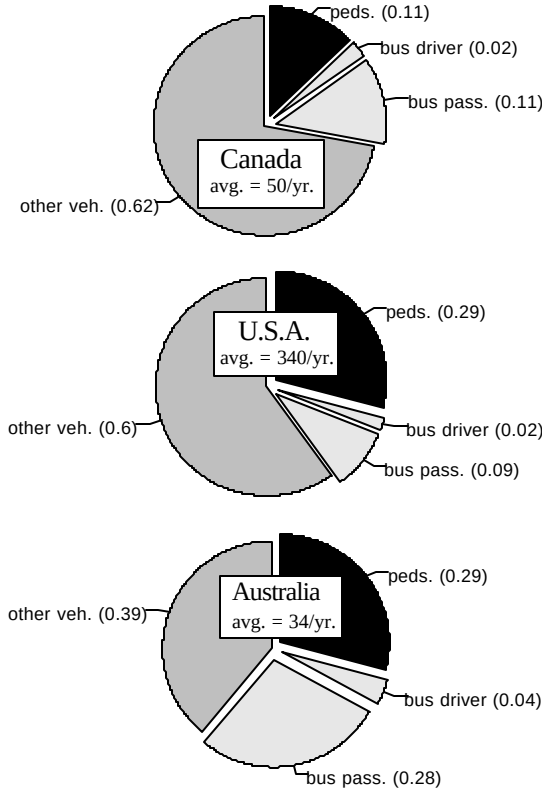

Figure 6: Bus Fatalities by Road User Group

4.1 School Bus Collision Rates

Considerable attention has been given to the issue of school bus safety. Given the level of effort and funding directed toward school bus safety initiatives, it is essential that a clear understanding of the issues be developed. While the recent review of Canadian bus safety issues provides a good overview of some outstanding issues (Transport Canada, 1998) a comparison of the Australian, Canada and U.S. experience is provided herein so that specific problem areas might be identified.

Table 5 provides a detailed summary of analyses conducted specifically for school bus operations. As shown, in Canada over a ten-year period (1989-1998) there averaged just over one death annually to occupants of the school bus. The Australian and U.S. experience is also comparatively low. However, all three countries had at least an order of magnitude more fatalities when

pedestrians and occupants of other vehicles are included.

Table 5: School Bus Fatality Rates

	Australia	U.S.A	Canada
Number of Buses (x1,000)	17.7	440	20.7
Exposure (x 1,000 km./bus)	19.3	15.8	23.0
Bus Fatalities			
-fatalities (avg. per year)	8	119	19
-bus occupants (avg. per year)	0.7	9.0	1.1
Fatality Rates:			
-fatalities (/ mill. people)	0.44	0.45	0.62
-bus occupants (/mill. people)	0.037	0.034	0.037
	0.45	0.27	0.90
-fatalities (/1,000 buses)	0.038	0.020	0.053
-bus occupants (/1,000 buses)	2.36	1.74	3.91
	0.20	0.13	0.23
-fatalities (/100 mill. bus-km.)			
-bus occupants (/100 mill.bus- km.)			

Figure 8 plots the school bus fatality rates from Table 5 in addition to comparable rates for all buses in general. As shown, **Canadian and Australian school buses have a substantially higher fatality rate than all bus categories combined**. The U.S. school bus rate is much lower than that for all buses combined. The figure also serves to illustrate the relative safety of school bus occupants.

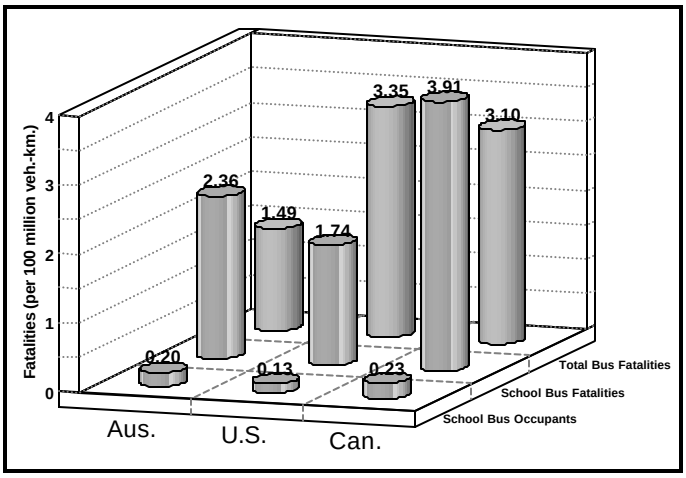

Figure 8: Comparative Fatality Rates: School Buses

Figure 9 contrasts the fatality rates of school bus occupants against occupants from all bus categories combined. All three countries show that school bus occupants are significantly less likely to be fatally injured than those in other bus types. Nevertheless, Australian and Canadian rates are substantially higher than equivalent American rates.

