NATIONAL ROAD TRANSPORT COMMISSION

TRUCK SAFETY BENCHMARKING STUDY

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National Road Transport Commission

Truck Safety Benchmarking Study

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Abstract:

This study was carried out to benchmark the safety performance of Australia's road transport industry against the safety performance of similar industries in a range of OECD countries. Comparisons were made of truck fatalities in Australia, the United States of America, Canada, New Zealand, the United Kingdom, France, Germany, and Sweden.

Comparisons were made of fatality rates of trucks with a gross vehicle mass rating exceeding 4.5 tonnes. For the purposes of this study buses have been excluded. Fatality rates were used because of the range of comparable data. Injury data were not used because injury reporting criteria and completeness of reporting vary within Australia and in other countries.

The study found that Australia's heavy vehicle fatality rate per kilometre travelled is 47% higher than the USA, 39% higher than the UK, comparable to Germany & Canada, 20% lower than Sweden, 45% lower than France, and 55% lower than New Zealand.

The study concludes that the higher fatality rates on Australian roads compared to Great Britain and the United States may be largely explained by the lower proportion of truck travel on divided and limited access roads in Australia, and possibly truck speed limits. The report focuses on a range of areas that have the potential to improve the safety performance of the heavy vehicle industry. These include road standards, targeted low cost road safety treatments, single vehicle crashes, day and night time driving, measures to improve the safety of truck occupants,

front and rear underrun protection, appropriate speed limits, and data collection.

Purpose: To guide the development of future policies to improve the safety of the Australian road transport industry, and to provide a focus for the national heavy vehicle safety strategy.

Key words: Road transport industry, international benchmarking, safety performance, truck fatality rates, road standards, low cost road safety treatments, single vehicle crashes, day and night time driving, safety of truck occupants, front and rear underrun protection, appropriate speed limits, data collection

FOREWORD

This benchmarking study seeks to compare truck safety in Australia with a range of OECD countries with good safety records. Comparisons were made of truck fatalities in Australia, the United States of America, Canada, New Zealand, the United Kingdom, France, Germany, and Sweden.The truck fatality rate has been declining in Australia and other countries during the past decade or so. While the Australian truck fatality rate is considerably higher than that in the United States and some other countries, the reasons for this are not well understood.

Comparisons were made of fatality rates of trucks with a gross vehicle mass rating exceeding 4.5 tonnes. For the purposes of this study buses have been excluded. Fatality rates were used because of the range of comparable data. Injury data were not used because injury reporting criteria and completeness of reporting vary within Australia and in other countries.

The study concludes that the higher fatality rates on Australian roads compared to Great Britain and the United States may be largely explained by the lower proportion of truck travel on divided and limited access roads in Australia, and possibly truck speed limits. The report focuses on a range of areas that have the potential to improve the safety performance of the heavy vehicle industry. These include road standards, targeted low cost road safety treatments, single vehicle crashes, day and night time driving, measures to improve the safety of truck occupants, front and rear underrun protection, appropriate speed limits, and data collection.

This study will be an important guide for the development of future policies to improve the safety of the Australian road transport industry, and will provide a focus for the development of a national heavy vehicle safety strategy.

SUMMARY

This study compares truck safety in Australia with that in a range of advanced countries with good safety records. During the past ten years the trend in the number of truck fatal crashes has been generally downward in Australia and most of the other countries.

The number of persons killed in crashes involving a truck per 100 million km of truck travel is lowest in the United States (1.7) and Great Britain (1.8), while the rate is somewhat higher in Canada (2.1), Germany (2.2) and Australia (2.5), with France (4.4) and New Zealand (5.5) having considerably higher rates. In summary, the Australian truck fatality rate is 47% higher than that for the United States, 39% higher than Great Britain, comparable to that for Germany and Canada, and about 45-55% below the rates for France and New Zealand.

About two-thirds of fatal truck crashes involved articulated trucks in Australia (63%), Canada (64%) and the United States (70%). The percentages were much lower in Great Britain (38%) and New Zealand (19%), which may reflect the greater use of truck and "dog trailers" in these countries. (In this study a rigid truck towing a trailer is defined as a rigid truck rather as an articulated truck.)

There are a number of other characteristics of Australian fatal truck crashes which differ from those in the other comparison countries for which data is available.

- The percentage of single vehicle crashes (including pedestrians) is higher for Australia (25%) than for the other countries (14% to 20%).
- The percentage of persons killed who are truck occupants is higher in Australia (19%) than in the other countries (10% to 16%).
- The percentage of crashes at night is higher for Australia (39%) than in France (29%), New Zealand (28%) and Great Britain (18%).
- The percentage of crashes which occur in speed zones of 100 km/h or greater is 58%, in Australia, 70% in New Zealand, but only 24% in Canada.
- The percentage of crashes in urban areas in Australia (42%) is higher than that in Canada (29%), New Zealand (28%), Germany (25%) and Sweden (21%).
- The percentage of crashes on freeways in Australia (2.0%) and New Zealand (2.5%) is much lower than that for United States (26%), Germany (21%) and presumably Great Britain (not known precisely). Similarly the percentage of crashes on divided roads in Australia is lower than that in the United States (43%), Great Britain (34%) and presumably Germany (not known precisely).

There are a number of characteristics of fatal **articulated** truck crashes in Australia which differ from those in the comparison countries for which data is available.

- The fatal crash rate per 100 million km travelled is much higher for Australia (3.0) than for Canada (1.5) and for Great Britain, although it is less than for New Zealand (5.0).
- The percentage of single vehicle crashes in Australia (25%) and New Zealand (25%) is much higher than in Canada (15%) and Great Britain (10%).

- The percentage of crashes at night in Australia (45%) is higher than in Canada (35%), New Zealand (31%) and Great Britain (25%).
- In Australia 22% of the fatalities are occupants of the articulated truck, compared with 12% in Canada and 15% in New Zealand.
- The percentage of crashes on divided roads (17%) is lower than in Canada (25%) and Great Britain (25% on motorways plus unknown on other divided roads).

There are also several characteristics of fatal **rigid** truck crashes in Australia which differ form those in the comparison countries, for which data is available. These differences may reflect different operating conditions for rigid trucks in those countries.

- The fatal crash rate per 0^8 km travelled for Australia (1.4) is considerably lower than in Canada (2.6) and New Zealand (4.6).
- The percentage of fatal single vehicle crashes in Australia (23%) is higher than in Canada (18%), New Zealand (19%) and Great Britain (10%).
- The percentage of crashes at night in Australia (31%) is higher than in New Zealand (27%), Canada (19%) and Great Britain (15%).

A study in the United States has reported that the truck fatal crash rate on rural limited access roads was 4.5 times less than on "other rural roads". In urban areas the rate was approximately 2.8 times less on the limited access roads. Similarly the truck fatal crash rates were more than 3 times greater at night than in the daytime. On the other hand when adjusted for road class and time of travel, the differences for various truck configurations were not large, except for bobtail tractors (prime movers without a trailer). The rate for a semi-trailer was 31% greater than for a rigid truck, but 17% less than that of a rigid truck towing a trailer. The rate for a bobtail tractor, however, was more than twice that of a semi-trailer.

Based on simple assumptions, it can be shown that if Australian roads were upgraded to having similar proportions of divided and limited access roads, as in the United States or Great Britain, the Australian truck fatality rate could be expected to be similar to that in these countries and well below the rates in Canada and Germany.

Upgrading of the Australian road system to these standards could take several decades and require significant investment. There are, however, lower cost road and roadside treatments which could achieve some of the potential benefits more rapidly and at a fraction of the cost. In the meantime there is also potential to achieve reductions in the truck fatal crash rate through measures directed at road user behaviour and the vehicle.

Higher speed limits in Australia than in Europe and parts of the United States, particularly for articulated trucks on roads of less than freeway standard may also be a contributory factor to the higher Australian truck fatal crash rate, although actual speeds depend on the extent of speed enforcement and use of speed limiters.

Compared with the other countries, Australia has the highest proportion of single vehicle fatal crashes and the highest proportion of truck occupant fatalities. There is potential to reduce truck occupant fatalities through less night-time driving, improved fatigue control, more protective cabin structures and increased use of seat belts by truck occupants.

In regard to multi-vehicle crashes there is also potential to reduce car occupant fatalities by providing improved truck rear and front underrun barriers. In addition, side underrun barriers or skirts have the potential to reduce fatalities of unprotected road users.

The data which is available for Australia and the other countries limited the comparisons which could be made, particularly for articulated and rigid trucks separately. There is a need to collect more data on both truck crashes and exposure to enable further progress to be made in research relating to truck safety in Australia.

The following recommendations to improve truck safety in Australia have been made.

1. In order to significantly improve the safety of truck operations in particular and road safety generally, the construction of divided highways, removal of roadside hazards and provision of other low cost safety treatments should be accelerated, where possible. Where warranted, consideration should be given to limited access roads (roads that are grade separated and have dual carriageways).

   While these road improvements have considerable potential in the longer term, in the meantime there is also potential to reduce the truck fatal crash rate through a range of measures directed at the vehicle and road user behaviour.

2. In order to address the fact that Australia has a higher proportion of truck fatal crashes at night and a higher proportion of single vehicle crashes, the road safety risks of day and night-time truck operation should be quantified and compared. (This may require the improvements in data collection outlined in Recommendations 6 and 7.) If night-time fatal crash risks are substantially higher than daytime risks, consideration should be given to the development, in consultation with the freight industry, of operating practices which reduce the amount of truck travel at night, or improve the fatigue management of night time travel.

3. Measures should be taken to improve the safety of truck occupants, which is both a road safety and an Occupational Health and Safety issue. Consideration should be given to the adoption of a cab-strength standard such as that used in Sweden. The wearing of seat belts by truck occupants should be further encouraged and enforced where practicable.

4. In order to provide improved protection for road users other than truck occupants, consideration should be given to adoption of the ECE Regulations for Rear Underrun Protection (No.58), Front Underrun Protective Devices (No.93) and Lateral Protection of Trailers and Semi-trailer Goods Vehicles (No.73).

5. Consideration should be given to adopting speed limits that better manage the risks of the road and traffic environment for each class of vehicle, as has been attempted in many European countries and some States in the United States.

6. In order to better monitor and understand truck safety in Australia, more timely and complete data about fatal truck crashes should be collected. Consideration should be given to supplementing the current monthly provision of data on fatal articulated truck crashes with similar data on rigid truck crashes.

In order to enable further progress to be made in research relating to truck safety, arrangements should be made for collection of truck travel data, especially on the major truck routes. As a first step, an investigation should be undertaken of what data could be obtained from existing collections.

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1. INTRODUCTION

This benchmarking study seeks to compare truck safety in Australia with several other countries with good safety records. For the purposes of this study a truck has been defined as a heavy commercial vehicle other than a bus with gross vehicle mass rating of 4.5 tonnes (or 3.5 tonnes for those countries where it was not possible to exclude vehicles of 3.5 to 4.5 tonnes from the data).

Comparison has been limited to fatality rates because it is known that injury reporting criteria and completeness of reporting vary within Australia and in other countries. The truck fatality rate has been declining in Australia and other countries during the past decade or so. Yet the Australian truck fatality rate is considerably higher than that in the United States and some other countries, but the reasons for this are not well understood.

The National Road Transport Commission requested the provision of data for this study from the relevant government agencies in Canada, France, Germany, New Zealand, Sweden, Great Britain and the United States. In order to facilitate the analyses and comparisons, it was requested that the following variables be provided for each fatal truck crash (ie where there was at least one fatality):

- type of truck involved (rigid or single-unit, towing one trailer, towing more than one trailer);
- number of vehicles involved;
- type of crash (rollover, run-off-road, other single vehicle, head-on, other multiple vehicle);
- number of truck occupants killed;
- number of other road users killed (ie occupants of other vehicles, motorcyclists, pedestrians, bicyclists, etc);
- urban or rural;
- State or region;
- speed limit applicable to heavy vehicles;
- road type (undivided, divided); and
- time of day.

If it was not possible to provide the above information for each individual crash, summary data relating to each of the variables was requested.

Disaggregation of the data into the above categories would enable more appropriate comparisons to be made, allowing for factors that are known to influence fatal crash rates.

In order to enable crash rates to be calculated, the number of registered vehicles and the annual distance travelled, if possible, for each category of truck was also requested. Disaggregation of this exposure data by as many of the above variables as possible was also requested.

Unfortunately the amount of data received varied greatly from country to country and the definitions of some of the variables eg type of truck, gross vehicle mass were different. Even after obtaining additional data from other sources such as reports, web sites and personal contacts, there are still gaps in the detailed data available for each of the eight countries.

Section 2 contains a summary of the analyses which have been possible given the data available. While some important comparisons of overall truck fatal crash rates have been possible for most of the countries, the gaps in data, particularly when disaggregated into articulated trucks and rigid trucks, have limited comparisons for these truck types.

Section 3 contains a discussion of the differences in fatality rates.

The appendices present the detailed data for each country and any qualifications or definitions which must be applied to that data.

The more important definitions are set out below.

Where possible, this report refers to prime movers with or without trailers as articulated trucks and refers to load-carrying trucks with or without trailers as rigid trucks. Articulated trucks also include prime movers towing more than one trailer (eg road trains and B-doubles).

In the New Zealand crash data articulated or rigid truck is not coded. Following advice from the Land Transport Safety Authority, trucks were classified based on what they were towing. Trucks not towing a trailer and trucks towing a boat, caravan or trailer, were classified as rigid trucks. Trucks towing a semi trailer, A train or B train, were classified as articulated trucks. Thus prime movers without a semi-trailer could not be separated from rigid trucks.

Those trucks referred to in the Canadian data as “straight trucks” are termed rigid trucks and “tractor trailers” are termed articulated trucks in this report.

Single unit trucks and truck/trailers in the US data were classified as rigid trucks in this report. Truck tractors (bobtails), tractor/semi trailers, tractor/doubles and tractor/triples were classified as articulated trucks.

The data from Great Britain divided the trucks into articulated and rigid categories but the definition was not stated. In other jurisdictions, type of truck was unavailable for either or both of the crash and distance travelled data.

2. SUMMARY TABLES

2.1 Trends in Fatal Truck Crashes

Table 2.1 shows that the trend in the number of fatal truck crashes is generally downward although it is less pronounced in the United States than in the other countries shown. In fact the number has risen in the United States during the past few years. For Australia, the total number of fatal crashes involving trucks is known for only a subset of years, so the number of articulated truck fatal crashes has been shown.

Various factors can influence the total number of fatal crashes, including total distance travelled, changes to vehicle safety standards, improvements to the road system and regulations relating to truck operations. As most fatalities in fatal truck crashes are not truck occupants, these factors are relevant not only for truck operations, but also for all road users.

Table 2.1 Trends in the number of fatal truck crashes

Year	Australia		New Zealand	United States	Canada	France	Germany
	All trucks	Articulated trucks					
1989		250	107	4674	574		
1990	342	205	85	4518	562		
1991		156	81	4097	502		
1992	270	154	78	3825	453	1120	1696
1993		171	87	4101	516	1106	1637
1994	265	151	96	4373	489	1065	1657
1995		165	107	4194	465	1086	1678
1996	245	161	77	4413	435	946	1526
1997	257	146	86	4614	468	918	1529
1998	227	151	75	4492	423	947	1372
1999		163	97			898	

2.2 Comparison of Fatality Rates for Trucks and all Vehicles

Table 2.2 shows that the number of persons killed in truck crashes per 10^8 kilometres of truck travel is lowest in the US (1.69) and Great Britain (1.79), while Germany (2.22), Canada (2.10) and Australia (2.49) have somewhat higher, but similar, rates. The rates for France (4.4) and New Zealand (5.52) are considerably higher. In summary the Australian truck fatality rate is 47% higher than that for the United States, 39% higher than Great Britain, comparable to that for Germany and Canada, and about 45-55% below the rates for France and New Zealand.

The rate for Sweden (3.12) may not be comparable as it is for trucks of GVM exceeding 7 tonnes, whereas those for the other countries are in the range 3.5 to 4.5 tonnes. This is consistent with the fact that the ratio of the truck to the all road fatality rate is considerably higher for Sweden than for the other countries. Hence the Swedish data will be used with caution.

The ratio of truck fatality rate to the total road fatality rate is an indicator of the extent to which the truck fatality risk is greater than the overall road fatality risk. If Sweden is omitted, then the ratio varies from a low of 1.49 in Great Britain, 1.72 in the United States and 1.79 in Germany, to 2.93 in France and 3.30 in New Zealand. The ratio of 2.07 for Australia is below the midpoint of the range, but it indicates that when compared with Great Britain, the United States and Germany, the Australian truck fatality risk is worse than the overall road fatality risk.

Table 2.2 Number of persons killed per 100 million kilometres travelled (fatality rate). Where numerator and denominator data are from different years, the year is expressed as numerator/denominator. "All vehicles" data are from International Road Traffic and Accident Database (IRTAD) or supplied by individual jurisdictions.

