4. TRAVEL AND ENVIRONMENTAL FACTORS

4.1 INTRODUCTION

This section of the report covers the work undertaken in Strand 3 of the study, the Strand dealing with the travel and environmental perspective from 1982 to 1988.

The specific research question covered in Strand 3 was:

. (vii) did economic and travel activity in 1988 differ from that in 1987, and if so, how?

Supplementary questions covered were:

. did economic and travel activity in 1988 differ from the trend in the period 1982 to 1987, and if so, how?

. was the weather pattern in 1988 significantly different to that experienced in the period 1982 to 1987 and if so can any relationship be drawn between the crashes and weather pattern?

Particular attention was given to the issue of heavy vehicle speeds.

The section concludes with a summary of the discussions held with a small selection of experienced interstate drivers. These discussions centred on changes in road conditions during the 1980s and drivers' views on a range of possible countermeasures.

4.2 DATA SOURCES AND ASSUMPTIONS

The various data sources used for this part of the study are outlined, together with the assumptions and limitations in the data.

AUSTRALIAN BUREAU OF STATISTICS SOURCES

The Australian Bureau of Statistics (ABS) publishes Australian National Accounts (Catalogue 5220.0) containing information on general economic activity for Australia as well as each State. Some statistics from this catalogue were useful for examination of economic activity.

The Survey of Motor Vehicle Usage (SMVU) is undertaken by ABS every three years. The survey covers the 12 months ending September 30th in those years. However, some disadvantages of SMVU are:

. being only every three years, the surveys are only a broad guide to the changes over the study period

. data for buses are available only for the 1976, 1979 and 1988 surveys. ABS notes that differences in scope, definitions and collection methodologies make meaningful comparisons difficult.

Therefore, only limited use has been made of ABS SMVU and other sources were investigated, particularly in relation to the trends in bus travel.

ABS Catalogue 9214.0 gives quarterly interstate road freight movements between major ports by enterprises estimated to constitute approximately 70% of total interstate road freight movements. The reporting commenced with the September 1982 quarter.

Use of these freight movement statistics for the purposes of this study encountered several obstacles. These obstacles were:

. there is no route specific information for freight on particular highways

. the statistics cover only interstate freight which is only about 60% of the non urban non-bulk freight activity (ISC 1988)

. commencing with the September 1984 quarter, additional enterprises were included in the data collection. (comparisons with previous statistics were given for only one quarter, the increase in the freight of interest being of the order of 10%)

To overcome these obstacles, it has been necessary to:

. assume that the freight split between the various highways was constant (while for the Pacific and New England Highways it is known that this is not strictly the case, no accurate information on splits is known)

. assume that the changes in interstate road freight movements reflected the changes in total road freight movements

. modify all freight flows prior to September 1984 by 10% to give an indicative comparison between the changes in freight flows in the period 1982 to 1988

. use the data to indicate only trends and comparisons

Assignment of values to ABS freight movement data

Interstate road freight with an origin or destination of Sydney is split approximately as follows:

Origin	Sydney	
Destination	Melbourne	50%
	Brisbane	25%
	Adelaide	12%
	Canberra	6%
	Other ports	7%
Destination	Sydney	
Origin	Melbourne	55%
	Brisbane	20%
	Adelaide	12%
	Canberra	2%
	Other ports	10%

Interstate road freight between Melbourne and Sydney travels primarily on the Hume Highway, and all freight between those ports has been assigned to the Hume. However, freight from Adelaide, Canberra and Perth travels on a significant portion of the Hume as well.

Interstate road freight between Sydney and Brisbane travels either on the Pacific or New England Highways, but little other interstate road freight uses these highways. The lowest level of traffic on the Pacific Highway ranged between 4800 and 6500 vehicles per day, with 14 percent commercial vehicles, while the lowest traffic on the New England increased from about 2500 to 3500 vehicles per day and 12 percent commercial vehicles. Based on this limited data, a rough estimate is that, over the period, the Pacific Highway carried 70% of the interstate freight between Sydney and Brisbane.

Virtually all interstate freight between Melbourne and Brisbane uses the Newell Highway, but Adelaide and Perth freight also travels on the Newell.