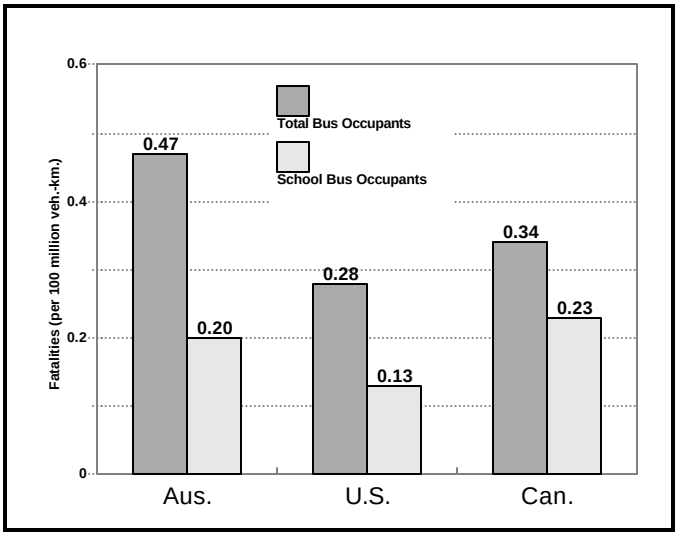

Figure 9: Comparative Occupant Fatality Rates: School Buses

In order to provide a better understanding of the differences in school bus accident rates among the three countries, Figure 10 was developed which plots school bus fatalities by each user group. The percentage of

pedestrians is much larger in Australia (79 percent) than in either Canada or the U.S. (26 percent each). This is a startling difference which may be explained, in part, by the differences in boarding/alighting procedures between Australian and North American school buses. Canadian and the U.S. both have large fleets of dedicated school buses equipped with red flashing lights which signal oncoming traffic to stop before children cross the road while boarding or alighting. Furthermore, the buses are equipped with a comprehensive series of designed mirrors to reduce blind spots around the bus so that the driver can see adjacent pedestrians before moving from a parked position. Much attention has been focused on the issue of providing seatbelts on school buses in North America and Australia. After reviewing Figure 10, it is clear that this effort might be better expended in other areas.

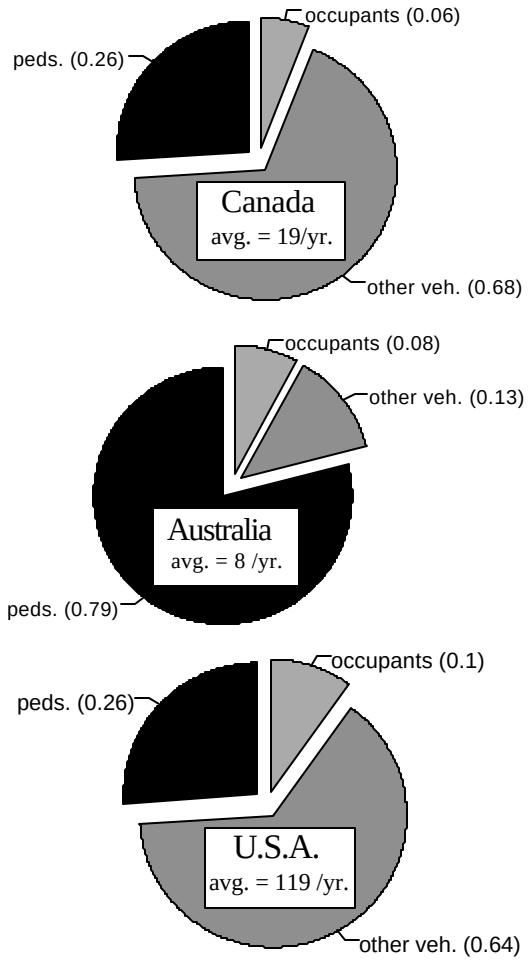

Figure 10: School Bus Fatalities by Road User Group

To explore the issue of school bus pedestrian fatalities further, the literature was reviewed to uncover any patterns. The National Highway Traffic Safety Administration (NHTSA, 1999) indicated that between 1988 and 1998 in the U.S. of the 237 pedestrians killed where a school bus was involved, 162 (or 68 percent) were struck by the school bus itself. Similarly, Transport Canada (1998) reported that the majority of pedestrian fatalities were struck by the school bus (37 of 46 cases, or 80 percent) between 1987 and 1996. While Austroads (2001) does not indicate whether pedestrians were struck by the school bus or an oncoming vehicle, they imply all, or the majority, of the 20 fatalities (1992, 1994 and 1996) involved an oncoming vehicle:

> "...the typical crash scenario appears to be that the child is on his or her way home from school and is unaccompanied by an adult. After getting off the bus they are hit by another vehicle in attempting to cross a 2-way undivided road (mid-block and with no pedestrian crossing in the vicinity). It appears that in most cases the child has attempted to cross the road without looking for oncoming traffic."

This is an important finding because it suggests that the apparent over representation of Australian pedestrian fatalities involving school buses is due to the relatively high incidence of children being struck by oncoming traffic rather than the school bus itself.

NHTSA (1999) reported that nearly half of the school bus fatalities involve those between 5 and 7 years of age. Similarly, Austroads (2001) noted that 77 percent of school bus fatalities of pedestrians involved those between the ages of 5 and 12 years. Clearly, there is a strong correlation between the younger children being transported on school buses and a higher risk of being killed boarding or alighting the vehicle.

4.2 Urban Transit Bus Collision Rates

Fatalities involving urban transit bus operations are summarized in Table 6. Unfortunately information on the Australian fleet size and vehicle use does not exist in a format that permits fatality rates to be developed for comparison with Canada and the U.S.. Nevertheless, fatality rates per capita could be developed. As shown, Canadian rates normalized by fleet populations and mileages are substantially better than U.S. rates. Note, however, that passenger loads are not reflected in these rates. The Australian fatality rate of bus occupants appears to be extremely high in contrast to the other countries. Again, caution needs to be exercised when dealing with numbers of relatively low frequencies, however, more investigation into this area is warranted.

Table 6: Urban Transit Bus Collision Rates

	Australia	U.S.A.	Canada
Number of Buses (x1,000)	n.a.	67.4	10.7
Exposure (x 1,000 km./bus)	n.a.	52.8	63.3
Bus Fatalities -fatalities (avg. per year) -bus occupants (avg. per year)	 6.7 1.9	 85 3.5	 10.1 0.3
Fatality Rates: -fatalities (per million people) -bus occupants (/mill. people) -fatalities (per 1,000 buses) -bus occupants (/1,000 buses) -fatalities (/100 mill. bus-km.) -bus occupants (/100 million bus-km.)	 0.37 0.105 n.a. n.a. n.a. n.a.	 0.32 0.013 1.26 0.052 2.36 0.10	 0.34 0.010 0.94 0.028 1.49 0.04

4.3 Intercity Motorcoach Fatality Rates

Long distance coach collisions were responsible for nearly 12 percent of Canadian bus fatalities as reported in Table 1. Table 7 summarizes the data for all three countries. Given a lack of Australian fleet data fatality rates could only be developed on a per capita basis. The Canadian fatality rates presented are alarmingly high compared to the U.S., particularly among bus occupants [1]. Australian rates appear to be extremely high, however, more information is needed to develop rates on a per vehicle and per vehicle-kilometre basis.

Table 7: Intercity Bus Fatality Rates

	Australia	U.S.A.	Canada
Number of Buses (x1,000)	n.a.	41.0	2.5
Exposure (x 1,000 km./bus)	n.a.	81.5	81.5
Bus Fatalities -fatalities (avg. per year) -bus occupants (avg. per year)	 9.3 4.7	 50.0 4.5	 6.8 1.0
Fatality Rates: -fatalities (per million people) -bus occupants (/ mill. people) -fatalities (/1,000 buses) -bus occupants (/1,000 buses) -fatalities (/100 mill. bus-km.) -bus occupants (/100 mill. bus- km.)	 0.51 0.26 n.a. n.a. n.a. n.a.	 0.19 0.02 1.22 0.11 1.49 0.14	 0.23 0.03 2.76 0.41 3.42 0.50

[1] Despite having excluded the 1997 Quebec accident resulting in 43 fatalities.