Nation	Trucks			All vehicles		Ratio of fatality rates trucks: all vehicles	Percent fatalities with trucks involved
	GVM exceed tonnes	Fatality rate	Year	Fatality rate	Year		
Australia	4.5	2.49	1996/95	1.2	1995	2.07	14.9
New Zealand	4.5	5.52	$\frac{1997-99}{1997}$	1.67	1998/95	3.30	20.3
Great Britain	3.5	1.79	1998	1.2	1998	1.49	16.8
France (1)	3.5	4.4 (2)	1995	1.50	1995	2.93	13.6
Germany	3.5	2.22	1998	1.24	1998	1.79	19.4
Sweden	7.0	3.12 (3)	1998/97	0.79	1998	3.94	15.3 (4)
Canada	4.54	2.10	1998/99	0.94	1998/99	2.23	16.3 (5)
United States	4.54	1.69	1998	0.98	1998	1.72	13.0

(1) France only counts fatalities within 6 days of crash (30 days elsewhere)
(2) exposure corrected for change to GVM>5 tonnes in travel data
(3) data from Swedish National Road Administration
(4) percent of fatal crashes involving trucks
(5) fatal truck crashes as a percentage of all fatalities

Further analyses are required to provide an indication of why the truck fatality rate in Australia is greater than that in the United States, Germany and Great Britain, both in absolute terms and when compared with the overall fatality rate. Similarly, both Australian rates are lower than the corresponding rates for New Zealand and France.

Table 2.2 also shows the relative importance of the truck fatalities, expressed as a percentage of total road fatalities. The percentage ranges from 13.0% in the United States to 20.3% in New Zealand. Australia's percentage is 14.9% which is towards the bottom of the range.

Comparisons of some of the factors which may influence truck fatal crash rates and the ratio to the overall road fatal rate are made in the remainder of this section.

2.3 Comparisons of Fatality Rates

The truck fatality rate per registered vehicle as shown in Table 2.3 shows a somewhat different relationship between countries to the extent that the distance travelled per truck varies between countries as shown in Table 2.4. Thus the much greater distances travelled by the average truck in Canada (54,751 km) and the United States (43,302 km) compared with Australia (30,046 km) result in the Canadian rate (11.48) being considerably above the Australian rate (7.47) and the United States rate (7.34) being approximately the same as the Australian one.

Table 2.5 also shows the average percentage of truck travel ranges from 5.0% (France) to 10.9% (Germany), with Australia at 7.1%, similar to the United States (7.3%), Canada (7.8%) and Great Britain (7.3%).

Table 2.3 Number of persons killed in truck crashes per 10,000 vehicles registered. Where numerator and denominator data are from different years, the year is expressed as numerator/denominator. All vehicles data derived from IRTAD 1998 values.

Nation	Trucks		All vehicles	
	Fatality rate	Year	Fatality rate	Year
Australia	7.5	1996/95	1.46	1998
New Zealand	14.0	$\frac{1997-99}{1997}$	2.17	1998
Great Britain	13.7 (1)	1998	1.26	1998
France			3.02	1998
Germany	7.6	1998	1.57	1998
Sweden			1.18	1998
Canada	11.5	1998/99	1.67	1998
United States	7.3	1998	1.99	1998

(1) may be inflated by crash data including non-GB trucks but registration data being GB-registered only

Table 2.4 Distance travelled per registered truck (kilometres)

Country	Articulated trucks	Rigid trucks	All trucks
Australia (1995)	87,900	20,000	30,046
New Zealand (1997)	45,661	23,237	24,080
Great Britain (1998) (1)	111,000	64,000	76,600
France			
Germany (1998)	83,000	24,400	
Sweden			
Canada (1999)	119,885	21,816	54,751
United States (1998) (2)	112,015	20,066	43,302

(1) may be inflated by travel data including non-GB trucks but registration data being GB-registered only
(2) definition of articulated and rigid not strictly comparable to Australian data.

Table 2.5 Percent of travel that is truck travel

Country	Truck travel (million VKT)	Total travel (million VKT)	Percent of travel that is truck travel
Australia (1995)	11,819	166,514	7.1
New Zealand (1997)	1,847	30,000	6.2
Great Britain (1998)	32,100	438,785	7.3
France (1995)	25,000	496,000	5.0
Germany (1998)	68,200	625,900	10.9
Sweden			
Canada (1999)	24,085	310,681	7.8
United States (1998)	313,685	4,306,136	7.3

Table 2.6 gives truck data similar to that in Table 2.2 and Table 2.3, but in terms of fatal crashes per 10^8 km travelled. As fatalities per fatal crash do not vary much between countries (from Germany at 1.10 to Australia at 1.20), these comparisons between countries do not differ greatly from those in Tables 1.2 and 1.3. The higher values of fatalities per crash may be the result of more severe (higher speed) crashes, or more road users involved in crashes.

Table 2.6 Fatal crashes of all Trucks – overall

Item	Nations							
	Aust	NZ	GB	France(1)	Germany	Sweden	Can	USA
Period	1996	1997-9	1998	1998	1998	1998	1998	1998
Fatalities	294	102	576	1102	1515		505	5,316
Fatal crashes	245	86		947	1372	106	423	4,492
Fatalities/fatal crash	1.20	1.19		1.16	1.10		1.19	1.18
Fatal crashes per 10^8 kms	2.07	4.66		3.79 (2)	2.01	3.12	1.76	1.43
Fatal crashes per 10,000 registered trucks	6.23	11.83			4.37	3.13	9.62	6.20

(1) France only counts fatalities within 6 days of crash (30 days elsewhere)
(2) exposure corrected for change to GVM>5 tonnes in travel data

Table 2.7 shows that about two-thirds of fatal truck crashes involved articulated trucks in Australia (62.9%), Canada (63.6%) and the United States (69.6%). The percentage of articulated trucks in crashes was much lower in New Zealand (18.6%) and Great Britain (38.2%), which may reflect the lower proportion of articulated trucks in these two countries. (Note that in this study a rigid truck towing a trailer such as the "truck and dog trailer" commonly used in New Zealand and Great Britain is defined as a rigid truck rather than as an articulated truck.)

The 42% of crashes in urban areas shown in Table 2.7 for Australia is higher than that for New Zealand, Germany, Sweden and Canada (23.6% - 28.8%) and may reflect the higher urban speed limit in Australia.

Table 2.7 shows that for trucks the percentage of single vehicle crashes (including pedestrians) is higher for Australia (24.9%) than is the case for other countries (14.0% to 19.8%). The percentage of single vehicle crashes that involved only the truck (not a pedestrian) was also higher in Australia (13.9%) than in the other jurisdictions (5.5% to 10.1%). The difference may be due to such factors as a lower traffic density which results in a lower probability of encountering other vehicles, a smaller percentage of travel on roads with safety features to reduce the probability of fatal single vehicle crashes, eg sealed shoulders and fewer roadside hazards, or possibly greater driver impairment due to fatigue, alcohol or drugs. These factors warrant further investigation, if the relevant data can be obtained.

The much higher percentage of truck fatal crashes on limited access roads in the United States (25.6%) compared with 2.0% for Australia and 2.5% for New Zealand, is a partial explanation for the lower fatality rates achieved in the United States and Great Britain. The same applies for the much higher percentage of truck crashes on divided roads (including freeways) in the United States (42.9%) compared with Australia (20.6%).

These findings are likely to reflect the much greater prevalence of limited access roads in the United States than in Australia. Austroads (2000) defines “controlled access roads” as roads that are grade separated, having dual carriageways and having a length greater than 5 km. There were 1563 kms of controlled access roads in Australia in June 1999. This compares to 18,400 kms of National highway, 96,840 kms of rural arterial roads and 12,232 kms of urban arterial roads. In urban areas of Australia, there is 6.6 km of controlled access road per billion vehicle-km. In urban areas of the United States, there is 8.3 km of controlled access road per billion vehicle-km.

Table 2.7 Summary table for all Trucks – characteristics of crashes

Item	Nations							
	Aust	**NZ**	**GB**	**France**	**Germany**	**Sweden**	**Can**	**USA**
Period	1996	1997-9	1998	1998	1998	1998	1998	1998
Fatal crashes	245	86		947	1372	106	423	4,492
Articulated truck crashes (%)	62.9	18.6	33.1				63.6	69.6 (1)
All SV crashes (incl. peds) (%)	24.9	19.8	10.2	14.0		19.8	16.1	18.0
Truck-only crashes (%)	13.9	10.1	5.9	5.5	6.3	5.7		
Truck-ped crashes (%)	11.0	9.7	4.3	8.6		14.2		
Urban (%)	42.1	27.5	63.9		24.9 (2)	23.6	28.8	
Rural (%)	57.9	72.5	36.1		53.9 (2)	76.4	71.2	67
Speed zone (%)								
<60 km/h	0.5	19.8	31.0 (3)			16.0	18.3	
60 km/h	25.0	2.3	9.6 (3)				5.1	
70-75 km/h	5.5	5.4				22.6	6.6	
80 km/h	10.0	3.1	3.5 (3)				16.5	
90 km/h	1.4	0.0				50.9	29.7	
100 km/h	39.5	69.4	29.0 (3)				23.4	
>100 km/h	18.2	0.0	26.8 (3)			10.4	0.3	
All night (%)	38.8	27.5	18.1	28.5			32.6	31.4
1800-2359	19.2	17.8						
0000-0559	19.6	9.7						
Intersection (%)	30.2		45.0	21.6				
Divided road (%)	20.6 (2.0 free-ways)	Unknown (2.5 motor-way)	34.4	Unknown (12.1 auto-routes)	Unknown (21.2 auto-bahns)	2.8	20.8 (3.1 freeways)	42.9 (25.6 Interstate Highway)

Note: Where some data is unknown, the percentages are calculated as "percent of known".

(1) based on trucks involved in fatal crashes, which would be somewhat greater than the number of crashes
(2) "inside towns" and "outside towns" both exclude autobahns
(3) GB speed limits are in mph. These have been grouped as following: (<30 mph, 30 mph into <60 km/h), (40 mph into 60 km/h), (50 mph into 80 km/h), (60 mph into 100 km/h), (70 mph and >70 mph into >100 km/h)

The percentage of fatal truck crashes which occur at night shown in Table 2.7 varies from 28.5% for France to 37.4% for Australia. This higher proportion of fatal crashes at night in Australia may be due to the greater exposure, or poorer conditions for night-time travel and warrants further investigation.

Table 2.7 also shows that in Australia 57.7% of truck crashes occur in speed zones of 100 km/h or greater, while in New Zealand the figure is 69.4%, but in Canada is only 23.7%. (When the 90 km/h speed zones are included the Canadian figure is 53.4% and the Australian figure 59.1%.) As discussed in Section 3, it should be noted that in New Zealand, Great Britain, several States of the United States and in some other countries the maximum speed limit of trucks is lower than that for cars.

As shown in Table 2.8, the percentage of persons killed who are occupants of the trucks varies from 9.8% (France) and 10.4% (GB) to 19.0% in Australia. The somewhat higher percentage in Australia is consistent with Australia having the largest percentage of truck-only truck fatal crashes. It also indicates the need for further analyses to determine whether occupant protection in Australian trucks is poorer than in those of other countries, or whether other factors are involved (see Section 3).

The percentage of persons killed who were non-occupants (pedestrians and bicyclists) in Australia was mid-way between the low percentages reported in France, Canada and the United States and the higher percentages reported in Great Britain. This probably reflects the greater number of unprotected road users exposed to crashes in Great Britain.

Table 2.8 Summary table for all Trucks – characteristics of persons killed

Item	Nations							
	Aust	NZ	GB	France	Germany	Sweden	Can	USA
Period	1996	1997-9	1998	1998	1998	1998	1998	1998
Fatalities	294	102	576	1102	1515		505	5,316
Fatalities per 10^8 kms	2.49	5.52	1.9	4.4	2.22		2.10	1.69
Fatalities per 10,000 registered trucks	7.47	14.03	13.7 (1)		4.83		11.48	7.34
Persons killed (%)								
Truck occupants	19.0	12.8	10.4	9.8	16.1		13.1	13.9
All other vehicle occupants (incl. motorcyclists)	65.3	72.4	68.9	78.6			76.0	76.8
Non-occupants	15.7	14.7	20.7	11.6			10.9	9.3
Car occupants		66.2		64.9				74.9
Motorcyclists		6.2		8.1			2.4	
Pedestrians		10.8		8.3			8.3	
Bicyclists		3.9		3.3			2.6	
Other vehicle occupants		0.0		5.7				1.9

(1) may be inflated by crash data including non-GB trucks but registration data being GB-registered only

The sections that follow present crash and fatality data disaggregated into articulated and rigid trucks. The definitions of articulated and rigid applied to the data from each country are described in the Appendices. Data for articulated and rigid were not available for France, Germany and Sweden. Very limited data was available for the United States and was expressed in terms of trucks involved, rather than in terms of number of crashes.

2.3.1 Articulated trucks

Table 2.9 shows that for articulated trucks the fatal crash rate per 10^8 km travelled is much higher for Australia (3.02) than for Canada (1.52) and for Great Britain. This is in contrast to these rates being similar for all trucks and shows a much greater risk for articulated trucks in Australia. The rate per 10^4 registered vehicles in Australia (26.6) is also higher than the Canadian rate (18.2), but the difference is not as large, because the average Canadian articulated truck travels a greater distance annually.

Australia has a similar number of fatalities per articulated truck crash as Canada (1.22 versus 1.19) but the number for New Zealand (1.38) is somewhat larger.

Table 2.9 Fatal crashes of Articulated Trucks – overall

Item	Nations							
	Aust	NZ	GB	France	Germany	Sweden	Can	USA
Period	1996	1997-9	1998		1998		1998	1998
Fatalities	188	22					319	
Fatal crashes	154	16	227 (1)				269	3,435 (1)
Fatalities/fatal crash	1.22	1.38					1.19	
Fatal crashes/10^8 artic km	3.02	4.97	1.83 (1)				1.52	
Fatal crashes/10,000 registered artics	26.6	22.69	20.5 (1)				18.2	

(1) based on trucks involved in fatal crashes, which would be somewhat greater than the number of crashes

Table 2.10 shows that, for articulated trucks, the percentage of single vehicle crashes in Australia (25.3%) and New Zealand (25.0%) is much higher than in Canada (14.5%) and Great Britain (10.3%). In Australia 71.2% of articulated truck fatal crashes occur in speed zones of 100 km/h or greater, while in New Zealand the figure is 85.4% and in Canada only 29.4%. (Even when the 90 km/h speed zones are included the Canadian figure is only 60.7%.) If travel speeds are related to the legal speed limit, this could be a partial explanation of the reasons why the Australian fatal crash rate is 99% higher than the Canadian rate.

Table 2.10 Summary table for Articulated Trucks – characteristics of crashes.

Item	Nations							
	Aust	**NZ**	**GB**	**France**	**Germany**	**Sweden**	**Can**	**USA**
Period	1996	1997-9	1998		1998		1998	1998
Fatal crashes	154	16	227 (1)				269	3,435 (1)
All SV crashes (%)	25.3	25.0	10.3				14.5	
Truck-only crashes (%)	16.9	20.8	8.1					
Truck-ped crashes (%)	8.4	4.2	2.3					
Urban (%)	34.5	14.6	57.0				25.7	
Rural (%)	65.5	85.4	43.0				74.3	
Speed zone (%)								
<60 km/h	0.7	6.3	17.4 (2)				15.4	
60 km/h	16.2	6.3	7.2 (2)				5.6	
70-75 km/h	2.9	2.1					6.1	
80 km/h	8.0	0.0	4.4 (2)				12.1	
90 km/h	0.7	0.0					31.3	
100 km/h	46.3	85.4	28.9 (2)				29.4	
>100 km/h	24.9	0.0	42.2 (2)				0.0	
Night (%)	44.8	31.3	24.9				34.8	
1800-2359	22.7	14.6						
0000-0559	22.1	16.7						
Intersection (%)	26.6		38.1					
Divided road (%)	17.4	Unknown (0.0 on motor-way)	27.8				25.3	

(1) based on trucks involved in fatal crashes, which would be somewhat greater than the number of crashes

(2) speed limits are in mph. These have been grouped as following: (<30 mph, 30 mph into <60 km/h), (40 mph into 60 km/h), (50 mph into 80 km/h), (60 mph into 100 km/h), (70 mph and >70 mph into >100 km/h)

The percentage of articulated truck fatal crashes on divided roads is 17.4% in Australia, lower than in Canada (25.3%) and Great Britain (25.1% on motorways plus an unknown percentage on other divided roads).

The percentage of articulated truck fatal crashes at night in Australia (44.8%) is higher than in Canada (34.8%) in New Zealand (31.3%) and in Great Britain (24.9%). This could be a contributor to the higher rate in Australia.

As shown in Table 2.11, in Australia 21.8% of the fatalities are occupants of the articulated truck compared with 11.9% in Canada and 15.2% in New Zealand. As discussed for all truck crashes, this is consistent with Australia having a high percentage of truck-only crashes among fatal articulated truck crashes.

Table 2.11 Summary table for Articulated Trucks – characteristics of persons killed

Item	Nations							
	Aust	NZ	GB	France	Germany	Sweden	Can	USA
Period	1996	1997-9	1998		1998		1998	
Fatalities	188	80					319	
Fatalities per 10^8 kms	3.69	6.83	1.8 (1)				1.80	
Fatalities per 10,000 registered artics	32.45	31.20					21.59	
Persons killed (%)								
Truck occupants	21.8	15.2					11.9	
All other vehicle occupants	66.5						74.0	
Car occupants		69.7						
Motorcyclists		6.1					2.8	
Pedestrians		4.5					7.2	
Bicyclists		4.5					3.1	
Other vehicle occupants								

(1) trucks involved in fatal crashes

2.3.2 Rigid trucks

Table 2.12 shows that for rigid trucks the number of fatal crashes per 10^8 km travelled in Australia (1.41) is considerably lower than in Canada (2.56) and New Zealand (4.59). Similarly, the number of fatal crashes per 10,000 registered vehicles in Australia (2.83) is considerably less than in Canada (5.58) and New Zealand (11.76). These results are in contrast to the higher fatality rates in Australia than in Canada for articulated trucks.