For this study (remembering that the aim is to provide trends and comparisons), the following assumptions will therefore be made:

- interstate road freight assigned to the Pacific Highway is 70% of the total interstate road freight between Sydney and Brisbane.

- road freight assigned to the Hume Highway will be the ABS statistics for interstate road freight between Sydney and Melbourne

- road freight on the Newell Highway is the total freight between Melbourne and Brisbane

PUBLISHED REFERENCES

Details of Australia wide surveys of vehicle speeds were obtained from three references:

Heavy vehicle speed limits issued by the Federal Department *of Transport in* 1985

Rural Truck Speed Differentials, the 1986/87 National Study issued by the Department of Transport and Communications as Report CR 82 (Fitzgerald 1989)

Car and Articulated Truck Speeds before and after July 1988 issued by the Department of Transport and Communications as Report CR 88 (Intstat 1989)

ROADS AND TRAFFIC AUTHORITY DATA

A variety of data was obtained from the Roads and Traffic Authority. Such data included:

- speed data covering both individual sites and State wide surveys
- traffic data, including historical data on Average Annual Daily Traffic (AADT) and whatever classification information was available

A significant lack of historical data on heavy vehicle usage of New South Wales roads created problems in accurately determining many of the changes which have occurred.

The mass crash data was used for the research question on the influence of weather on crashes.

OTHER SOURCES

Data on bus and coach travel was, as previously mentioned, not available from ABS. Two other sources were used for this information:

- Bureau of Tourism Research statistics
- information obtained from industry sources

The long distance express and charter markets have undergone significant change in ownership and operations over the last eight years. Information from these sources should therefore be treated as a guide only.

The same difficulties of ownership and structural change occurred in the road freight industry. Very few, if any, road freight companies have the same type of operation now as eight years ago, and it proved impossible to separately validate the freight statistics obtained from ABS.

Driver discussions were arranged with the full co-operation of the transport companies involved.

Bureau of Meteorology data was investigated for use on the weather question.

4.3 RESEARCH QUESTION (VII) - DID ECONOMIC AND TRAVEL ACTIVITY IN 1988 DIFFER FROM THAT IN 1987, AND IF SO,

ECONOMIC ACTIVITY

Gross Domestic Product (GDP) for Australia increased 12.2% from 1986/87 to 1987/88, when the NSW GDP increase was 14.3%. The NSW Consumer Price Index increased 7.3% from June 1987 to June 1988.

The general economic change in freight activity is measured by ABS statistics in the Transport, Storage & Communication industry. The Wages, Salaries & Supplements component of this industry in NSW increased 7.7% between 1986/87 and 1987/88, while the equivalent for Australia increased 7.0%.

Economic activity, as measured by interstate road freight movements, shows an increase in corresponding quarters from 1987 to 1988, both in freight with an origin and destination of Sydney and in the Brisbane and Melbourne freight corridors (Table 4.1). Freight activity is considered to be a sound indicator of economic activity, although it may tend to lead changes in general economic activity.

Table 4.1 Increases in road freight for the corresponding quarters of 1987 to 1988

	increase 87 to 88 (percent)				
	Mar Q	Jun Q	Sep Q	Dec Q	Year
origin Sydney	7.4	11.0	1.8	10.8	10.1
destination Sydney	17.6	14.1	5.1	3.5	9.7
Syd/Bne & Bne/Syd	8.7	14.9	6.8	31.8	15.9
Syd/Mel & Mel/Syd	19.4	14.4	1.6	6.4	10.1
Mel/Bne & Bne/Mel	16.3	5.2	8.4	-1.2	6.7

Source: ABS cat 9214.0

The most significant changes were the increase in freight from Sydney to Brisbane in the December 1988 quarter (22% increase to Brisbane, 8% increase to Sydney), and the increase in freight from Melbourne to Sydney in the March quarter.

The reduction in the Melbourne/Brisbane corridor in the December 1988 quarter reflected a fall from a large December 1987 result in freight from Melbourne to Brisbane.