5.0 Bus Safety Issues

Following a review of the recent literature and consultation with stakeholders a number of outstanding issues related to bus safety have been identified. These issues are summarized in the following sections and contrasted against ongoing efforts in other countries.

5.1 Bus Data

Although much insight has been gained through the analyses undertaken in Section 4, the lack of detailed data restricted a more thorough examination of issues and trends. At the most basic level, there is much disparity regarding how different jurisdictions delineate different bus types in their police accident reports. Transport Canada (1998) noted that except for school buses ".....other buses are not well defined and are more likely to have interchangeable or overlapping duties." Not only is the bus *type* an important and often missing data element, but the vehicle's *use* may be just as important. In fact, Australian vehicle use estimates are delineated by bus use rather than vehicle type. Nevertheless, most Canadian accident reports generated by the Provinces divide buses into four groups, namely: transit, intercity, school, and other. U.S. data have the same distinctions, however, they also further define school and transit buses according to whether they are van-based. There is much disparity regarding how each Australian State/Territory delineate different bus types. Most simply record a vehicle as a 'bus' without further description.

Interestingly, a review of bus safety presented to the Minister for Transport Victoria (1991) recommended that:

> "...reporting arrangements for Police-reported bus accidents be developed to record bus function (such as route, charter, school trip, private trip) at the time of the accident, to allow improved identification of target groups for educational and other safety initiatives."

It is suggested that bus type as well as function must be recorded to permit more detailed analyses of bus accident/use data.

Detailed analysis of Australian bus collisions typically must rely on more detail provided in coronial reports. Consequently, Australian accident information for injury-only accidents cannot be delineated on the basis of bus type. American data is also somewhat limited beyond that contained in the FARS database. While fatalities are an important aspect of bus safety, they should not be used as the sole source of information to allocate resources or develop policies. Without current data, policy formulation becomes based on averaged data that may not reflect recent behaviour or improved operational procedures.

Austroads (2001) identify a number of data elements not presently collected that are needed to gain better insight into the issues surrounding school bus accidents. They list the following specific elements that should be collected so that analysts might be provided with the information necessary to optimize investments aimed at improving school bus safety:

- pedestrian action prior to collision
-origin and destination of pedestrian trip
-data on secondary vehicles not directly involved in the collision (eg. presence of bus or other vehicle that obscured visibility)
-absence of safety measures (flashing lights, school bus markings, school speed zones, proximity of pedestrian crossing, presence of crossing guard/parent, etc.)

5.2 Bus Design Standards

Adequate passenger protection is as much related to the vehicle design as it is the operating environment. While standards have been developed specifically for school buses less attention has been given to other bus categories. In fact, Canadian and U.S. federal safety standards define safety standards for buses other than school buses collectively.

Transport Canada (1998) notes that there are few Canadian or U.S. federal standards that specifically address structural integrity of motorcoaches (other than for window retention and glazing materials). The U.S. National Transportation Safety Board recently recommended that the National Highway Traffic Safety Administration commence research toward the development and implementation of motorcoach roof strength requirements (NTSB, 1999). The ECE sets out roof strength standards through its Regulation 66.

The Australian Design Rules (ADRs) are federal safety standards that dictate the performance and design requirements for motor vehicle safety. ADRs are broadly similar to those developed in the U.S. (Federal Motor Vehicle Safety Standards, FMVSS) and Canada (Canadian Motor Vehicle Safety Standards, CMVSS). As of 1991, more than 60 percent of the ADRs were aligned with international standards, predominately the Economics Commission for Europe (ECE) regulations (Seyer, 1991). The standards apply to vehicles new to the Australian market, while the State and Territory ministers are responsible for vehicles already in service.

Following two tragic intercity coach accidents in NSW in 1989 (Macksville and Kempsey) that resulted in a total of 57 fatalities, a rash of reforms to ADRs that apply to buses were proposed. Reforms for bus standards for rollover strength, improved seat strength and padding for coaches, and speed limiting had already been in development prior to the collision. The accidents raised concerns over additional issues including emergency exits, laminated glass for side windows, and the need for improved occupant restraint.

5.2.1. Occupant Restraints

5.2.1.1 Intercity Coaches

North American standards have adopted a passive restraint system for large coaches whereby the seatbacks are designed to provide a cushioning function in the event of a collision. NHTSA (1998) has expressly stated that:

> "...there is not a safety need for safety belts or another type of occupant crash protection at these seating positions (aboard commercial buses weighing more than 10,000 pounds)."