Table 2.12 Summary table for Rigid trucks – overall

Item	Nations							
	Aust	NZ	GB	France	Germany	Sweden	Can	USA
Period	1996	1997-99	1998				1998	1998
Fatalities	110	80	408				187	
Fatal crashes	95	70	368 (1)				163	1,195(1)
Fatalities/crash	1.16	1.14	1.11 (1)				1.15	
Fatal crashes/10^8 rigid km	1.41	4.59	1.87				2.56	
Fatal crashes/ 10,000 registered rigids	2.83	10.67	11.9 (2)				5.58	

(1) based on trucks involved in fatal crashes, which would be somewhat greater than the number of crashes
(2) may be inflated by crash data including non-GB trucks but registration data being GB-registered only

Table 2.13 shows that in Australia 23.2% of rigid truck fatal crashes are single vehicle compared with 17.8% in Canada, 18.6% in New Zealand and 10.2% in Great Britain. This difference is consistent with the data for all trucks.

Table 2.13 also shows that in Australia about half of the rigid truck crashes occurred in urban areas. In contrast, only about 30% of rigid truck crashes in New Zealand and Canada occurred in urban areas. This may reflect greater use of rigid trucks in urban areas (compared to rural areas) in Australia, than in New Zealand and Canada.

In Australia 37.8% of rigid truck fatal crashes occur in 100 km/h or greater speed zones, whereas in Canada the corresponding figure is 16.5% (if the 90 km/h speed zones are included the Australian figure rises to 41.9% and the Canadian to 42.5%). In Australia 30.4% of rigid truck crashes occur at night compared with 18.7% in Canada and 26.7% in New Zealand. This difference is not as great as for articulated truck crashes. The 28.9% of rigid truck fatal crashes which occur on divided roads in Australia is greater than the 14.2% in Canada.

These differences may reflect the greater use of truck and dog trailers in preference to articulated trucks in Great Britain and New Zealand.

Table 2.13 Summary table for Rigid trucks – characteristics of crashes

Item	Nations							
	Aust	NZ	GB	France	Germany	Sweden	Can	USA
Period	1996	1997-9	1998				1998	1998
Fatalities	110	80	408				187	
Fatal crashes	95	70	368 (1)				163	1,195 (1)
All SV crashes (%)	23.2	18.6	10.2				17.8	
Truck only crashes (%)	8.4	7.6	4.9					
Truck-ped crashes (%)	14.7	11.0	5.3					
Urban (%)	52.7	30.5	67.4				31.8	
Rural (%)	47.3	69.5	32.6				68.2	
Speed zone (%)								
<60 km/h	0.0	22.9	37.8 (2)				22.0	
60 km/h	36.5	1.4	10.8 (2)				14.7	
70 km/h	9.5	6.2					7.1	
80 km/h	12.2	3.8	3.0 (2)				23.6	
90 km/h	4.1	0.0					26.0	
100 km/h	29.7	65.7	29.2 (2)				15.7	
>100 km/h	8.1	0.0	19.2 (2)				0.8	
Night (%)	30.5	26.7	14.6				18.7	
1800-2359	13.7	18.6						
0000-0559	16.8	8.1						
Intersection (%)	36.7		48.5					
Divided road (%)	28.9	2.9 (motor-way)	47.5				14.2	

(1) based on trucks involved in fatal crashes, which would be somewhat greater than the number of crashes
(2) speed limits are in mph. These have been grouped as following: (<30 mph, 30 mph into <60 km/h), (40 mph into 60 km/h), (50 mph into 80 km/h), (60 mph into 100 km/h), (70 mph and >70 mph into >100 km/h)

Table 2.14 shows that the number of fatalities per rigid truck fatal crash is similar for Australia (1.16), Canada (1.15) and New Zealand (1.14). The proportion of persons killed who were occupants of the rigid trucks is somewhat higher in Australia (17.3%) than in Canada (15.0%) and in New Zealand (12.1). This is consistent with the figures for all trucks.

Table 2.14 Summary table for Rigid trucks – persons killed

Item	Nations							
	Aust	NZ	GB	France	Germany	Sweden	Can	USA
Period	1996	1997-9	1998				1998	
Fatalities	110	80	408				187	
Fatalities/crash	1.16	1.14	1.11(1)				1.15	
Fatalities per 10^8 kms	1.64	5.25	1.9(2)				2.93	
Fatalities per 10,000 registered rigids	3.28	12.19					6.40	
Persons killed (%)								
Truck occupants	17.3	12.1					15.0	
All other vehicle occupants	60.9						70.1	
Car occupants		65.3						
Motorcyclists		6.3					1.6	
Pedestrians		12.6					10.2	
Bicyclists		3.8					1.6	
Other vehicle occupants								

(1) based on trucks involved in fatal crashes, which would be somewhat greater than the number of crashes
(2) based on trucks involved in fatal crashes

3. DISCUSSION OF DIFFERENCES IN FATALITY RATES

3.1 Background

The truck fatality rate per km of travel depends on the interaction of a combination of factors involving the road user, the vehicle and the road system, including traffic density. Whether a crash outcome is fatal or not may also depend on the quality of emergency medical services, including time elapsed between crash occurrence and arrival at the scene.

This Section focuses on a discussion of some possible explanations for those differences in truck fatality rates which have been identified and discusses the potential for reduction in the Australian fatality rates.

3.2 Overall Fatality Rate

As discussed in Section 2, the overall number of persons killed in truck crashes per kilometre of truck travel in Australia is 47% higher than in the United States, 39% higher than in Great Britain, somewhat higher than the rates in Canada and Germany, and about 45-55% below the rates for France and New Zealand.

The ratio of the truck fatality rate to the overall road fatality rate is an indicator of the extent to which the truck fatality risk is greater than the overall road fatality risk. This ratio for Australia is 39% higher than that for Great Britain, 20% higher than that for the United States and 16% higher than that for Germany. On the other hand this ratio for Australia is 27% lower than that in New Zealand, 29% lower than in France and 7% lower than in Canada. Thus the Australian truck fatality rate is greater than that in Great Britain, United States and Germany, but lower than that in New Zealand and France, both in absolute terms and when compared with the overall road fatality rates.

3.3 Road Factors

A study in Michigan, USA, found that there are substantial differences in truck fatal crash involvement rates for different classes of roads and for day and night (Campbell, Blower, Gaths and Wolf, 1988). These are shown in Table 3.1.

It can be seen that the ratio of fatal crash involvement rate for “other roads” versus limited access roads (O/L) was in the range 2.12-4.61, with the higher ratios being for rural roads. Also when travelling on a rural road at night the possibility of involvement in a fatal truck crash was 4.61 times less if the road had limited access.

Similarly the ratio of night/day fatal crash involvement rates (N/D) was in the range 3.15-5.10, with the higher ratios being on “other roads”. It can be seen that when travelling on an urban road which is not limited access, the probability of involvement in a fatal truck crash is 5.1 times greater at night than in the daytime. (A later study cited on the US Federal Motor Carrier Safety Administration website has found fatal truck crash rates to be similar across the 24 hours of the day. The reason for the difference in results is not known.)

Table 3.1 Normalised truck fatal involvement rates in Michigan (Campbell et al., 1988)

	Limited access roads (L) normalised rate (4)	N/D (1, 3)	All other roads (O) normalised rate	N/D (1)	O/L (2, 3)
Day/urban	0.41	(3.15)	0.87	(5.10)	2.12
Night/urban	1.29		4.44		3.44
Day/rural	0.31	(3.19)	1.36	(3.35)	4.39
Night/rural	0.99		4.56		4.61

Notes:
(1) N/D( ) = night versus day ratio (night is 9.00 pm to 6.00 am)
(2) O/L = all other roads versus limited access roads, ratio
(3) The N/D and O/L ratios were not given in the original study, but have been calculated for this study
(4) The rates have been normalised so that the overall average is 1.00.

In the study, the truck fatal crash involvement numbers were obtained from FARS for 1980-84 (augmented from other sources) and the truck travel from a survey of 5,112 truck owners on each of four randomly selected days during a year (mainly 1986). No more recent studies of such a comprehensive nature have been found.

3.3.1 Freeways

The data in Table 2.7 show that in the United States 25.6% of all fatal truck crashes occurred on interstate highways, in Great Britain 18% were on motorways and in Germany 21.2% were on autobahns, while in Australia the corresponding percentage was 2.0% on freeways.

This factor alone could account for most of the difference in the truck fatality rate between these countries and Australia. The effect of improving the Australian road system by increasing the proportion of limited access divided roads (ie “freeways” of standard equivalent to the US “interstate system”, or motorways or autobahns) so that say 18% of all truck fatal crashes occur on these roads can be calculated.

Based on the results of the Michigan study shown in Table 3.1, it would be reasonable to assume a truck fatal crash rate on these freeways of about 25% of the rate on other roads, (O/L ratio of 4.00), particularly as most of the road improvements would be on rural highways, rather than urban roads. However a more conservative figure of 33% (O/L ratio of 3.00) will be used in this calculation, which is set out in Box 1.

The calculation in Box 1 shows that if the Australian road system were upgraded so that 40% of all truck travel were on roads of freeway standard, then the total truck fatal crash rate would be reduced to 1.58 fatal crashes per 10^8 km.

If this were achieved, the percentage of truck fatal crashes on freeways would be 18.2%, which is still below the 25.6% on the United States’ Interstate System, or the 21.2% on the German autobahns, while close to the 18% on motorways in Great Britain.

Based on the above calculations and assumptions, it can be seen that the truck fatal crash rate in Australia would be expected to be close to that in the United States (1.43) and Great Britain (estimated 1.5) and below Germany (2.01), if the road system were upgraded so that the proportion of travel on freeways were increased so that the proportion of truck fatal crashes on freeways were comparable to these countries.

Naturally such an upgrading of the road system would take several decades to achieve and would require significant capital investment, but the above calculations illustrate the scope for reductions which would be possible if sections of the road system were upgraded to limited access divided roads. For example if the upgrade could achieve 20% of truck travel on freeway standards roads, the truck fatality rate could be reduced to approximately 1.87 fatal crashes per 10^8 km.

A summary of the results of these calculations is given in Table 3.2. The sensitivity of results to the assumption of the value of the ratio of the truck fatal crash rate on freeways (R_F) to that on other roads (R_O) is shown in the two right-hand columns of the Table. In this caculation it is assumed that R_O remains the same, while R_F reflects the change in the ratio R_F / R_O. It can be seen that changing the assumed ratio of the truck fatal crash involvement rate on freeways to that on the other roads from 0.33 up to 0.40 or down to 0.25 makes little difference to the overall fatal crash rate.

Box 1: Calculation of effect on fatal crash rates of increasing the proportion of truck travel on freeways

assume $R_F = 0.33\ R_O$

where R_F = fatal crash rate on freeways

R_O = average fatal crash rate on other roads

(All numbers are for trucks)

According to the Australian Transport Safety Bureau Fatal File, in 1996 there were five fatal crashes on freeways out of a total of 245 truck fatal crashes, ie 2%. (This is similar to the average of 2.2% for the three years, 1992, 1994, 1996.)

$$\therefore R_O = \frac{245-5}{V_O} = \frac{240}{V_O} \qquad \text{- (1)}$$

$$\text{and } R_F = 0.33\ R_O = \frac{5}{V_F} \qquad \text{- (2)}$$

where V_O = total truck travel on other roads

V_F = truck travel on freeways.

According to the 1995 ABS Survey of Motor Vehicle Usage the total truck travel was 118.2 x 10^8 km.

Hence $V_O + V_F = 118.2 \times 10^8$ - (3)

Solving these three simultaneous equations gives

$V_F = 7.02 \times 10^8$ km

$V_O = 111.18 \times 10^8$ km

ie 5.9% of total truck travel was on freeways.

Hence $R_F = \dfrac{5}{7.02}$ = 0.71 fatal crashes per 10^8 km

$R_O = \dfrac{240}{111.18}$ = 2.16 fatal crashes per 10^8 km

and R, the truck fatal crash rate for the whole road system = $\dfrac{245}{118.2}$ = 2.07 fatal crashes per 10^8 km.

The above calculation has estimated the amount of truck travel on freeways versus all other roads, and consequently the truck fatal crash rates on these roads, using only one assumption, namely that the truck fatal crash rate on freeways in Australia is 33% of the average rate for all other roads.

If the road system were upgraded so that say 40% of all truck travel were on freeways then, assuming the same figures for total truck travel as in the above calculation, and the same truck crash rates on each road class, ie

$V_F{}^1$ = new travel on freeways = 0.4 x 118.2 x 10^8 = 47.28 x 10^8 km

$V_O{}^1$ = new travel on other roads = 0.6 x 118.2 x 10^8 = 70.92 x 10^8 km

R_F = 0.71 fatal crashes per 10^8 km (as previously)

R_O = 2.16 fatal crashes per 10^8 km (as previously)

Then:

number of fatal crashes on freeways = 47.28 x 0.71 = 34

number of fatal crashes on other roads = 70.92 x 2.16 = 153

Thus the total number of truck fatal crashes would be reduced to 187, and the new fatal crash rate would be:

$\dfrac{187}{118.2}$ = 1.58 fatal crashes per 10^8 km

Table 3.2 Effect of upgrading portion of road system to freeway standard

Percent of travel on freeways	5.9% (1996 value)	20%	40%	40%	40%
Assumed ratio of fatal crash involvement rates (R_F/R_O)	0.33	0.33	0.33	0.25	0.40
Percent of fatal crashes on freeways	2.0%	7.6%	18.2%	14.3%	21.1%
Truck fatal crash rate per 10^8 km	2.07	1.87	1.58	1.51	1.64

3.3.2 Divided roads

A similar type of calculation could be undertaken to estimate the effect of increasing the proportion of truck travel and consequently the proportion of fatal crashes on divided roads rather than undivided ones. As shown in Table 2.7, in the United States 42.9% of truck fatal crashes occur on divided roads (with 25.6% on limited access Interstate Highway) compared to 20.6% (with 2% on freeways) in Australia. Unfortunately the equivalent percentage is unknown for several of the other countries of interest, particularly the U.K.

The only assumption which needs to be made in this calculation is the ratio of the truck fatal crash rate on divided roads (R_D) versus the rate on undivided roads (R_U). The authors are not aware of any quantitative studies which have determined this ratio, and have not been able to obtain appropriate Australian data to enable it to be calculated.

In a study of rural truck fatal crashes in NSW, it was concluded that as many as 73% of the crashes might not have occurred if the road had been divided at the location of the fatal crash (Sweatman, Ogden, Haworth, Vulcan and Pearson, 1990). In the absence of better information, it seems reasonable to use a conservative figure of 50%, in the calculation which is set out in Box 2.

The calculation in Box 2 shows that if the road system were upgraded so that 60% of all truck travel were on divided roads (including an estimated 5.9% on freeways as at present) then the total truck fatal crash rate would be reduced to 1.76 per 10^8 km.

If this were achieved then the total percentage of truck fatal crashes on divided roads would be 42.8% which compares with the 42.9% on divided roads in the United States. However in the United States 25.6% of truck fatal crashes occur on the Interstate Highway system, whereas in this calculation it was assumed that the Australian truck fatal crashes on freeways remain at the current 2%. Hence it is not surprising that the Australian calculated truck fatal crash rate of 1.76 fatal crashes per 10^8 km would still be 23% above the United States' rate of 1.43.

A summary of the results of this calculation is given in Table 3.3. The sensitivity of the results to the assumption of the value of the ratio of the truck fatal crash rate on divided roads (R_D) to that on undivided roads (R_U) is shown in the two right-hand columns of the Table. In this caculation it is assumed that R_U remains the same, while R_D reflects the change in the ration R_D / R_U. It can be seen that changing the ratio R_D/R_O down to 0.4 or up to 0.6 makes not much difference to the overall crash rate.

Table 3.3 Effect of upgrading portion of road system from undivided to divided roads (but not to freeway standard)

Percent of travel on divided roads	35.6% (1996 value)	60%	60%	60%
Assumed ratio of fatal crash involvement rates (R_D/R_U)	0.5	0.5	0.4	0.6
Percent of fatal crashes on divided roads	21.6%	42.8%	37.5%	47.4%
Truck fatal crash rate per 10^8 km	2.07	1.76	1.61	1.91

Box 2: Calculation of effect on fatal crash rates of increasing the proportion of truck travel on divided roads

assume $R_D = 0.5\ R_U$

where R_D = fatal crash rate on divided roads,

R_U = fatal crash rate on undivided roads

(All numbers are for trucks)

As in the previous calculation it is first necessary to calculate the distribution of truck travel on the road system in 1996, given that 5 (2%) of fatal crashes occurred on freeways, 48 (19.6%) other divided roads and the remaining 192 (78.3%) on other roads, which were mainly undivided, (except for 6 crashes which were “unknown’ and 2 on other roads).

To simplify the calculation the 5 fatal crashes on freeways will be combined with the 48 on other divided roads to give 53 fatal crashes on divided roads:

$$\therefore R_D = 0.5\ R_U = \frac{53}{V_D} \quad - (1)$$

$$\text{and } R_U = \frac{192}{V_U} \quad - (2)$$

where V_D = total truck travel on divided roads

V_U = truck travel on undivided roads.

According to the 1995 ABS Survey of Motor Vehicle Usage the total truck travel was 118.2×10^8 km.

Hence $V_D + V_U = 118.2 \times 10^8$ - (3)

Solving these three simultaneous equations gives

$V_D = 42.045 \times 10^8$ km

$V_U = 76.155 \times 10^8$ km

ie 35.6% of total truck travel was on divided roads.

$$\text{Hence } R_D = \frac{53}{42.045} = 1.26 \text{ fatal crashes per } 10^8 \text{ km}$$

$$R_U = \frac{192}{76.155} = 2.52 \text{ fatal crashes per } 10^8 \text{ km}$$

and R, the truck fatal crash rate for the whole system = $\frac{245}{118.2}$ = 2.07 fatal crashes per 10^8 km.