Although not shown, it should be noted that interstate freight in the first half of 1989 on the Sydney to Brisbane run dropped 44% from the previous half year and 15% from the corresponding first half of 1988. These reductions were not reflected in the Sydney/Melbourne corridor, but Melbourne to Brisbane freight dropped 20% compared to the corresponding first half of 1988.

TRAVEL ACTIVITY

Traffic volumes measured by Average Annual Daily Traffic (AADT) increased from 1987 to 1988. Table 4.2 shows a greater increase in traffic flows on the Pacific Highway than on the Hume Highway, averaging 8.6 percent compared to 4.2 percent average increase on the Hume.

Both the Newell and New England Highways showed a substantial increase in traffic volumes, averaging 9.2 and 13.9 percent increases respectively. One count station at Glen Innes on the New England Highway recorded a 33% increase in traffic from 2771 to 3682 vehicles per day.

The use of annual data was checked to determine if significant changes were caused by travel to Expo, which occurred mainly in the second half of 1988 if the bus passenger statistics are used as a guide (see below)

The approximate quarterly proportions of traffic on each of the highways in 1988 was:

Highway	1st Q	2nd Q	3rd Q	4th Q
Pacific	27.5%	23.5%	24.5%	24.5%
Hume	25.2%	23.9%	24.2%	26.7%
Newell	21.6%	23.5%	29.8%	25.1%
New England	23.7%	24.2%	25.9%	26.2%

Thus the Newell Highway was the only highway to show a substantial rise in traffic in the third quarter of 1988.

There was an increase of 14.5 percent in heavy trucks passing through Marulan from 1987 to 1988. As trucks increased by about 14 percent but total traffic by only 4.2 percent, it appears likely that car traffic on the Hume dropped between 1987 and 1988.

Table 4.2 Changes in traffic volumes, 1987 to 1988

	% change
average of AADTs at selected sites	
- Pacific Highway sites	8.6
- Newell Highway sites	9.2
- Hume Highway sites	4.2
- New England Highway sites	13.9
trucks passing through Marulan truck checking station, Hume Highway	14.5

Source: RTA data

Bus and coach passenger visit statistics were obtained from the Bureau of Tourism Research. The most relevant statistic is the number of 'visits' undertaken by domestic passengers. A visit is included in statistics if a visitor spent at least one night at that location, irrespective of other 'visits' on the trip. It is thus a more useful guide than trips, which records only the main destination.

The changes between 1987 and 1988 included:

total visits by coach - Australia:	22% increase
visits Sydney to Brisbane:	105% increase
visits Melbourne to Brisbane:	63% increase

The majority of the increase to Brisbane came in the second half of 1988. The six monthly breakup of visits is:

	87 Jul/Dec	88 Jan/Jun	88 Jul/Dec	89 Jan/Jun
Sydney to Brisbane	142,000	167,000	424,000	209,000
Melbourne to Brisbane	75,000	70,000	163,000	73,000

Clearly, the 250% increase in the second half of 1988 in the Sydney/Brisbane visits creates the peak, although the vehicle travel statistics quoted above did not reveal a similar peak.

Industry sources indicated that long distance bus and coach passenger numbers increased by about 30 or 40 percent from 1987 to 1988. It was not possible, however, to translate that information into actual coach kilometres of travel, although it was thought to have increased by about 20 to 25 percent.

VEHICLE SPEEDS

The speed limit for heavy vehicles was increased from 90 km/h to 100 km/h throughout Australia on 1 July 1988. A national study, 'Car and Articulated Truck Speeds before and after July 1988' (Intstat 1989) came to the following conclusions:

- mean speeds of both cars and articulated trucks [in Australia] were higher after the speed limit change than before. Over all sites, the median increase was 1.5 km/h for cars and 1.9 km/h for articulated trucks

- the size of the change in mean speed for trucks seems to vary with the number of lanes

Intstat did not draw any conclusions about individual State speeds, but Table 4.3 shows the changes summarised in the report. The increases for NSW seem to be slightly above the national average.