Nevertheless, the National Transportation Safety Board (NTSB, 1999) has recommended the development of occupant protection performance standards for frontal, side, rear, and rollover impacts involving both motorcoaches and school buses.

Following the 1989 Australian motorcoach collisions, the ADRs were changed to require medium to large coaches (greater than 3.5 tonnes) to be fitted with 3-point seatbelts for all occupants (Brooks, 2000). The design standard was implemented before any other international standard and is subsequently more stringent than the comparable ECE standard. This requirement does not apply to route service buses, those with less than 17 seats, or buses where the seat is mounted close to the ground (less than 1 metre). Smaller buses are treated much the same as passenger vehicles (3-point restraints for outboard passengers and at least a lap belt for others).

ECE Regulation 14 specifies seatbelts for passenger seats in highway coaches, replacing an earlier guideline for seatbelts only in "exposed seats," usually the first row (ECE, 1999).

5.2.1.2 School Buses

The Canadian and United States have large dedicated school bus fleets which primarily incorporate passive restraints through their seat designs (spacing, seat padding, and seatback height), an approach referred to as *compartmentalization*. Although there continues to be public debate over the merits of seatbelts in school buses, studies have concluded that the passive system provides optimal protection in light of varying passenger heights/weights and seating arrangements (eg., up to three passengers per seat). A NHTSA study in the late 1980s concluded that "School bus crash data show that a Federal requirement for belts on buses would provide

little, if any, added protection in a crash." Interestingly, the Australian ADRs do not recognize "School Buses" as a distinct vehicle category so there are no specific requirements for seat belts for this class of buses.

A few jurisdictions in the U.S. and Canada require the installation of seatbelts on school buses (New York, New Jersey, and Etobicoke). Furthermore, the U.S. has installed seatbelts on small school buses (less than 4536 kg GVW) since the mid 1970s. Evidence suggests that wearing rates diminish to less than 50 percent by the time students reach secondary school (Transport Canada, 1998). A number of studies have concluded that there is no evidence (despite years of experience with seatbelts in small buses in the U.S.) that supports the use of seatbelts in North American post-standard school buses (TRB, 1989, CTSR, 1989, Hatfield and Womack, 1986). Nevertheless, NHTSA is currently undertaking a multi-year comprehensive review of occupant protection for school buses (NHTSA, 1998). Detailed investigations of school bus accidents undertaken by Transport Canada's multi-disciplinary accident teams have concluded that mechanisms provided in school buses according to CMVSS 220 "roof strength," CMVSS 221 "joint strength" and CMVSS 222 "passenger protection" function as designed resulting in very few injuries inside the school buses (Transport Canada, 1989 and 1998).

Since 1998, Great Britain has required seatbelts on all coaches and minibuses used to transport children (School Transportation News, 1998). It is noted, however, that buses used to transport children in Great Britain do not feature passive restraint design as adopted in North America.

5.2.2 School Bus Operations

The U.S. and Canada have harmonized standards that address the operational procedures for loading/unloading of school bus passengers. A long-standing regulation stipulates that traffic must stop while red flashing lights signal when a school bus is embarking or disembarking passengers. A newer standard introduced in 1996 requires stop arms to be installed on the driver side of the bus to reinforce the necessity for other traffic to stop. Some jurisdictions also require a warning period of flashing amber lights to precede flashing red lights (a so-called eight lamp system).

In 1997 Transport Canada introduced a regulation for school buses to have a more complex mirror system fitted to extend the driver's view of blind spots (Transport Canada, 1998). The United States have also recently adopted a similar regulation.

"Crossing control arms" are currently installed on about half of all North American school buses and are required by some jurisdictions (Specialty Manufacturing, 1998). The arms are mounted on the front bumper of the vehicle and force pedestrians crossing in front of the bus into a more direct vision field for the driver. Consideration is also being given to the installation of retro-reflective markings on school buses to increase their conspicuity. A similar regulation has been adopted in both the U.S. and Canada for heavy trucks.

The Austroads study (2001) of school bus safety commissioned by the Australian Transport Council (ATC) learned that there are many differences among the State/Territory safety programs and policies related to school buses. Some of the more contentious issues are highlighted below. Note that policies are in some cases less stringent for nondedicated school bus operations. It is interesting to note differences between North American policies and those in Australia especially in light of the accident experiences previously contrasted in Section 4.1.