If the road system were upgraded so that say 60% of all truck travel were on divided roads, then using the same figures for total truck travel as in the above calculation, and the same truck fatal crash rates on each road class, ie

V_D^1 = new travel on divided roads = $0.6 \times 118.2 \times 10^8$
= 70.92×10^8 km

V_U^1 = new travel on undivided roads = $0.4 \times 118.2 \times 10^8$
= 47.28×10^8 km

R_D = 1.26 fatal crashes per 10^8 km (as previously)

R_U = 2.52 fatal crashes per 10^8 km (as previously)

then, number of fatal crashes on divided roads = $70.92 \times 1.26 = 89$

number of crashes on other roads = $47.28 \times 2.52 = 119$

Thus the total number of fatal crashes would be reduced to 208, 42.8% of which occurred on divided roads and the new fatal crash rate would be $\frac{208}{118.2}$ = 1.76 per 10^8 km.

Clearly the Australian road system with 20.6% of truck fatal crashes on divided roads (2% on freeways) is not at all comparable with the United States, with 42.9% of truck fatal crashes on divided roads (25.6% on the Interstate Highway System). The calculation in Section 3.3.1 (Box 1) has shown that if the Australian road system had a similar proportion of fatal truck crashes on freeways as in the United States, then the truck fatal crash rates would be comparable. The only assumption in that calculation was that the truck fatal crash rate on freeways in Australia is one-third the average on all other roads.

The calculation in this Section (Box 2) has shown that if the Australian road system had a similar proportion of crashes on divided roads, as in the United States, then the Australian truck fatal crash rates would be lowered to 1.76 fatal crashes per 10^8 km, which is still 23% higher than that for the United States. The difference in this case is that in the United States, 25.6% of the truck fatal crashes occurred on limited access Interstate Highways, whereas in Australia it was assumed that only 2% of these crashes would occur on freeways, as was the case in 1996. Hence if fatality rates comparable to those in the United States are to be achieved, some upgrading of highways to freeway standard would be required, as part of the increase in the proportion of divided roads.

The only assumption in this second calculation was that the average truck fatal crash rate on divided roads (including freeways) in Australia is one-half the average on all other roads.

There is some data on the total casualty crash rate (all vehicles) for different classes of Australian roads, which indicates that the above assumptions are reasonable. Ogden (1996) cites a 1988 study by the Australian Road Research Board that showed that “freeways/motorways are at least 4 times as safe as other roads, and can be as much as 20 times as safe as other arterial roads. New freeways/motorways, built to contemporary standards, are the safest form of road, and may be twice as safe as older freeways/motorways built to lower standards” (p.155). The study found that the typical casualty crash rate for undivided arterial roads fell in the range 20-100 casualty crashes per hundred million vehicle kilometres, whereas the rate for divided arterial roads fell in the range 10-100 and all freeways and motorways had crash rates of about 10 per 100 million vehicle kilometres.

For Great Britain, Table A.3.3 (in Appendix A) shows that the truck fatal crash rate (measured in terms of vehicles involved in fatal crashes per 100 million vehicle km) is 1.0 for motorways compared with 2.6 for major roads and 2.4 for minor roads, both in non built-up areas.

It is recommended that further efforts be made to collect further data to enable the truck fatal crash rate on freeways, divided roads and all other roads in Australia to be calculated, so that the validity of the above two assumptions can be tested. Once these rates have been established, it will be possible to calculate, with more certainty, how much of the 47% discrepancy between the Australian truck fatal crash rate and that of the United States can be attributed to the difference in road standards.

As previously discussed, such upgrading of the Australian road system could take several decades and require significant capital investment. There are, however, lower cost treatments such as treatment of roadside hazards, provision of guardrails, shoulder sealing and provision of appropriate median barriers, which could achieve some of the potential benefits more rapidly and at a fraction of the cost.

There are also other measures directed at the vehicle or road user behaviour which have potential to achieve reductions in the truck fatal crash rate which are discussed in the remainder of this Section

3.4 Truck Configuration

The study in Michigan, USA, cited in Section 3.3 (Campbell et. al., 1988) also found that if comparisons between truck configuration types are to be made, the crash involvement rates must be adjusted for the different distances travelled on each class of road. When this was done the fatal crash involvement rates differed much more by class of road than by truck configuration type, except for bobtails (prime movers).

The normalised fatal crash involvement rates for different truck configurations, adjusted to take account of distance travelled on different road classes, were:

straight trucks with no trailers (rigids)	0.81
straight truck pulling one or more trailers	1.27
bobtail tractors (prime movers)	2.27
tractors pulling one trailer (semi-trailers)	1.06
tractors pulling two trailers (doubles)	0.90

It can be seen, that with the exception of bobtail tractors (prime movers without a trailer), the range of normalised involvement rates is not large (0.81-1.27). In fact, the fatal crash involvement rate of a semi-trailer was found to be 31% greater than for a rigid truck without a trailer, but 17% less than that of a rigid truck towing a trailer.

Based on this single study there appears to be more potential in the longer term to reduce truck fatal crash rates by improvements to the road system than by changes to truck configuration. There have, however, been improvements in truck/trailer designs during the past two decades which have potential to reduce the crash rates reported in that study. Some comparisons of articulated and rigid truck crashes in the different countries are discussed in the following sub-sections.

3.4.1 Articulated Trucks

The Australian articulated truck fatal crash rate of 3.02 per 10^8 km is almost double that for Canada (1.52), even though the overall Australian truck rate is only 18% greater than that for Canada, but this could be a reflection of the different road environment or the larger proportion of fatal crashes at night (44.8% in Australia versus 34.8% in Canada).

In Australia, 71% of these crashes occur in speed zones of 100 km/h or greater, whereas in Canada the figure is only 29%. (Even when the 90 km/h speed zones are included the Canadian figure is only 61%.) If travel speeds are related to the legal speed limit, then this would be a partial explanation of the higher fatal crash rate in Australia. The issue of Australian speed limits for all trucks being higher than those in Europe, particularly for undivided roads and in built-up areas has already been discussed in Section 3.5.

Another feature of articulated truck fatal crashes in Australia when compared with Canada is that there are more single vehicle crashes (25.3% versus 14.5%), more at night (44.8% versus 34.8%), more truck occupants killed (21.8% versus 11.9%) and fewer crashes occur on divided roads (17.4% versus 25.3%). The significance of each of these factors in relation to fatal crash involvement has been discussed in Sections 3.4, 3.5 and 3.6 for all trucks.

Unfortunately, there is insufficient data available to enable comparison with any other country except New Zealand, which has a 65% higher fatal crash rate than Australia. A partial explanation of this difference may be the lack of divided roads in New Zealand, although the exact proportion of crashes or travel on divided roads is not known.

3.4.2 Rigid Trucks

The Australian rigid truck fatal crash rate of 1.41 per 10^8 km is only 55% that of Canada and 30.1% that of New Zealand. This may reflect some differences in data definitions, or a real difference in rates.

In Australia 52.7% of rigid truck fatal crashes occur in urban areas, compared with 30.5% in New Zealand and 31.8% in Canada. In addition, the percentage of these crashes that occur on divided roads (28.9%) is much greater than in Canada (14.2%) and probably in New Zealand. The combination of lower speeds associated with urban areas and more use on divided roads may provide at least a partial explanation of the lower fatal crash rate of Australian rigid trucks.

The percentage of rigid truck crashes which occur in speed zones of 60 km/h or less is almost the same for Australia (36.5%) as for Canada (36.7%), as is the percentage for speed zones of 90 km/h or greater, with Australia 41.9% versus Canada 42.5%. New Zealand has 65.7% in speed zones of 100 km/h.

Analysis of the Australian data showed that fatality rates were lower for rigid trucks than for articulated trucks, regardless of area of operation (see Table A1.12). In addition to this, rigid truck fatality rates in capital cities were less than half the rates found in other urban areas or rural areas and almost half of the distance travelled by rigid trucks was in capital cities. These data suggest that part of the lower fatality rates of rigid trucks is intrinsic and part relates to the area of operation of rigid trucks.

3.5 Speed

Another factor which will influence the truck fatality rate and specifically the ratio of the truck fatality rate to the overall fatality rate is the truck speed limit (the actual truck travel speed distribution is more relevant but is not known).

In Germany the speed limit for all vehicles is 50 km/h in built-up areas. Outside built-up areas the limit for trucks with GVM in the range 3.5-7.5 tonnes is 80 km/h, except when towing a trailer, when the limit becomes 60 km/h. For trucks of GVM exceeding 7.5 tonnes the speed limit is also 60 km/h.

In France the speed limits for trucks outside built-up areas are set out in Table 3.4.

Table 3.4 Truck speed limits in France (km/h). Information supplied by SETR

Type of vehicle	Type of road			
	Autoroutes	Priority routes	Priority routes with divided carriageways	Other roads
Goods transports				
Vehicle between 3.5 t to 12 t	110	80	100	80
Non-articulated vehicle of more than 12 t	90	80	80	80
Articulated vehicle of more than 12 t	90	80	80	60
Dangerous goods transports				
Vehicle between 3.5 t to 12 t	110	80	100	80
Non-articulated vehicle of more than 12 t	80	60 (70 with ABS)	60 (70 with ABS)	60
Articulated vehicle of more than 12 t	80	60 (70 with ABS)	60 (70 with ABS)	60
Public transport vehicles	90 (100 with ABS)	90	90	90

In Great Britain, goods vehicles not exceeding 7.5 tonnes maximum laden weight are subject to a speed limits 10 mph lower than that applying to cars on single carriage-ways and dual carriage-ways outside built-up areas (see Table 3.5). They have the same speed limit on motorways unless they are articulated or are towing a trailer, in which case they are restricted to 60 mph (instead of 70 mph). Goods vehicles with a maximum laden weight exceeding 7.5 tonnes are restricted to 20 mph below the car speed limit outside of built-up areas, except on motorways where they are restricted to 10 km/h below the car speed limit.

In the United States truck speed limits vary in different states. In most states, trucks are allowed to travel at the posted speed limit. Some states have a lower speed limit for trucks than cars on rural interstates (see Table 3.6), but these limits are still higher than apply to trucks in Europe and New Zealand.

Table 3.5 Speed limits in the United Kingdom. From DETR, 2000

Type of vehicle	Type of road			
	Built-up areas mph (km/h) (1)	Single carriage-ways mph (km/h) (1)	Dual carriage-ways mph (km/h) (1)	Motorways mph (km/h) (1)
Cars	30 (48)	60 (97)	70 (117)	70 (113)
Cars towing caravans or trailers	30 (48)	50 (80)	60 (97)	60 (97)
Buses and coaches (not exceeding 12 m in overall length)	30 (48)	50 (80)	60 (97)	70 (113)
Goods vehicles (not exceeding 7.5 tonnes maximum laden weight)	30 (48)	50 (80)	60 (97)	70 (2) (113)
Goods vehicles (exceeding 7.5 tonnes maximum laden weight)	30 (48)	40 (64)	50 (80)	60 (7)

(1) converted and rounded to nearest whole number
(2) 60 if articulated or towing a trailer

Table 3.6 States of the United States with lower speed limits for trucks on Rural Interstate Highways (from IIIHS, 2000)

State	Car speed limit mph (km/h) (1)	Truck speed limit mph (km/h) (1)
Arkansas	70 (112)	65 (104)
California	70 (112)	55 (89)
Idaho	75 (121)	65 (105)
Indiana	65 (105)	55 (89)
Michigan	70 (113)	55 (89)
Montana	75 (121)	65 (105)
Ohio	65 (105)	55 (89)
Oregon	65 (105)	55 (89)
Washington	70 (112)	60 (97)

(1) converted and rounded to nearest whole number

In New Zealand vehicles over 3000 kg including semi trailers, have a maximum speed limit of 90 km/h. Heavy motor vehicles towing a trailer excluding semi trailers, have a maximum speed limit 80 km/h.

Research in Sweden has found that when travel speed is lowered, crashes, injuries and fatalities are reduced. A fourth power relationship was found between the fatal crash rate and the mean speed reduction, but this was for all traffic rather than for truck speeds (Nilsson, 1984). Thus a drop in the median speed of traffic from 100 km/h to 95 km/h could be expected to result in an 18.5% drop in fatalities.

While the same laws of physics still apply to trucks, both in relation to stopping distance and energy dissipation on impact being dependent on impact speed, the fourth power relationship may not apply when the issue is one of reducing the maximum speed limit of trucks in Australia from the same as that for light vehicles to say 10 km/h below that limit. In fact the effect is likely to be less than that predicted by the fourth power law.

Nevertheless, it could be expected that lower truck speed limits on the lower standard roads, as is the case in Germany, France and Great Britain are likely to result in lower truck fatality rates, if the lower speed limit results in some reduction in travel speeds. The authors are not aware of any data that could provide quantitative evidence regarding this issue.

3.6 Truck Occupant Fatalities

In most fatal crashes involving a truck it is not the truck occupant who is killed (occupants of the other vehicles being the most common group). Table 2.8 shows, however, that in Australian truck crashes the proportion of persons killed that are truck occupants is 19.0%, compared with 16.1% in Germany, with all other countries being in the range 9.8%-13.9%. The truck occupant fatality rate per 10^8 kilometres travelled in Australia is only exceeded by the rate in New Zealand (see Table 3.7). Interestingly, the high occupant fatality rate in Australia comes largely from crashes involving articulated trucks, the Australian occupant fatality rate in rigid truck crashes being lower than the Canadian rate.

Table 3.7 Number of truck occupants killed per 100 million vehicle kilometres travelled

Country	All truck crashes	Articulated truck crashes	Rigid truck crashes
Australia	0.47	0.80	0.28
New Zealand	0.70	1.02	0.64
Great Britain	0.19		
France	0.39		
United States	0.24		
Canada	0.27	0.21	0.44

There are a number of possible reasons why Australia has the largest proportion of truck occupants killed. Truck occupant fatalities occur in single vehicle crashes (about 70%), crashes involving two or more trucks (about 20%) and other crashes (about 10%).

Australia has the highest proportion of single vehicle (truck-only) crashes of the jurisdictions compared. The large number of fatal single vehicle crashes could be because trucks are more likely to have single vehicle crashes in Australia or because single vehicle crashes in Australia are more likely to be fatal. Some factors that could possibly contribute to more single vehicle crashes occurring are:

- poorer road geometries;
- lower traffic volumes;
- more night-time driving;
- fatigue; and
- higher speeds (see Section 3.5).

More single vehicle crashes could result in a fatality because of:

- more dangerous roadside hazards (see Section 3.3);
- higher speeds (see Section 3.5);
- less protective cabin structure; and
- lower use of seat belts.

Analysis of data for all truck single vehicle crashes, rather than just fatal crashes, would allow an assessment of the extent to which the large number of truck occupants killed in single vehicle crashes is due to the greater frequency or the greater severity of these crashes in Australia.

Crashes involving two or more trucks could be more likely to be fatal because of:

- higher speeds (see Section 3.5);
- less protective cabin structure; and
- lower use of seat belts.

A study of seat belt use in trucks in Australia in 1994 found a wearing rate of between 4% and 10% (Haworth, Bowland, Foddy and Elliot, 1999), whereas a wearing rate of 54% was observed in the United States in 1991 (Krall, 1993). For many designs of truck seat, lap sash belts with the anchorages not attached to the seat are uncomfortable as the seat moves up and down. However, in the Australian study, the wearing rate was low even for trucks where the belt was attached to the seat. There is considerable potential to reduce truck occupant fatalities, if their seat belt wearing rates could be increased.

3.7 Fatal Crashes Involving Other Road Users

In regard to multi-vehicle crashes, as car occupants represent the largest proportion of fatalities in truck fatal crashes (56%-75%), any factors which protect car occupants would tend to reduce the overall truck fatality rate. Australian safety standards for car occupant protection are equal to the best in the world, although some European and United States' cars achieve better NCAP ratings than Australian cars. Furthermore the car occupant seat belt wearing rate in Australia is similar to that in the U.K. and Sweden and higher than that in the other comparison countries, particularly the United States. Similarly the level of blood alcohol content among car drivers is lower than that in each of the comparison countries except the U.K. and Sweden. Hence it would be expected that these three factors, which tend to reduce car occupant fatalities, would offset some of the disadvantages which Australia suffers because of its limited proportion of high standard divided roads, particularly when compared with the United States.

The provision of energy-absorbing front and rear under-run barriers on trucks have considerable potential to reduce car occupant fatalities (Rechnitzer and Foong, 1991; Rechnitzer, 1993).

In regard to unprotected road users, ie pedestrians, cyclists and motorcyclists, the design of the truck exterior is important. Side under-run rails or skirts which are used on some trucks in Europe, have the potential to reduce fatalities amongst these unprotected road users (Rechnitzer, 1993). Traffic management measures to separate pedestrians and bicyclists from truck traffic can also reduce fatalities among this group.

4. CONCLUSIONS

The trend in the number of fatal truck crashes has been generally downward in Australia and the other comparison countries, although less so in the United States than in the other countries.

In terms of the number of persons killed in crashes involving a truck per 10^8 km of truck travel, the United States (1.69) and Great Britain (1.79) have the lowest rates, while Canada (2.10), Germany (2.2) and Australia (2.49) have somewhat higher rates. The rates for France (4.4) and New Zealand (5.52) are considerably higher.