Table 4.3 Car and articulated truck speeds in NSW October/November 1987 and November 1988

	cars		artics	
	1987	1988	1987	1988
mean free speeds (km/h)	104	106	100	103
85th percentile (km/h)	116	118	110	114
% exceeding 90 km/h	89	91	83	89
% exceeding 100 km/h	61	66	47	56
% exceeding 110 km/h	27	35	14	22

Source: Intstat 1989

These surveys did not cover any sites on the Pacific Highway north of Karuah, the focus of the Strand 1 study. Speed data from individual sites was scarce for the period under review, but those available showed results were variable.

CONCLUSIONS ON CHANGES 1987 TO 1988

There is strong evidence that economic and travel activity in New South Wales increased across the board from 1987 to 1988.

In particular:

- general economic activity increased by at least 12 percent, while the Consumer Price Index in NSW increased by 7.3 percent, about the same as the Wages, Salaries and Supplement component of GDP in NSW.

. road freight activity increased about 10 percent, but in the Sydney/Brisbane corridor, freight was 16 percent higher in 1988 than in 1987, with a peak increase of 32 percent in the December 1988 quarter over the corresponding quarter in 1987

. traffic volumes increased by about 4 percent on the Hume Highway over their 1987 levels, while on the routes to Brisbane, traffic volumes increased between 9 and 14 percent. The increased travel activity to Brisbane may have centred on the second half of 1988

. bus passengers from Sydney to Brisbane more than doubled in 1988 from 1987, but the increase in bus and coach travel may have been considerably lower

. travel speeds of cars and articulated trucks generally increased with mean and 85th percentile free speeds increasing by 2 km/h for cars and about 3 or 4 km/h for articulated trucks

4.4 SUPPLEMENTARY RESEARCH QUESTION (VII) - DID ECONOMIC AND TRAVEL ACTIVITY IN 1988 DIFFER FROM THE TREND IN THE PERIOD 1982 TO 1987, AND IF SO, HOW?

GENERAL ECONOMIC ACTIVITY

Apart from Gross Domestic Product (GDP), the most appropriate measure of general economic activity for this Study is 'Wages, Salaries and Supplements' for the Transport, Storage and Communication industry in the National Accounts. These entries are shown in Table 4.4 together with GDP for both Australia and New South Wales.

Table 4.4 INDICATORS OF GENERAL ECONOMIC ACTIVITY, 1982-1988 ($ Million)

	82/83	83/84	84/85	85/86	86/87	87/88
Gross Domestic Product						
Australia	150063	168133	185996	208306	230085	258168
% increase	8.6	12.0	10.6	12.0	11.0	12.2
New South Wales	53169	58696	63820	71521	79390	90791
% increase	6.2	10.4	8.7	12.0	11.0	14.3
Transport, Storage & Communication industry Wages, Salaries & Supplements						
Australia	8304	8907	9484	10206	11186	11972
% increase	12.1	7.2	6.5	7.6	9.6	7.0
New South Wales	3282	3427	3697	3958	4248	4575
% increase	11.9	4.4	7.9	7.1	7.3	7.7

Source: ABS catalogue 5220.0

The trend in both GDP and the wages/salaries areas was continued growth in the period 1982 to 1988. There is no significant difference in 1988 from the trend in the preceding four years, but NSW was higher than the total for Australia. The Consumer Price Index for New South Wales rose as follows:

year to June	84	85	86	87	88
increase (percent)	3.0	6.5	8.8	9.3	7.3

TRAVEL ACTIVITY

Information from the ABS SMVU shows that the following changes in travel occurred in the period 1982 to 1988:

change in total annual kilometres of travel

- articulated trucks 26% increase
- cars and station wagons 20% increase

change in total annual tonne kilometres of travel

- articulated trucks 47% increase

Figures 4.1 and 4.2 illustrate the trends in total articulated truck travel, but it is difficult to determine if and how 1988 was different from previous years with such broad statistics. (Figures for this section are to be found in pages 163 to 170).

Traffic counts

Data for Average Annual Daily Traffic (AADT) for the period 1982 to 1988 was examined for a range of sites on the Pacific, Newell, Hume and New England Highways. Figure 4.3 illustrates the average volumes for these sites and Table 4.5 indicates the comparisons of the increases.