1. Vehicle Design:

   Although all jurisdictions require school bus signs on the vehicle, there is a great variance of requirements for flashing lights, hazard lights, additional cross-view mirrors, seatbelts, and rollover protection. (Note: for nondedicated school bus service, SA, WA, and QLD do not require bus signs).

No Australian jurisdiction requires the following devices common in North America: high back seats, mechanical crossing arms/barriers, or stop sign arms.

2. User Safety:

All jurisdictions provide educational programs for school children and bus drivers. Furthermore, parents, teachers, motorists, and preschoolers are targeted by all jurisdictions except ACT and NT.

A fundamental procedural difference exists between jurisdictions regarding passing traffic having to slow/stop when school buses are stopped to allow children to board/alight. WA, QLD, and NT do not require motorists to slow/stop, while VIC requires action only in specified speed zones.

3. Road Environment

All jurisdictions have developed guidelines for school bus stop locations and routes. SA and QLD have undertaken school bus route audits, while WA and VIC are considering implementing like schemes. NSW and WA have restricted operating speeds of school buses. Only ACT prohibits "3 for 2" seating (TAS does not allow the practice for excursions), while all jurisdictions permit students to stand when there are no longer seating positions.

Following the consultation process, a comprehensive Action Plan has been proposed. The Action Plan identifies many detailed strategies for road users, vehicles, and the road environment. In essence, the plan attempts to harmonize policies/practices among the States/Territories by incorporating as many "best-practice" safety-related initiatives as possible. A criticism of the Action Plan is that the recommendations are all-encompassing thereby setting what some view as an unrealistic agenda.

5.3 Regulations for Bus Driving Hours

While most jurisdictions set limits of work during specific periods of time, they do not recognize the dangers of so-called *inverted duty-sleep* periods currently under study by the FHWA (NTSB, 1999). The ATSB, NRTC, and New Zealand are working with recent drivers hours research from the U.S. in an effort to perhaps develop a more 'flexible' framework for drivers that is not as dependent on the 24-hour clock to which the current model is based.

5.4 Non-Collision Injuries

It was previously noted that analysts typically must rely on fatality statistics to delineate the issues/needs related to bus safety since detailed information is often not available for injury-only collisions. Although somewhat dated, a U.K. study (Johnson, 1977) found that **86 percent of injuries to bus passengers occur under non-collision circumstances**. There is no reason to believe a similar distribution doesn't exist in Canada. Johnson indicated that 57 percent occurred under normal conditions (mostly during boarding/alighting or stopping) while the remaining 29 percent resulted from an emergency action taken by the driver (eg., swerve to avoid collision). This is a staggering finding when one considers that few, if any, of these injuries would be captured by a police accident report. In theory, if the bus is moving while such an injury occurs, it should be captured by a police accident report. In practice, such instances are seldom reported. **If one is to consider bus safety, non-collision injuries must be part of the baseline of information.**

6. Summary

Some of the key findings of this study include:

- The Canadian bus fatality rate (expressed per bus-kilometre) is nearly three times that of all road vehicles combined and more than double that experienced in Australia.

- Canada was found to have the highest school bus fatality rate (expressed per bus-kilometre) of all three countries; despite the lack of national school bus standards in Australia. The Canadian school bus fatality rate is even higher than that for all buses combined.

- Australian school bus fatalities are three times more likely to involve a pedestrian than in Canada or the United States.

- Canadian transit fatality rates are substantially lower than those in either the U.S. or Australia.

- The proportion of pedestrians fatally injured in Canadian bus accidents is less than half the proportion in either the U.S. or Australia.

None of the preceding analyses were able to include passenger loads to develop accident rates on a passenger-kilometre basis. When studying the relative safety of bus occupants, this is perhaps the most appropriate measure particularly when examining bus occupant casualty rates. The lack of good data describing passenger loads, vehicle type/use, and injuries resulting from non-collisions precludes a fuller understanding of the safety issues.

The study by Hildebrand and Rose (2001) showed that shuttle or mini-buses were involved in collisions responsible for nearly 20 percent of Australian bus fatalities. Furthermore, the data suggest that this class of bus might also be over represented in personal injury collisions. Little is currently known about the circumstances of these collisions (eg., restraint use, hire/drive, etc.) or whether this rate is over representative given the number of vehicles in this category and exposure. The North American picture is equally unclear. More detailed analyses of this segment of the bus industry are required.

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