The ratio of the truck fatality rate to the total road fatality rate is an indicator of the extent to which the truck fatality risk is greater than the overall fatality risk. This ratio varies from a low of 1.49 in Great Britain, 1.72 in the United States and 1.79 in Germany, to 2.93 in France and 3.30 in New Zealand. The ratios of 2.07 for Australia and 2.23 for Canada are in the middle of the range. This means that the Australian truck fatality risk is worse than the overall road fatality risk, when compared with Great Britain, United States and Germany.

The number of fatalities per fatal truck crash varies little from country to country, from 1.10 in Germany to 1.20 in Australia. Thus the relativity between countries does not differ whether the rate is expressed in terms of number of fatalities involving a truck or number of truck fatal crashes, per 10^8 km travelled by trucks.

Estimated truck travel ranges from 5.0% of total road travel in France to 10.9% in Germany, with Australia (7.1%) similar to Great Britain (7.3%) and the United States (7.3%). The percentage of road fatalities which involve a truck ranges from 13% in the United States to 20.3% in New Zealand. It is related to a combination of the amount of truck travel and to the truck fatality rate.

About two-thirds of fatal truck crashes involved articulated trucks in Australia (63%), Canada (64%) and the United States (70%). The percentages were much lower in Great Britain (38%) and New Zealand (19%), which may reflect the greater use of truck and “dog trailers” in these countries. (In this study a rigid truck towing a trailer is defined as a rigid truck rather an articulated truck.)

There are a number of other characteristics of Australian fatal truck crashes which differ from those in the other comparison countries for whom data is available.

- The percentage of single vehicle crashes (including pedestrians) is higher for Australia (25%) than for the other countries (14% to 20%).
- The percentage of persons killed who are truck occupants is higher in Australia (19%) than in the other countries (10% to 16%).
- The percentage of crashes at night is higher for Australia (39%) than in France (29%), New Zealand (28%) and Great Britain (18%).
- The percentage of crashes which occur in speed zones of 100 km/h or greater is 58%, in Australia, 70% in New Zealand, but only 24% in Canada.
- The percentage of crashes in urban areas in Australia (42%) is higher than that in Canada (29%), New Zealand (28%), Germany (25%) and Sweden (21%).

- The percentage of crashes on freeways in Australia (2.0%) and New Zealand (2.5%) is much lower than that for United States (26%), Germany (21%) and presumably Great Britain (not known precisely). Similarly the percentage of crashes on divided roads in Australia is lower than that in the United States (43%), Great Britain (34%) and presumably Germany (not known precisely).

There are a number of characteristics of fatal **articulated** truck crashes in Australia which differ from those in the comparison countries for which data is available.

- The fatal crash rate per 10^8 km travelled is much higher for Australia (3.0) than for Canada (1.5) and for Great Britain, although it is less than for New Zealand (5.0).
- The percentage of single vehicle crashes in Australia (25%) and New Zealand (25%) is much higher than in Canada (15%) and Great Britain (10%).
- The percentage of crashes at night in Australia (45%) is higher than in Canada (34.8%), New Zealand (31%) and Great Britain (25%).
- In Australia 22% of the fatalities are occupants of the articulated truck, compared with 12% in Canada and 15% in New Zealand.
- The percentage of crashes on divided roads (17%) is lower than in Canada (25%) and Great Britain (25%) on motorways plus unknown on other divided roads.

There are also several characteristics of fatal **rigid** truck crashes in Australia which differ form those in the comparison countries, for which data is available. These differences may reflect different operating conditions for rigid trucks in those countries.

- The fatal crash rate per 10^8 km travelled for Australia (1.4) is considerably lower than in Canada (2.6) and New Zealand (4.6)
- The percentage of fatal single vehicle crashes in Australia (23%) is higher than in Canada (18%), New Zealand (19%) and Great Britain (10%).
- The percentage of crashes at night in Australia (31%) is higher than in New Zealand (27%), Canada (19%) and Great Britain (15%).

A study in Michigan, USA has reported substantial differences in truck fatal crash rates for different classes of road and for night and day. For example, rural truck fatal crash rates were approximately 4.5 times lower on limited access roads than on other roads. In urban areas they were approximately 2.8 times lower. Similarly the truck fatal crash rates were more than 3 times greater at night than in the daytime. On the other hand, when adjusted for road class and time of travel, the differences between truck configurations were not large, except for bobtail tractors (prime movers without a trailer). For example the normalised fatal crash involvement rate of a semi-trailer was 31% greater than for a rigid truck, but 17% less than that of a rigid truck towing a trailer. The rate for a bobtail tractor was more than twice that of a semi-trailer. Hence there appears to be much more scope to reduce truck fatal crash rates by improving roads and limiting night travel, than by changing truck configuration.

It has been shown that, based on simple assumptions, much of the difference in truck fatal crash rates between Australia and countries such as the United States and Great Britain can be explained by differences in the road system, namely fewer divided roads in Australia and much fewer limited access roads. In other words, if the Australian road system were upgraded to the standard of the road system in the United States or Great Britain, the Australian truck fatality rate could be expected to be similar to that in these countries and well below that in Canada and Germany.

Upgrading of the Australian road system to these standards could take several decades and require significant investment. There are, however, lower cost road and roadside treatments which could achieve some of the potential benefits more rapidly and at a fraction of the cost. In the meantime there is also potential to achieve reductions in the truck fatal crash rate through measures directed at road user behaviour and the vehicle.

Higher speed limits in Australia than in Europe and some parts of the United States particularly for articulated trucks on roads of less than freeway standard and in urban areas, may also be a factor, although this depends on the extent to which actual travel speeds reflect the legal speed limits. In Australia the increasing use of speed limiters on trucks and greater enforcement should assist in ensuring that this happens.

Compared with other countries Australia has the highest proportion of single vehicle fatal crashes and the highest proportion of truck occupant fatalities. In addition to road standards and speed control, there is potential to reduce truck occupant fatalities through improved fatigue control, more protective cabin structures and increased use of seat belts by truck occupants. For example in the United States a wearing rate of 54% has been reported, compared with 4% to 10% in Australia.

In regard to multi-vehicle crashes, there is also potential to reduce car occupant fatalities by providing improved truck rear and front under-run barriers. In addition, side under-run barriers or skirts have the potential to reduce fatalities of unprotected road users.

There may be other factors which also affect the truck fatal crash rates in the countries which have been compared. These could include vehicle safety standards, traffic management to protect other road users, driver training and selection processes, operator licensing, and general enforcement of road laws. The data available has not enabled such factors to be compared, nor is this type of benchmarking study the most appropriate for such comparisons, which are best done by specifically designed evaluations of a particular factor/program. However, it is considered that the differences in each of the above factors between Australia and the countries compared would be unlikely to explain as much of the differences in fatality rates, as the factors which have already been discussed.

The data which is available for Australia and has been provided by other countries is insufficient to enable some of the desirable analyses to be made. Chira-Chavala (1991) notes:

"Fatalities, personal injuries, and property damage resulting from truck crashes constitute major public health and economic problems.... Public concern is growing that truck safety is quickly deteriorating. However, existing truck accident and travel data are inadequate to address this concern, support essential government planning functions, guide public and private policy decisions on truck operations, or guide actions to reduce accidents and losses" (p.44).

Much of this comment is as relevant today as it was in 1991.

5. RECOMMENDATIONS TO IMPROVE TRUCK SAFETY IN AUSTRALIA

1. In order to significantly improve the safety of truck operations in particular and road safety generally, the construction of divided highways, removal of roadside hazards and provision of other low cost safety treatments should be accelerated, where possible. Where warranted, consideration should be given to limited access roads (roads that are grade separated and have dual carriageways).

   While these road improvements have considerable potential in the longer term, in the meantime there is also potential to reduce the truck fatal crash rate through a range of measures directed at the vehicle and road user behaviour.

2. In order to address the fact that Australia has a higher proportion of truck fatal crashes at night and a higher proportion of single vehicle crashes, the road safety risks of day and night-time truck operation should be quantified and compared. (This may require the improvements in data collection outlined in Recommendations 6 and 7.) If night-time fatal crash risks are substantially higher than daytime risks, consideration should be given to the development, in consultation with the freight industry, of operating practices which reduce the amount of truck travel at night, or improve the fatigue management of night time travel.

3. Measures should be taken to improve the safety of truck occupants, which is both a road safety and an Occupational Health and Safety issue. Consideration should be given to the adoption of a cab-strength standard such as that used in Sweden. The wearing of seat belts by truck occupants should be further encouraged and enforced where practicable.

4. In order to provide improved protection for road users other than truck occupants, consideration should be given to adoption of the ECE Regulations for Rear Underrun Protection (No.58), Front Underrun Protective Devices (No.93) and Lateral Protection of Trailers and Semi-trailer Goods Vehicles (No.73).

5. Consideration should be given to adopting speed limits that better manage the risks of the road and traffic environment for each class of vehicle, as has been attempted in many European countries and some States in the United States.

6. In order to better monitor and understand truck safety in Australia, more timely and complete data about fatal truck crashes should be collected. Consideration should be given to supplementing the current monthly provision of data on fatal articulated truck crashes with similar data on rigid truck crashes.

7. In order to enable further progress to be made in research relating to truck safety, arrangements should be made for collection of truck travel data, especially on the major truck routes. As a first step, an investigation should be undertaken of what data could be obtained from existing collections.

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APPENDICES

APPENDIX 1: AUSTRALIA

DATA SOURCES

The Australian Transport Safety Bureau supplied electronic data for 780 fatal truck crashes that occurred in 1992, 1994 and 1996.

Crash type

Coded by DCA.

Location data

Urban/rural coded for most crashes. Speed limit coded but missing for almost 10% of crashes. Road type eg two-way undivided is coded for each road (multiple at intersection).

Vehicle data

Articulated or rigid truck is coded. Body type is also coded so can pick up tankers, B-doubles etc There are several variables to cope with multiple trucks involved.

Severity data

Number of fatalities in truck is coded for all trucks. Number of fatalities which were not occupants of trucks is coded.

Drawbacks

What type of vehicle the truck ran into is not coded. Truck-pedestrian crashes can be identified from DCA coding. Non-fatal injuries to truck occupants or others are not coded.

Other crash data

Trend data for numbers of articulated (but not rigid) truck fatal crashes and fatalities are available in the FORS 1998 Road Fatalities Australia. It also contains some cross-tabulations of variables for 1998 data.

Exposure data

Distance travelled and number registered is available separately for articulated and rigid trucks for 1995 and 1998 (Survey of Motor Vehicle Usage). More detailed analyses of the SMVU or possibly other more relevant data have been requested from the NRTC.

Definitions

The crash data supplied by ATSB includes trucks with a gross vehicle mass of greater than 4.5 tonnes.

The crash data codes trucks as articulated or rigid. Articulated trucks include prime movers without a trailer, those towing a table top, pantechnicon, tip truck, fuel or other tanker or a car carrier. Articulated trucks also include road trains and B-doubles. Rigid trucks include table top, pantechnicon, tip truck, fuel or other tanker or cement truck bodies. Rigid trucks can be towing trailers.

In the Survey of Motor Vehicle Usage, trucks comprise rigid trucks and articulated trucks. Rigid trucks are vehicles exceeding 3.5 tonnes GVM. Rigid trucks with tow bar, draw bar or other non-articulated coupling are included. Articulated trucks are vehicles consisting of a prime mover having no significant load carrying area, but with a turntable device which can be linked to a trailer.

RESULTS

Truck type and location

Table A1.1 summarises the number of fatal crashes involving articulated and rigid trucks in 1992, 1994 and 1996. The crash numbers were almost identical in 1992 and 1994 (270 and 265). In 1996, the number of fatal crashes involving rigid trucks fell by about 20, leading to a reduction in the total number of fatal truck crashes to 245.

Table A1.1: Overall summary of fatal truck crashes in Australia in 1992, 1994, 1996

Year	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes
	Number	Percent	Number	Percent	
1992	158	58.5	116	43.0	270
1994	156	58.9	115	43.4	265
1996	154	62.9	95	38.8	245

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

The data set provided by ATSB included variables to identify whether a trailer was being towed and, if so, the type of trailer. Of the 821 trucks involved in crashes, 672 (82%) were coded as not towing trailers. This included 79% of articulated trucks and 86% of rigid trucks. The percentage for articulated trucks is considerably higher than expected and may reflect problems in the crash information.

Over the 3 years, 24.1% of fatal truck crashes occurred in capital cities, 21.4% in other urban areas and 52.3% in rural areas. The patterns for 1992 and 1994 were very similar, but in 1996 relatively more crashes occurred in rural areas and relatively fewer occurred in capital cities (see Table A1.2).

Generally, about 15% of articulated truck crashes occurred in capital cities, about 22% in other urban areas and about 59% in rural areas. The patterns for 1992 and 1994 were very similar, but in 1996 relatively fewer crashes occurred in other urban areas and relatively more in rural areas.

For rigid trucks, the distribution of locations was more even. Generally, about 36% occurred in capital cities, 20% in other urban areas and 42% in rural areas. The proportion of rigid truck crashes occurring in rural areas appears to have increased from 1992 to 1996. The proportion of rigid truck crashes occurring in capital cities appeared to be lower in 1996 than in the earlier years.

The overall reduction in rigid truck crashes in 1996 which was apparent in Table A1.1 appears to have contributions reductions in both capital city and rural crashes.

Table A1.2: Location of fatal truck crashes in Australia in 1992, 1994 and 1996

Year and Truck type	Capital city		Other Urban		Rural		Missing	Total
	Number	Percent of known	Number	Percent of known	Number	Percent of known	Number	
Articulated								
1992	25	15.8	38	24.1	95	60.1	0	158
1994	26	16.7	38	24.4	92	59.0	0	156
1996	20	14.4	28	20.1	91	65.5	15	154
Rigid								
1992	45	38.8	26	22.4	45	38.8	0	116
1994	45	39.1	20	17.4	50	43.5	0	115
1996	28	30.8	20	21.1	43	47.3	4	95
All trucks								
1992	69	25.6	62	23.0	139	51.5	0	270
1994	71	26.8	57	21.5	137	51.7	0	265
1996	48	21.1	48	21.1	132	57.9	17	245

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

The speed limits at the locations of fatal truck crashes in 1992, 1994 and 1996 are summarised in Table A1.3. About half of all fatal crashes involving trucks occurred where the speed limit was 100 or 110 km/h. About one-quarter of crashes occurred where the speed limit was 60 km/h. Only one crash occurred where the speed limit was less than 60 km/h.

Table A1.3 Speed limits at locations of fatal truck crashes in Australia in 1992, 1994, 1996

Speed limit (km/h)	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
60 or less	85	18.2	114	35.0	196	25.1
70 or 75	21	4.5	20	6.1	41	5.3
80	40	8.5	45	13.8	83	10.6
90	9	1.9	7	2.1	16	2.1
100	215	45.9	104	31.9	314	40.3
110	74	15.8	27	8.3	97	12.4
Unknown or unlimited	24	5.1	9	2.8	33	4.2
Total	468	100.0	326	100.0	780	100.0

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

Roughly 62% of crashes involving articulated trucks occurred in 100 or 110 km/h speed zones, compared with about 40% of crashes involving rigid trucks. On the converse, 35%

of crashes involving rigid trucks occurred in 60 km/h speed zones, compared with only 18% of crashes involving articulated trucks.

About two-thirds of crashes occurred on two way undivided roads (see Table A1.4). Less than 15% of crashes occurred on divided roads or dual carriageway freeways. Road configuration was coded as unknown for a large number of crashes in 1992 and 1994. In 1996, when road configuration was coded for almost all crashes, the percentage of crashes on two way undivided roads was 75%, and 22% of crashes occurred on divided roads and dual carriageway freeways.

Crashes involving articulated trucks were more likely to occur on two way undivided roads than crashes involving rigid trucks (71.4% versus 61.7%).

Table A1.4: Road configurations at locations of fatal truck crashes in Australia in 1992, 1994, 1996. Where the crash occurred at an intersection, the configuration of the first-mentioned road is recorded

Road configuration	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
One way	1	0.2	2	0.6	3	0.4
Two way undivided	334	71.4	201	61.7	526	67.4
Divided	52	11.1	46	14.1	96	12.3
Dual carriageway freeway	13	2.8	6	1.8	17	2.2
Other	4	0.9	0	0.0	4	0.5
Unknown/ not applicable	64	13.7	71	21.7	134	17.2
Total	468	100.0	326	100.0	780	100.0

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

About one quarter of fatal truck crashes occurred at intersections (see Table A1.5). Crashes involving rigid trucks were more likely than crashes involving articulated trucks to occur at intersections (30.1% versus 21.4% within the intersection).

About two-thirds of fatal truck crashes occurred during daytime (6 am to 6 pm). The percentage of crashes occurring during daytime was higher for rigid trucks (74.5%) than articulated trucks (59.2%, see Table A1.6).

Table A1.5: Mid-block or intersection locations of fatal truck crashes in Australia in 1992, 1994, 1996

Crash location	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
Mid-block	365	78.0	214	65.6	566	72.6
Within intersection	100	21.4	98	30.1	197	25.3
Related to intersection	3	0.6	14	4.3	17	0.3
Total	468	100.0	326	100.0	780	100.0

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

Table A1.6: Time of occurrence of fatal truck crashes in Australia in 1992, 1994, 1996

Time of occurrence	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
Day	277	59.2	243	74.5	513	65.8
Night	191	40.8	83	25.5	267	34.2
Total	468	100.0	326	100.0	780	100.0

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

Crash types

Overall, 25.5% of fatal truck crashes involved only one vehicle. Of these crashes, 14% involved the truck only and 11.5% involved a pedestrian. The percentages of crashes that fell into each category were similar in 1992, 1994 and 1996 (see Table A1.7). The percentage of crashes that involved more than one vehicle was slightly higher for rigid trucks. Articulated trucks had relatively more truck only crashes than rigid trucks while rigid trucks had relatively more truck-pedestrian crashes.

Persons killed

The number of persons killed in truck crashes fell from 330 in 1992 to 311 in 1994 to 294 in 1996. Table A1.8 shows that almost 60% of these fatalities resulted from crashes involving an articulated truck. The actual numbers and percentages of fatalities resulting from crashes involving rigid trucks, but not articulated trucks, appear to have fallen from 1992 to 1996.

Of the 935 people killed in truck crashes in 1992, 1994 and 1996, 17.9% were occupants of the truck and 82.1% were other road users (see Table A1.9). A larger percentage of persons killed in rigid truck crashes than articulated truck crashes were "other road users" – including pedestrians and cyclists. A larger percentage of persons killed in articulated truck crashes than rigid truck crashes were occupants of trucks (articulated or rigid trucks).

Table A1.7: Single and multiple vehicle fatal truck crashes in Australia in 1992, 1994, 1996

Year and Truck type	Single vehicle		Truck-pedestrian		Multiple vehicle		Total
	Number	Percent	Number	Percent	Number	Percent	
Articulated							
1992	33	20.9	14	8.9	111	70.3	158
1994	26	16.7	14	9.0	116	74.4	156
1996	26	16.9	13	8.4	115	74.7	154
Rigid							
1992	7	6.0	19	16.4	90	77.6	116
1994	9	7.8	16	13.9	90	78.3	115
1996	8	8.4	14	14.7	73	76.8	95
All trucks							
1992	40	14.8	33	12.2	197	73.0	270
1994	35	13.2	30	11.3	200	75.5	265
1996	34	13.9	27	11.0	184	75.1	245

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

Table A1.8: Summary of fatalities in truck crashes in Australia in 1992, 1994, 1996

Year	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes
	Number	Percent	Number	Percent	
1992	188	57.0	146	43.0	330
1994	184	59.2	133	40.8	311
1996	188	63.9	110	36.1	294
Total	560	59.9	389	40.1	935

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

Table A1.9 Road users killed in truck crashes in Australia in 1992, 1994, 1996

Road user type	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
Driver of other vehicle	240	42.9	162	41.6	401	42.9
Passenger of other vehicle	120	21.4	77	19.8	196	21.0
Other road user	73	13.0	98	25.2	171	18.3
Total other road users	433	77.3	337	86.6	768	82.1
Truck occupant	127	22.7	52	13.4	167	17.9
Total	560	100.0	389	100.0	935	100.0

Note that artic. plus rigid is greater than total because of crashes which involved both types of trucks.

Of the 780 crashes, 144 (18.5%) resulted in a truck occupant fatality - 103 of these crashes were single vehicle crashes, 39 involved two vehicles and 2 involved three vehicles. Of the 41 multiple vehicle crashes which resulted in at least one truck occupant fatality, 27 of these involved more than one truck.

Crashes involving articulated trucks were more likely to result in a truck occupant fatality than crashes involving rigid trucks. Overall, 35.5% of articulated truck crashes resulted in a truck occupant fatality, compared with 12.3% of rigid truck crashes.

Fatality rates

Table A1.10 summarises the number of trucks and the distances travelled according to the 1995 ABS Survey of Motor Vehicle Use. While there were about six times as many rigid than articulated trucks, each articulated truck travelled about four times further per year than a rigid truck.

Table A1.10: Summary of number of trucks and the distances travelled according to the 1995 ABS Survey of Motor Vehicle Use

Measure	Articulated trucks	Rigid trucks	Total
Number of vehicles	57,939	335,430	393,369
Total distance travelled (million kms)	5,094	6,725	11,819
Average distance travelled per vehicle	87,900	20,000	30,046

Applying the exposure information in Table A1.10 to the 1996 fatal truck crash data, results in the rates summarised in Table A1.11. The greater distance travelled on average by articulated trucks results in the fatal crash or fatality rates for articulated trucks being about 10 times greater than for rigid trucks on a per 10,000 vehicle basis. On a per 100 million kms travelled basis, the fatal crash or fatality rates for articulated trucks are about double those for rigid trucks.

Table A1.11: Rates derived from 1996 fatal crash data and the 1995 ABS Survey of Motor Vehicle Use 1

Measure	Articulated trucks	Rigid trucks	Total
Fatal crashes	154	95	245
Fatalities	188	110	294
Fatal crashes per 10,000 vehicles	26.58	2.83	6.23
Fatalities per 10,000 vehicles	32.45	3.28	7.47
Fatal crashes per 100 million kms travelled	3.02	1.41	2.07
Fatalities per 100 million kms travelled	3.69	1.64	2.49

Fatality rates for capital city, other urban and rural operations of articulated and rigid trucks are presented in Table A1.12. Calculation of fatality rates required adjustments to deal with the unknown crash locations and interstate travel. These adjustments are presented in Table A1.13. The numbers of fatal crashes and the numbers of fatalities per 100 million vehicle kilometres were higher for articulated trucks than rigid trucks regardless of location. For both types of trucks, capital city rates were lower than other urban and rural rates.

Table A1.12 Fatality rates for capital city, other urban and rural operations of articulated and rigid trucks. Crash data are for 1996 and the distance travelled is from the 1995 Survey of Motor Vehicle Use.

	Capital city	Other urban	Rural	Interstate	Unknown	Total
Articulated trucks						
Fatal crashes	20	28	91		15	154
Fatalities	21	33	117		17	188
Distance travelled	1,027	453	2,299	1,315		5,094
Fatal crash rate*	1.45	4.58	3.42			
Fatality rate*	1.52	5.40	4.32			
Rigid trucks						
Fatal crashes	28	20	43		4	95
Fatalities	29	20	57		4	110
Distance travelled	3,377	919	2,193	236		6,725
Fatal crash rate*	0.80	2.10	2.07			
Fatality rate*	0.83	2.10	2.68			
All trucks						
Fatal crashes	48	48	132		17	245
Fatalities	50	53	172		19	294
Distance travelled	4,404	1,372	4,492	1,551		11,819
Fatal crash rate*	0.95	3.04	2.88			
Fatality rate*	0.99	3.35	3.69			

*In calculation of the crash rates, where crash location was unknown, this has been assumed to be rural since the speed zone was 100 or 110 km/h for most of these crashes. The interstate distances travelled have been incorporated into the capital city, other urban and rural in relation to their original proportions.

Table A1.13 Calculation of fatality rates for capital city, other urban and rural operations of articulated and rigid trucks. Crash data are for 1996 and the distance travelled is from the 1995 Survey of Motor Vehicle Use.

	Capital city	Other urban	Rural	Interstate	Unknown	Total
Articulated trucks						
Fatal crashes	20	28	91		15	154
Fatalities	21	33	117		17	188
Distance travelled	1,027	453	2,299	1,315		5,094
Adjusted fatal crashes	20	28	106			
Adjusted fatalities	21	33	134			
Percent of intrastate travel	27.1	12.0	60.8			
Adjusted travel	1,383	611	3,099			
Fatal crash rate*	1.45	4.58	3.42			
Fatality rate*	1.52	5.40	4.32			
Rigid trucks						
Fatal crashes	28	20	43		4	95
Fatalities	29	20	57		4	110
Distance travelled	3,377	919	2,193	236		6,725
Adjusted fatal crashes	28	20	47			
Adjusted fatalities	29	20	61			
Percent of intrastate travel	52.0	14.2	33.8			
Adjusted travel	3,500	953	2,273			
Fatal crash rate	0.80	2.10	2.07			
Fatality rate	0.83	2.10	2.68			
All trucks						
Fatal crashes	48	48	132		17	245
Fatalities	50	53	172		19	294
Distance travelled	4,404	1,372	4,492	1551		11,819
Adjusted fatal crashes	48	48	149			
Adjusted fatalities	50	53	191			
Percent of intrastate travel	42.9	13.4	43.7			
Adjusted travel	5,069	1,580	5,170			
Fatal crash rate	0.95	3.04	2.88			
Fatality rate	0.99	3.35	3.69			

*In calculation of the crash rates, where crash location was unknown, this has been assumed to be rural since the speed zone was 100 or 110 km/h for most of these crashes. The interstate distances travelled have been incorporated into the capital city, other urban and rural in relation to their original proportions.

APPENDIX 2: NEW ZEALAND

DATA SOURCES

The Land Transport Safety Authority provided data for fatal truck crashes in 1997, 1998 and 1999 in electronic format. A separate text file summarised data over 10 years.

Crash type

Accident configuration is available for all crashes. Number of vehicles in the crash is coded. Time of crash is coded.

Location data

Urban/rural has been derived from the speed limit. Speed limit is coded. Road type is available. The LTSA advised that motorways and divided state highways are the only divided road categories. Sections of open road that are not state highways will generally not be divided. Some small sections of major urban road will be divided, but in general this can also be considered to be undivided road. ADT at the crash site is coded.

Vehicle data

Articulated or rigid truck is not coded. The LTSA advised that the variables tow1 and tow2 can be used to derive articulated and rigid categories. Where these variables are blank, or take any of the values boat, caravan or trailer, then the truck is a rigid truck. Where these variables take the value semi trailer, A train or B train, then the truck is an articulated truck. Thus prime movers without a semi-trailer are included in the rigid truck category. GVM is coded for trucks and trailers.

Severity data

The types of road users killed are coded as well as total number killed.

Drawbacks

No information about injuries received in fatal crashes.

Exposure data

Exposure data were extracted from a report by Baas and Arnold (1999) entitled *Profile of the Heavy Vehicle Fleet*.

Definitions

In New Zealand, a heavy vehicle is defined as an individual truck or trailer weighing between 3.5 tonnes and 30 tonnes when fully laden. Trucks are all heavy powered vehicles including tractors. Trailers are towed vehicles including full trailers and semi-trailers.

Vehicle types (both powered and unpowered) are defined for the purposes of Road User Charges. These vehicle types depend on the number of axles and whether they are single or twin tyred.

RESULTS

Summary data

Over the ten-year period 1989-98, 56.7% of fatal truck crashes involved a single unit truck, 35.5% involved a truck with one trailer and 9.9% involved a truck with multiple trailers (see Table A2.1).

Table A2.1: Summary of fatal truck crashes in New Zealand, 1989-1998

Year	All fatal crashes	Fatal truck crashes	Single unit truck crashes	Truck and 1 trailer crashes	Truck and multiple trailer crashes
1989	651	107	64	37	7
1990	638	85	48	29	9
1991	555	81	46	26	11
1992	542	78	41	31	7
1993	517	87	45	37	6
1994	496	96	44	42	14
1995	502	107	67	34	9
1996	457	77	39	31	8
1997	468	86	51	27	9
1998	436	75	53	18	7

Truck type and location

The percentage of crashes that involved articulated trucks varied from 10.7% in 1998 to 23.7% in 1999 (see Table A2.2). Over the three-year period, 18.6% of crashes involved articulated trucks. Given the variability from year to year, averages over the three-year period have been reported.

Just over one-quarter of all fatal crashes occurred in urban areas (27.5%, see Table A2.3). A larger proportion of rigid truck crashes than articulated truck crashes occurred in urban areas (30.5% versus 14.6%).

Table A2.2: Overall summary of fatal truck crashes in New Zealand in 1997, 1998 and 1999

Year	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes
	Number	Percent	Number	Percent	
1997	17	19.8	69	80.2	86
1998	8	10.7	67	89.3	75
1999	23	23.7	74	76.3	97
Total	48	18.6	210	81.4	258

Table A2.3: Location of fatal truck crashes in New Zealand in 1997, 1998 and 1999

Truck type	Urban		Rural		Total
	Number	Percent	Number	Percent	
Articulated	7	14.6	41	85.4	48
Rigid	64	30.5	146	69.5	210
All trucks	71	27.5	187	72.5	258

Almost 70% of fatal truck crashes in New Zealand occurred in 100 km/h speed zones (see Table A2.4), with the percentage being higher for crashes involving articulated trucks than crashes involving rigid trucks (85.4% versus 65.7%).

Table A2.4: Speed zone at location of fatal truck crashes in New Zealand in 1997, 1998, 1999

Speed zone	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
50	3	6.3	48	22.9	51	19.8
60	3	6.3	3	1.4	6	2.3
70	1	2.1	13	6.2	14	5.4
80	0	0.0	8	3.8	8	3.1
100	41	85.4	138	65.7	179	69.4
Total	48		210		258	

Information about type of road at the crash location was supplied for 1997 and 1998. Consistent with the speed zone data, most crashes occurred on undivided State highways (see Table A2.5). Again, the percentage of crashes involving articulated trucks compared with rigid trucks was greater on Undivided State Highways.

Table A2.5: Type of road at location of fatal truck crashes in New Zealand in 1997 and 1998

Type of road	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
Undivided State Highway	18	72.0	65	47.8	83	51.6
Major urban road	3	12.0	32	23.5	35	21.7
Minor urban road	0	0.0	16	11.8	16	9.9
Other open road	4	16.0	19	14.0	23	14.3
Motorway	0	0.0	4	2.9	4	2.5
Total	25		136		161	

Overall, 72.5% of crashes occurred during the day (6 am to 6 pm) and 27.5% occurred at night (6 pm to 6 am). Crashes involving articulated trucks were somewhat more likely to occur at night than crashes involving rigid trucks (31.3% versus 26.8%).

Crash types

The number of vehicles in fatal truck crashes is summarised in Table A2.6. The crash involved the truck and one other vehicle in about 65% of crashes. Almost 20% of crashes involved only one vehicle. Table A2.7 shows that about half of these crashes involved only the truck and half involved the truck and a pedestrian.

Crashes involving motorcycles comprised a larger proportion of daytime than night-time crashes (19.4% versus 12.7%) while the reverse pattern was true for crashes involving cars (51.1% versus 63.4%).

Table A2.6: Number of vehicles in fatal truck crashes in New Zealand in 1997, 1998 and 1999

Number of vehicles	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
1	12	25.0	39	18.6	51	19.8
2	30	62.5	137	65.2	167	64.7
3	5	10.4	28	13.3	33	12.8
>3	1	2.1	6	2.9	7	2.7
Total	48		210		258	

Table A2.7: Crash type in fatal truck crashes in New Zealand in 1997, 1998 and 1999

Crash type	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
Pedestrian	2	4.2	23	11.0	25	9.7
Single truck	10	20.8	16	7.6	26	10.1
Car	24	50.0	116	55.2	140	54.3
Motorcycle	9	18.8	36	17.1	45	17.4
Bicycle	3	6.3	9	4.3	12	4.7
Truck-truck	0	0.0	10	4.8	10	3.9
Total	48		210		258	

Persons killed

Over the period 1997-1999 inclusive, there were 305 persons killed in truck crashes in New Zealand. This is an average of just under 102 persons killed per year. There were 66 people killed in crashes involving articulated trucks (22 per year) and 239 people killed in crashes involving rigid trucks (80 per year).

About two-thirds of the persons killed in truck crashes were car occupants (see Table A2.8). Pedestrians made up a larger percentage of fatalities in rigid truck crashes than in articulated truck crashes (12.6% versus 4.5%). Overall, 12.8% of persons killed were truck occupants. Two-thirds of the truck occupant fatalities (8.5% of all fatalities) occurred in single truck-only crashes. Baas and Arnold (1999) comment that there is a high proportion of truck roll-over crashes in New Zealand compared to other similar countries. The remainder of the truck occupant deaths was divided evenly between car-truck crashes and truck-truck crashes.

Table A2.8: Number of persons killed in truck crashes in New Zealand in 1997, 1998 and 1999

Type of road user	Crashes involving articulated trucks		Crashes involving rigid trucks		All truck crashes	
	Number	Percent	Number	Percent	Number	Percent
Truck occupant	10	15.2	29	12.1	39	12.8
Car occupant	46	69.7	156	65.3	202	66.2
Motorcyclist	4	6.1	15	6.3	19	6.2
Bicyclist	3	4.5	9	3.8	12	3.9
Pedestrian	3	4.5	30	12.6	33	10.8
Total	66		239		305	

Truck travel in New Zealand

In 1997, trucks travelled 1,847 million vehicle kms in New Zealand and trailers travelled 813 million vehicle kms (Baas and Arnold, 1999). Of the trailer travel, 399 million km was by semi-trailers and 413 million km was by full trailers. This data was derived from an analysis of Road User Charges.

Baas and Arnold (1999) have estimated that articulated trucks travelled approximately 17.5% of the total distance travelled by heavy vehicles (see Table A2.9). They also state that main roads (rural highways, urban arterials and motorways) account for 18 percent of the network but carry 70 percent of the traffic.

Table A2.9 Estimated distance travelled and number of trucks in use by vehicle combinations in New Zealand (from Baas and Arnold, 1999)

Vehicle type	Distance travelled		Trucks in use	
	Million km	Percentage	Number of trucks	Percentage
Truck only	1,134	61.3	54,594	75.1
Truck-trailer	391	21.2	11,034	15.2
Tractor-semi	223	12.1	5,312	7.3
B-train	77	4.2	1,540	2.1
A-train	22	1.2	200	0.3
Total	1,847	100.0	72,680	100.0

Total travel on New Zealand's public road network has been estimated at 30 billion vehicle-km annually (LTSA, 1995, cited in Baas and Arnold, 1999). Thus truck travel comprises approximately 6% of total travel.

The numbers of articulated and rigid trucks (as defined in this report) is not directly available from New Zealand registration data. Baas and Arnold (1999) estimated the number of trucks in use from Road User Charges data. These estimates are summarised in Table A2.9. The numbers correspond to 65,628 rigid trucks and 7,052 articulated trucks using the definitions adopted in this report.

Fatality rates

Table A2.10 summarises the fatality rates as a function of distance travelled. Average annual values for 1997-1999 inclusive have been entered for the number of fatal crashes and the number of persons killed. Distance travelled data is for 1997.

Table A2.10: Fatality rates as a function of distance travelled – New Zealand 1997-99

	Articulated	Rigid	All trucks
Number of fatal crashes	16	70	86
Number of persons killed	22	80	102
Vehicles registered*	7,052	65,628	72,680
Distance travelled (100 million kms)	3.22	15.25	18.47
Number of fatal crashes per 10,000 vehicles registered	22.69	10.67	11.83
Number of persons killed per 10,000 vehicles registered	31.20	12.19	14.03
Number of fatal crashes per 100 million kms travelled	4.97	4.59	4.66
Number of persons killed per 100 million kms travelled	6.83	5.25	5.52

*Estimated from Road User Charges (see earlier discussion).

APPENDIX 3: GREAT BRITAIN

DATA SOURCES

Copies of the following reports were downloaded from the Department of the Environment, Transport and the Regions website:

- Road Accidents Great Britain 1998
- Road Traffic Statistics 1998
- The Transport of Goods by road in Great Britain 1998

Definitions

Heavy goods vehicles have a mass of over 3.5 tonnes.

The definition of rigid and articulated trucks was unclear.

RESULTS

Truck type and crash location

Table A3.1 summarises information about articulated and rigid trucks in fatal crashes in Great Britain in 1998. About half of the crashes occurred on major roads in non built-up areas. Of the 595 heavy goods vehicles in fatal crashes, 38.2% were articulated trucks and 61.8% were rigid trucks. Articulated trucks had a larger proportion of their crash involvement on motorways and non built-up roads and less on built-up roads than rigid trucks.

Table A3.1: Articulated and rigid trucks in fatal crashes, by type of road – Great Britain 1998

	Articulated trucks		Rigid trucks		All trucks	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Motorways	57	25.1	50	13.6	107	18.9
Non built-up roads	147	64.8	208	56.5	355	59.7
Major roads					*302*	*50.8*
Minor roads					*53*	*8.9*
Built-up roads	23	10.1	110	29.9	133	22.4
Major roads					*80*	*13.4*
Minor roads					*53*	*8.9*
Total	227	100.0	368	100.0	595	100.0

major=A roads
minor=B, C and unclassified
built-up=speed limit 40 mph (64 km/h) or less

Persons killed

There were 576 persons killed in crashes involving a heavy goods vehicle in 1998. One-fifth (119) of the casualties were cyclists and pedestrians, 60 were occupants of the heavy goods vehicle (DETR Factsheet Heavy Goods Vehicles in Road Accidents: Great Britain 1998).

Trucks registered and truck travel

There were 308,000 heavy rigid trucks and 111,000 heavy articulated trucks with current licences (registered) in Great Britain in 1998.

Table A3.2 shows that total travel for rigid trucks in Great Britain in 1998 was greater than for articulated trucks. However, articulated trucks travelled more (in absolute and relative terms) on motorways than rigid trucks. Rigid trucks travelled further on built-up major roads and minor roads.

Table A3.2: Goods vehicle travel by road class – Great Britain 1998 (from Table 5.1 Road Traffic Statistics 1998). Expressed in billion vehicle kilometres travelled

Road class	Articulated	Rigid	All goods vehicles
Motorways	6.2	4.9	11.1
Non built-up major roads			
Trunk	3.4	3.7	7.4
Principal	1.3	3.1	4.4
All non built-up major roads	4.7	6.7	11.4
Built-up major roads			
Trunk	0.2	0.4	0.6
Principal	0.6	2.6	3.2
All built-up major roads	0.8	3.0	3.8
Minor roads			
Minor non built-up roads	0.3	1.9	2.2
Minor built-up roads	0.4	3.2	3.6
All minor roads	0.7	5.1	5.8
All roads	12.4	19.7	32.1

Direct comparison of the registration and travel data may be misleading because travel may include vehicles not registered in Great Britain while registration data does not.

Fatality rates

Combination of data from the previous two tables allows the calculation of fatal crash rates – the numbers of articulated and rigid trucks involved in fatal crashes per 100 million vehicle kilometres travelled. These rates are summarised in Table A3.3. The table shows that the lowest fatal crash rates for both articulated and rigid trucks were on motorways. The data suggest that fatal crash rates are generally lower on built-up roads than non built-up roads. Overall, there was little difference in the rates for articulated and rigid trucks although there is crash rates for articulated trucks appear somewhat higher than for rigid trucks on non built-up roads. The overall parity between the vehicle types may stem from the greater use of motorways by articulated trucks.

Table A3.3: Fatal crash rates – vehicles involved in fatal crashes per 100 million VKT (over 3.5 t)

Road type	**Articulated**	**Rigid**	**Total**
Motorways	0.9	1.0	1.0
Non built-up roads	2.9	2.4	2.6
major roads			*2.6*
minor roads			*2.4*
Built-up roads	1.9	1.8	1.8
major roads			*2.1*
minor roads			*1.5*
Total	1.8	1.9	1.9

major=A roads (perhaps 50% divided roads?)
minor=B, C and unclassified
built-up=speed limit 40 mph (64 km/h) or less

APPENDIX 4: FRANCE

DATA SOURCES

A hard copy of data describing injury and fatality crashes in involving trucks in 1998 was supplied. A report on heavy vehicle safety in 1996 (in French) was also supplied. The report (Lagache, Groleau, Decamme and Page, 1997) presents crash data and some exposure data - numbers of vehicles registered, numbers of licences, millions of vehicle-kms travelled by heavy vehicles in France (broken down by those registered in France and those registered abroad). It also gives a summary of accident data, rates etc for the years 1992 to 1996 separately.

Crash type

Accident configuration is available for all crashes.

Month of year, time of day and day of week are presented for fatal crashes, injury crashes, fatalities, injuries and severity.

Location data

Cross-tabulations by urban/rural and road type (autoroutes, routes nationales, routes départmentales, other routes separated by urban/rural) were provided. Speed limit is not coded but might be able to use road type as a proxy.

Vehicle data

Tractor-trailers and straight trucks is coded for all crashes. Type of trailer is not coded.

Severity data

Material provides percentage of injury and fatal crashes which were fatal tabulated by a number of variables. Percentages of fatal and serious crashes which involve trucks and which don't involve trucks are provided. Gives severity of injuries to different road users classified by type of crash and urban/rural (but not broken down by articulated/rigid).

Exposure data

Total numbers of heavy vehicles and numbers of prime movers registered and distance travelled in France by all heavy vehicles from 1985 to 1996 are presented in Lagache et al. (1997). The data is not broken down by articulated and rigid trucks, however.

DEFINITIONS

Trucks are included if their unladen mass exceeds 3.5 tonnes. Rigid trucks towing trailers can be separated from prime movers towing trailers in the crash data supplied.

The French crash data record as fatalities only those persons who die within 6 days of the crash, compared to 30 days in most countries. This may reduce the numbers of fatalities, but the reduction is expected to be small compared to the magnitude of other possible data errors.

In the crashdata, rural is defined as “rase campagne”, or the open road. The urban areas include even small towns of less than 5,000 inhabitants.

RESULTS

The data in this section relate to truck crashes in 1998. The data for 1996 were also available and showed almost exactly the same patterns (Lagache, Groleau, Decamme and Page, 1997).

Truck type and location

In 1998, there were 947 fatal crashes involving trucks in France, which resulted in 1102 persons killed. Of the fatal crashes, 709 (74.9%) occurred in rural areas.

Table A4.1 shows that prime movers towing trailers (51.1%) and single unit trucks weighing more than 7.5 tonnes (29.4%) were the most common trucks involved in fatal crashes in France in 1998.

Table A4.1: Trucks involved in fatal crashes in France in 1998

Type of truck	Urban	Rural	Total	Percent
Single unit trucks >3.5 t, <=7.5t	16	24	40	3.9
Single unit trucks >7.5t	96	204	300	29.4
Rigid trucks towing trailers	39	112	151	14.8
Prime movers	4	3	7	0.7
Prime movers towing trailers	91	430	521	51.1
Total	246	773	1019	
Percent	24.1	75.9		

Table A4.2 summarises the fatal crashes, persons killed and crash severity according to type of road. Most crashes and fatalities occurred on Routes nationales and Routes départmentales in rural areas. In general, the crash severity (measured as persons killed per 100 casualty crashes) was lower on autoroutes than other routes and was lower in urban than rural crashes.

Overall, 28.5% of the fatal truck crashes in France in 1998 occurred at night (6pm to 6am). Intersection crashes comprised 21.6% of fatal truck crashes.

Table A4.2: Fatal truck crashes according to type of road – France, 1998

Road type	Fatal crashes		Persons killed		Persons killed per 100 casualty crashes
	Number	Percent	Number	Percent	
Autoroutes privately-operated	100	10.6	134	12.2	23.14
Autoroutes state-operated	15	1.6	17	1.5	3.57
Autoroutes total	115	12.1	151	13.7	14.31
Routes nationales – rural	285	30.1	343	31.1	28.70
Routes nationales – urban	77	8.1	84	7.6	13.08
Routes nationales - total	362	38.2	427	38.7	23.24
Routes départmentales - rural	285	30.1	328	29.8	23.61
Routes départmentales - urban	90	9.5	97	8.8	12.40
Routes départmentales – total	375	39.6	425	38.6	19.58
Other roads	95	10.0	99	9.0	6.28
Total	947	100.0	1102	100.0	16.60

Crash type

Single vehicle crashes comprise only a small proportion of fatal truck crashes in France. In urban areas, they comprise less than 2% of fatal crashes and about 7% in rural areas.

Table A4.3 shows that the most common type of fatal truck crash in both urban and rural areas was a collision between a truck and a light vehicle (car). Truck-light vehicle crashes comprised 55.6% of crashes in rural areas and 37.8% of crashes in urban areas. Pedestrian crashes comprised about a quarter of urban fatal truck crashes. A relatively large percentage of rural crashes involved 3 or more vehicles (19% compared to 9% in urban areas). In urban areas, collisions with motorised two-wheelers were next most common type of crash.

Table A4.3: Types of fatal truck crashes in France in 1998. Note that only crashes in which someone died within 6 days are included

Crash type	Urban		Rural		Total	
	Number	Percent	Number	Percent	Number	Percent
Truck only	4	1.7	48	6.8	52	5.5
Pedestrian	59	24.8	22	3.1	81	8.6
Truck-truck	2	0.1	17	2.4	19	2.0
Light vehicle	90	37.8	394	55.6	484	51.1
Two-wheeler	41	17.2	41	5.8	82	8.7
Bicycle	16	6.7	19	2.7	35	3.7
Other	5	2.1	33	4.7	38	4.0
3 or more vehicles	21	8.8	135	19.0	156	16.5
Total	238	100.0	709	100.0	947	100.0

Persons killed

As noted earlier, there were 1102 persons killed in fatal crashes in France in 1998 (see Table A4.4). The vast majority of persons killed were occupants of other vehicles (78.8%), with smaller numbers of truck occupants (9.8%) and pedestrians (8.3%).

Table A4.4 Persons killed in fatal truck crashes in France in 1998

Crash type	Type of road user killed				Total
	Truck occupant	Other vehicle occupant	Bicyclists	Pedestrians	
Truck only	54				54
Pedestrian				82	82
Truck-truck	18			3	21
Light vehicle	12	558		5	575
Two-wheeler	1	82		0	83
Bicycle			35		35
Other	3	43			46
3 or more vehicles	20	185		1	206
Total	108	868	35	91	1102

Fatality rates

Calculation of truck fatality rates for France is complicated somewhat by the change in 1993 from reporting distance travelled by trucks of more than 3.5 tonnes to reporting distance travelled by trucks of more than 5 tonnes. As Table A4.5 shows, this led to a discontinuity in the travel data series and resulted in the distance travelled data being collected for a different set of trucks than the crash data is collected for. Extrapolation of the pre-1993 data would suggest that the distance travelled by all trucks of more than 3.5

tonnes in 1995 should be approximately 29 billion vehicle-kilometres, not 25 billion vehicle-kilometres as is reported.

Table A4.5: Distance travelled (billion vehicle-kilometres) in France, 1990-1995

Year	Registered in France	Registered elsewhere	All trucks	All traffic
1990	22.7	3.3	26.0	436
1991	23.2	3.4	26.6	448
1992	23.7	3.5	27.2	462
1993	19.7	3.5	23.2	471
1994	20.3	3.9	24.2	487
1995	21.0	4.0	25.0	496

From 1993, distance travelled includes only trucks of more than 5 tonnes (previously 3.5 tonnes)

The fatality rates for truck crashes based on the uncorrected distance travelled data are shown in Table A4.6. The data suggest that the fatality rate has fallen somewhat from 1993. Applying a correction to the distance travelled to account for the change in 1993, would result in a somewhat lower fatality rate (approximately 4.4).

Table A4.6: Fatality rates for truck crashes – France

Year	Fatalities	Billion VKT	Fatality rate per 10^8 kms
1990		26.0	
1991		26.6	
1992	1281	27.2	4.71
1993	1339	23.2	5.77
1994	1250	24.2	5.17
1995	1276	25.0	5.10
1996	1097		

The French fatality rate for all vehicles is approximately one-third of that for trucks (see Table A4.7). The number of persons killed per 100 casualty crashes is approximately 2.5 times higher for truck crashes than for all crashes (Lagache, Groleau, Decamme and Page, 1997). In 1998, the number of persons killed per 100 casualty crashes was highest for rural truck-pedestrian crashes (43.40) and rural truck-bicycle crashes (33.93).

In 1996, heavy vehicles of more than 3.5 tonnes represented 2% of the vehicle fleet (excluding two-wheelers) and travelled 5% of total distance travelled but were involved in 5.4% of casualty crashes and 13.2% of fatal crashes, which resulted in 13.6% of fatalities (Lagache et al., 1997).

Table A4.7: Fatality rates for all vehicles – France

Year	Fatalities	Billion VKT	Fatality rate per 10^8 kms
1990		436	
1991		448	
1992	8114	462	1.76
1993	8005	471	1.70
1994	7609	487	1.56
1995	7453	496	1.50
1996	7178		

APPENDIX 5: GERMANY

DATA SOURCES

The crash and fatality data has been taken and translated from "Verkehr, Fachserie 3, Reihe 7, Verkehrsunfälle, 1998" produced by Statisches Bundesamt.

The distance travelled data has been taken and translated from "Verkehr in Zahlen 1999" published by Deutsher Verkehrs-Verlag GmbH, Hamburg.

Additional information was provided by Institut für Fahrzeugsicherheit, GDV, Germany.

DEFINITIONS

"Goods road vehicles" comprise:

- delivery vans and motor lorries with standard body;
- motor lorries with special body;
- semi-trailer truck, with or without trailer; and
- other tractors.

Mass criteria for both crash and exposure datasets are currently unclear, as any mass or size category is called a truck or commercial vehicle if it is designed for carrying goods.

RESULTS

In 1998, 1372 fatal crashes involved goods vehicles. These crashes resulted in 1515 fatalities.

Table A5.1 shows that about one-quarter of crashes occurred inside towns, over half occurred outside towns and just over 20% occurred on autobahn. The distribution of locations in terms of persons killed was similar. Goods vehicle occupants comprised 244 of the persons killed (16.1%).

Table A5.1: Location of fatal truck crashes – Germany, 1998

Location	Fatal crashes		Persons killed	
	Number	Percent	Number	Percent
Inside towns	341	24.9	355	23.4
Outside towns	740	53.9	808	53.3
Autobahns	291	21.2	352	23.2
Total	1372		1515	

For semi-trailers, with or without trailers, there were 19 single vehicle fatal crashes (truck only) and 210 fatal crashes involving two vehicles. The number of fatal crashes involving more than two vehicles was not available.

For rigid trucks, there are 68 single vehicle fatal crashes (truck only) and 758 fatal crashes involving two vehicles. The number of fatal crashes involving more than two vehicles was not available.

The distance travelled in 1998 was 68.2 billion kilometres by trucks and 625.9 billion kilometres for all vehicles.

APPENDIX 6: SWEDEN

DATA SOURCES

An electronic data file describing fatal truck crashes in Sweden in 1998 was supplied by the Swedish National Road Administration. In addition, a copy of the Statistics Sweden report entitled Road Traffic Injuries 1998 was supplied. The Statistics Sweden report gives a higher number of fatalities than that provided by the SNRA. Swedish sources suggest that the Statistics Sweden data may include some deaths that would not be considered road fatalities by the SNRA or most road authorities (eg deaths from natural causes while driving).

Neither data source provided information about truck type, so articulated and rigid trucks could not be discriminated.

Definitions

The SNRA data for fatal truck crashes includes crashes involving large trucks only. Only one of the large trucks in the data was less than 7 tonnes (6.57 tonnes). The travel data was available for large trucks of 7 tonnes or greater.

Crash and distance travelled data did not distinguish between rigid and articulated trucks.

RESULTS

Crash location

According to the Swedish National Road Administration, in Sweden in 1998 there were 81 fatal crashes in rural areas and 25 fatal crashes in urban areas involving trucks greater than 7 tonnes. One fatal crash in an urban area involved a truck of 6.5 tonnes.

Table A6.1 shows that most of the rural crashes occurred where the speed limit was 90 km/h. Most of the urban crashes occurred where the speed limit was 50 km/h. Table A6.2 shows that the vast majority of both rural and urban crashes occurred on undivided roads.

Table A6.1: Locations and speed zones of fatal truck crashes in Sweden, 1998. Includes trucks of 7 tonnes or greater only

Speed zone	Rural		Urban		Total	
	Number	Percent	Number	Percent	Number	Percent
50	2	2.5	15	60.0	17	16.0
70	15	18.5	9	36.0	24	22.6
90	53	65.4	1	4.0	54	50.9
110	11	13.6	0	0.0	11	10.4
Total	81	100.0	25	100.0	106	100.0

Table A6.2: Types of road where fatal truck crashes occurred in Sweden, 1998. Includes trucks of 7 tonnes or greater only

Type of road	Rural		Urban		Total	
	Number	Percent	Number	Percent	Number	Percent
Divided	3	3.7	0	0.0	3	2.8
Undivided	68	84.0	20	80.0	88	83.0
Unknown	10	12.3	5	20.0	15	14.2
Total	81	100.0	25	100.0	106	100.0

Crash types

Almost half of the fatal truck crashes in rural areas involved an oncoming vehicle (see Table A6.3). In urban areas, crashes involving cyclists, mopeds and pedestrians accounted for more than three-quarters of fatal truck crashes.

Table A6.3: Types of crashes - fatal truck crashes in Sweden, 1998. Includes trucks of 7 tonnes or greater only

Type of crash	Rural		Urban		Total	
	Number	Percent	Number	Percent	Number	Percent
Turning at intersection	4	4.9	1	4.0	5	4.7
Cycle/moped	6	7.4	7	28.0	13	12.3
Pedestrian	8	9.9	7	28.0	15	14.2
Cross road	8	9.9	5	20.0	13	12.3
Oncoming vehicle	39	48.1	4	16.0	43	40.6
Overtaking	4	4.9	0	0.0	4	3.8
Single vehicle	5	6.2	0	0.0	5	4.7
Rear end	1	1.2	0	0.0	1	0.9
Other accident	5	6.2	1	4.0	6	5.7
Wild animal	1	1.2	0	0.0	1	0.9
Total	81	100.0	25	100.0	106	100.0

Fatality rates

Information supplied by the Swedish National Road Administration shows that trucks of mass greater than 7 tonnes travelled 3.4 billion kilometres and buses 1.1 million kilometres in 1997. They estimate that approximately 75% of travel was urban and 25% was non-urban.

Based on this information, the fatal crash rates per 100 million vehicle kilometres travelled were calculated and are summarised in Table A6.4. The data show that the fatal crash rate was much higher in rural areas than in urban areas.

Table A6.4: Calculation of fatal crash rates – Sweden. Includes trucks of 7 tonnes or greater only

Measure	Rural	Urban	Total
Number of fatal crashes (1998)	81	25	106
Distance travelled (1997) 100 millions of vehicle kms	8.5	25.5	34
Fatal crash rate	9.53	0.98	3.12

APPENDIX 7: CANADA

DATA SOURCES

A number of electronic data files were supplied by Transport Canada. The summary EXCEL file provides summaries of the numbers of trucks etc involved in crashes in each province in each year. Two additional EXCEL files were supplied, one for tractor-trailer crashes and one for straight-truck (>4536 kg) crashes. Within each file there are three sheets relating to collisions, vehicles and victims. The sheets can be linked by Accident Investigation Number. Data is for 5,039 fatal crashes that occurred in 1988-1997. Not all data items are available for all provinces.

Data for 1998 were provided separately by Transport Canada.

Crash type

Accident configuration is available for crashes in some provinces only.

Location data

Urban/rural crash location is coded for almost all crashes. Speed limit and road type are coded for most provinces.

Vehicle data

Tractor-trailers and straight trucks coded for all crashes. Type of trailer is not coded for some provinces.

Severity data

The victims sheet contains information about the type of vehicle the injured person was travelling in, whether they were a driver or a passenger, injury severity.

Drawbacks

There is missing data for some important variables for some provinces. Where a percentage distribution is used and a particular province does not report the data element, generally the other provinces are used to represent the national distribution.

Exposure data

The Canadian Vehicle Survey (CVS) provided numbers of vehicles and distances travelled for all vehicles for the period Quarter 4 1999 to Quarter 3 2000. Trucks are coded in two mass ranges – 4.5t to15t and 15t and over. In the distance travelled data, trucks are divided into “pickup”, “straight truck” and “tractor trailer”. The distances travelled by pickups were excluded for the analyses reported here, however it was not possible to exclude them from the number of trucks.

Definitions

Straight trucks are referred to as rigid trucks in this section. Tractor trailers are referred to as articulated trucks.

The exposure data is for trucks 4.5t and over.

RESULTS

Truck type and crash location

Over the period 1993 to 1998 (inclusive), there was an average of 483 fatal truck crashes per year which comprised 17.0% of all of Canada's fatal crashes (see Table A7.1). Articulated crashes comprised 63.5% of the fatal truck crashes during this period .

Table A7.1: Fatal truck crashes and all fatal crashes – Canada 1993-1998

Type of crash	1993	1994	1995	1996	1997	1998
Fatal rigid crashes	204	192	159	159	168	163
Fatal articulated crashes	319	308	314	283	308	269
Fatal truck crashes	516	489	465	435	468	423
All fatal crashes	3121	2869	2854	2708	2647	2598

In 1997, 71% of fatal truck crashes occurred in rural areas and 29% in urban areas. Articulated truck crashes were more likely to occur in rural areas than rigid truck crashes (74% versus 68%).

About three-quarters of fatal truck crashes occurred on undivided roads (see Table A7.2). A somewhat larger proportion of rigid than articulated truck crashes occurred on undivided roads.

Table A7.2: Road types at locations of fatal truck crashes – Canada, 1998

Road type	Articulated truck crashes		Rigid truck crashes		All truck crashes	
	Number	Proportion	Number	Proportion	Number	Proportion
Undivided	141	74.2	90	84.9	227	78.8
Divided	42	22.1	11	10.4	51	17.7
Freeway	6	3.2	4	3.8	9	3.1
Other	1	0.5	1	0.9	1	0.3
Unknown	79		57		135	
Total	269		163		423	

About 53% of crashes occurred where the speed limit was 90 km/h or greater (see Table A7.3). Articulated truck crashes were more likely to have occurred in these higher speed zones than rigid truck crashes (60% versus 43%).

Table A7.3: Speed limits at locations of fatal truck crashes – Canada, 1998

Speed limit (km/h)	Articulated truck crashes		Rigid truck crashes		All truck crashes	
	Number	Proportion	Number	Proportion	Number	Proportion
<60	33	0.15	28	0.22	61	0.18
60	12	0.06	6	0.05	17	0.05
70	13	0.06	9	0.07	22	0.07
80	26	0.12	30	0.24	55	0.17
90	67	0.31	33	0.26	99	0.30
100	63	0.29	20	0.16	78	0.23
110	0	0.00	1	0.01	1	0.00
Unknown	55		36		14	
Total	269		163		423	

Overall, 67% of fatal truck crashes in 1997 occurred during daytime (6am to 6pm). The percentage was higher for rigid truck crashes (81%) than articulated truck crashes (65%).

Persons killed

Over the period 1994 to 1998 (inclusive), an average of 554 persons were killed in truck crashes per year which comprised 17.6% of all of Canada's fatalities (see Table A7.4). Articulated truck crashes accounted for 66.0% of the fatalities resulting from truck crashes during this period.

Table A7.4: Fatalities resulting from truck crashes and all fatal crashes – Canada 1993-1998

Type of crash	1993	1994	1995	1996	1997	1998
Rigid truck crashes	250	233	175	179	186	187
Articulated truck crashes	369	364	406	346	400	319
All truck crashes	619	592	571	520	583	505
All crashes	3615	3263	3351	3091	3063	2934

Over the period 1994 to 1998, 11.8% of the persons killed in truck crashes were truck occupants, 8.2% were pedestrians and 80.0% were occupants of other vehicles. The pattern was similar for articulated and rigid trucks, with a little more involvement of truck occupants and pedestrians and fewer occupants of other vehicles for rigid trucks.

Table A7.5: Persons killed in truck crashes – Canada 1993 to 1998

	1993	1994	1995	1996	1997	1998
Rigid truck crashes						
Truck occupants	33	40	25	25	18	28
Pedestrians	23	22	16	25	20	19
Occupants of other vehicles	194	171	134	129	148	140
Total	250	233	175	179	186	187
Articulated truck crashes						
Truck occupants	44	34	38	33	47	38
Pedestrians	32	26	26	22	27	23
Occupants of other vehicles	293	304	342	291	326	258
Total	369	364	406	349	400	319

Fatality rates

Table A7.6 summarises the fatal crash rates for Canada. The vehicle registrations and distance travelled estimates were obtained from the Canadian Vehicle Survey Quarter 4-1999 to Quarter 3-2000. The rates per 10,000 vehicles were higher for articulated trucks than rigid trucks. The rates per 100 million kms travelled were somewhat less for articulated trucks than for rigid trucks.

Table A7.6: Calculation of fatal crash rates – Canada. Distance travelled and vehicle registrations from Canadian Vehicle Survey Q4-1999 to Q3-2000

Measure	Articulated trucks	Rigid trucks	All trucks
Fatal crashes (1998)	269	163	423
Fatalities (1998)	319	187	505
Number of vehicles registered	147,733	292,160	439,893
Distance travelled (1999) 100 millions of vehicle kms	177.11	63.74	240.85
Fatal crashes per 10,000 vehicles	18.2	5.58	9.62
Fatalities per 10,000 vehicles	21.6	6.40	11.48
Fatal crashes per 100 million kms travelled	1.52	2.56	1.76
Fatalities per 100 million kms travelled	1.80	2.93	2.10

APPENDIX 8: UNITED STATES

DATA SOURCES

A report entitled Large Truck Crash Profile: The 1998 National Picture was obtained from the Federal Motor Carrier Safety Administration (FMCSA) website. "Traffic Safety Facts 1999 Large Trucks" was obtained from the National Highway Safety Administration website. "Fatality Facts: Large Trucks" was obtained from the Insurance Institute for Highway Safety website.

The 1997 United States Economic Census Vehicle Inventory and Use Survey was examined to provide information on truck registrations and travel. "Traffic Safety Facts 1999 Large Trucks" also provided information about vehicle miles travelled.

Definitions

In both the crash and exposure data, large trucks are defined as trucks with a mass of over 10,000 pounds which is approximately 4.5 tonnes. For the purpose of comparison with the Australian data, single unit trucks and truck/trailers are classified as rigid trucks. Truck tractors (bobtails), tractor/semitrailers, tractor/doubles and tractor/triples are classified as articulated trucks. Only the data presented in the FMCSA and Vehicle Inventory and Use documents allow this reclassification to be made.

RESULTS

Truck type and crash location

In 1998, 4,935 trucks were involved in fatal crashes in the United States (FMCSA). Table A8.1 below shows that tractor/semitrailers comprised almost two-thirds of trucks involved in fatal crashes. Using the classification described above, 69.6% (3,435) of the trucks in fatal crashes were articulated trucks, 24.2% (1,195) were rigid trucks and 6.3% (311) were unknown.

The Large Truck Crash Profile 1998 stated that 67% of fatal truck crashes occurred in rural areas.

Fatal crashes are coded by roadway type and by trafficway type in the Fatal Accident Reporting System. These data are summarised in Tables 9.2 and 9.3.

More than one-third of fatal truck crashes occurred on Other Principal Arterials (see Table A8.2). The Large Truck Crash Profile comments that "many of these highways are high-quality divided highways, but many others are not divided and do not have controlled access, both conditions that make them more dangerous than Interstate highways...For more than half of all trucks involved in fatal crashes in 1998 the crashes took place on highways that were not physically divided. When divided highways without barriers are included, 87% of the trucks involved in fatal crashes were operating on highways where the opposing lanes were not separated by barriers." (p.27)

Table A8.1: Large trucks in crashes by vehicle configuration, United States 1998

Vehicle configuration	Percent of trucks in fatal crashes
Single unit truck, 2 axles	10.8
Single unit truck, 3+ axles	9.6
Truck/trailer(s)	3.8
Truck tractor (bobtail)	2.1
Tractor/semitrailer	64.5
Tractor/double	2.8
Tractor/triple	0.2
Unknown	6.3
Total number	4,935

Table A8.2: Percent of large trucks in fatal crashes by roadway type (Table 22 from National Truck Crash Profile 1998 (FMCSA) – data from FARS)

Roadway type	Percent of trucks in fatal crashes
Interstate Highway	25.6
Other Principal Arterial	36.7
Minor Arterial	17.1
Collector	13.1
Local Road/Street	6.2
Unknown/Missing	1.3
Total number	4,871

Table A8.3: Percent of large trucks in fatal crashes by trafficway type (Table 23 from National Truck Crash Profile 1998 (FMCSA) – data from FARS)

Trafficway type	Percent of trucks in fatal crashes
Not physically divided	55.8
Divided highway without barrier	31.2
Divided highway with barrier	11.7
One-way trafficway	0.6
Missing/Unknown	0.6
Total number	4,935

Crash types

In 1999, 18% of fatal large truck crashes were single-vehicle crashes, 77% were two-vehicle crashes and 16% involved more than two vehicles (IIHS).

According to FMCSA, in almost 80% of trucks in fatal large truck crashes, the first harmful event was a collision with another moving vehicle (see Table A8.4).

Table A8.4: Types of fatal large truck crashes – United States 1998. From 1998 Large Truck Crash Overview (FMCSA, 2000). Coded on basis of first harmful event or first crash event.

Type of crash	Percent of large trucks in crashes
Collision with vehicle in transport	78.8
Collision with fixed object	7.3
Collision with pedestrian	6.2
Rollover	4.2
Collision with cyclist	1.1
Collision with parked motor vehicle	0.7
Collision with train	0.5
Collision with other object	0.6
Collision with animal	0.3
Explosion/fire	0.0
Other	0.5
Total	100.0

Persons killed

In 1998, 5,374 persons were killed in large truck crashes in the United States. In 1997, 5,398 persons were killed (FMCSA).

In 1998 and 1999, only about 14% of those killed and 23% of those injured in crashes involving large trucks were occupants of large trucks (see Table A8.5).

Table A8.5: Deaths in large truck crashes – United States 1998 and 1999 (from IIHS). The definitions of tractor-trailer and single-unit truck in this table cannot be directly compared with the Australian data.

Road user type	1998		1999	
	Number	Percent	Number	Percent
Tractor-trailer occupant	501	9.4	536	10.1
Single-unit truck occupant	212	4.0	189	3.6
Truck type unknown	26	0.5	21	0.4
Passenger vehicle occupant	3,981	74.9	3,907	74.0
Other or Unknown vehicle	101	1.9	119	2.3
Nonoccupant deaths	495	9.3	510	9.7
Total	5,316	100.0	5,282	100.0

Truck registration and travel

The 1997 United States Economic Census Vehicle Inventory and Use Survey was used to provide information on truck registrations and travel in a form comparable to that in the Australian data. There were approximately twice as many rigid trucks as articulated trucks but the total distance travelled was about double for articulated trucks (see Table A8.6). This resulted from the average distance travelled being approximately four times greater for articulated trucks than rigid trucks.

According to the FHWA's Highway Statistics 1998, 41% of all large truck miles travelled and 50% of all combination truck miles travelled in 1997 were on Interstate highways. In contrast, only 26% of crashes occurred on Interstate highways (National Truck Crash Profile 1998, FMCSA 2000). Thus the crash rate was much lower on Interstate highways than on other routes.

Table A8.6: Number of large trucks registered, total distance travelled and average distance travelled – United States, 1997. Data from 1997 United States Economic Census Vehicle Inventory and Use Survey.

Truck type	Number registered (thousand trucks)		Total distance travelled (million miles)		Average distance travelled (thousand miles)	
	Articulated	Rigid	Articulated	Rigid	Articulated	Rigid
Medium (10,001 to 19,500 pounds)	16.3	1,419.2	336.1	19,478.8	20.62	13.73
Light-heavy (19,501 to 26,000 pounds)	39.1	690.1	1,057.1	9,071.7	27.04	13.15
Heavy-heavy (26,001 pounds or more)	1,486.9	1,048.6	99,720.9	18,208.9	67.07	17.36
Total	1,542.3	3,157.9	101,114.1	46,759.4	65.56	14.81

Fatality rates

The NHTSA estimates of number of large trucks involved in fatal crashes per 10,000 registered vehicles and per 100 million vehicle miles travelled are presented in Table A8.7. The number of vehicles registered and the distance travelled are almost double the numbers in the Vehicle Inventory and Use Survey. The reasons for these discrepancies are not clear.

Chira-Chavala (1991) has pointed out discrepancies between various US data sets. He states that the annual numbers of truck accidents reported by NHTSA's National Accident Sampling System, the National Safety Council accident statistics, and the Office of Motor Carriers accident data are not in agreement. Estimates of annual truck miles of travel also vary between the FHWA's Highway Statistics, the Census Bureau's Truck Inventory and Use Survey and the private National Truck Trip Information System. He concludes that "as a result, information is not available to reliably assess the magnitude and the trends of safety performance of various truck types or to determine the extent to which truck safety may be improving or worsening. This has helped to fuel controversy about truck safety" (p.44).

Table A8.7: Estimates of large truck fatality rates in 1998 (NHTSA and IIHS)

Measure	Value
Trucks in fatal crashes	4,955
Fatalities (IIHS)	5,316
Number of vehicles registered	7,244,135
Distance travelled 100 millions of vehicle miles	196,053
Distance travelled 100 millions of vehicle kms	313,685
Trucks in fatal crashes per 10,000 vehicles	6.84
Trucks in fatal crashes per 100 million miles travelled	2.53
Trucks in fatal crashes per 100 million kms travelled	1.58
Fatalities per 10,000 vehicles registered	7.34
Fatalities per 100 million kms travelled	1.69