Over the study period, the general trend was increased traffic volumes. The general trend continued on the Hume Highway from 1987 to 1988, but traffic increases on the Pacific, Newell and New England Highways in 1988 were significantly greater than the increases for the previous years.

The number of trucks passing through the truck checking station at Marulan on the Hume Highway for the period 1982 to 1988 is given in Figure 4.4, and shows an increase from 1982 to 1987 of 23 percent (an average of 4.2 percent) compared to an increase from 1987 to 1988 of 14.5 percent. However, the average measure does not illustrate the variability of the yearly increases, such as for example from 1986 to 1987 the increase was 11.5% and from 1985 to 1986 truck volumes on the Hume Highway declined.

The increases in total distances travelled for Australia in the period 1982 to 1988, as shown by ABS SMVU (26% for articulated trucks and 20% for cars), does not differ greatly from the general range on increases in AADTs as shown by Table 4.5 for the Pacific Highway, but less than the increases on the Hume Highway.

Table 4.5 Changes in traffic volumes, averaged from data at selected sites, 1982 to 1988

Highway	increase 82/87	average yearly increase 82/87	increase 87/88
Pacific Highway	17.8%	3.3%	8.6%
Newell Highway	13.0%	2.4%	9.2%
Hume Highway	26.0%	4.7%	4.2%
New England Highway	6.3%	1.2%	13.9%

Source: RTA data

Freight movements

Earlier, the difficulties with data from ABS were outlined, and the statistics presented here take account of the modifications and assumptions discussed at the time.

Quarterly variations in freight are shown :-

- in Figure 4.5, with an origin or destination of Sydney
- in Figure 4.6, the interstate road freight in the Sydney/Brisbane and Sydney/Melbourne corridors.

The December quarters in each year are usually more active than the other quarters. The increase in freight in the Melbourne/Sydney corridor from 1986 onwards (Fig 4.6) is reflected in Figure 4.5 because of the amount of freight in this corridor.

Note the significant increases in freight in the December 1988 quarter.

Yearly percentage changes in interstate freight flows are given for the highways in Figure 4.7. In 1988, the percentage increase was greater than for all previous years except for the Hume Highway in 1987 and the Pacific in 1984.

Bus and coach information

Statistics provided by the Bureau of Tourism Research (BTR) from the period 1984/85 are given in Table 4.6. Earlier details are not available in a form from which comparisons can be made.

BTR statistics record passenger visits to particular centres and are therefore not a direct measure of bus and coach travel. Nevertheless, the statistics show the sharp increase in passenger travel in 1988/89 compared to the earlier years. It is likely that this increase in travel was accompanied by an increase in bus and coach kilometres of travel.

This total increase in travel over the period is supported by industry statistics. However, the industry figures showed both a greater increase and more steady increase than the BTR statistics. Because the industry figures are individual companies and subject to changes in ownership and route changes, they are less reliable and not reported here.

Table 4.6 Bus passenger visits 1984/85 to 1988/89

(thousands of visits)

	84/85	85/86	86/87	87/88	88/89
Total visits - Aust	2167	2436	2657	2695	3300
% inc over previous year	na	12	9	1	22
% of all forms of travel	5	5	6	6	7
visits - Syd/Bne	318	323	230	309	633
% increase per year	na	2	-29	34	105
visits - Mel/Bne	137	125	109	145	237
% increase per year	na	-9	-13	33	63

Source: Bureau of Tourism Research

VEHICLE SPEEDS

Introduction

The speed of heavy vehicles in rural areas is an issue causing significant debate in New South Wales. Considerable attention was therefore given to vehicle speeds.

Truck speed limits were changed:

- on 1 January 1987 from 80 km/h to 90 km/h in all States and the ACT, except Queensland which already had a 90 km/h speed limit

- on 1 July 1988 from 90 km/h to 100 km/h in all States and the ACT

. on 23 December 1989 from 100 km/h to 90 km/h in New South Wales only, apart from speed limited trucks on designated highways.

The primary sources used for information on heavy vehicle speeds were reports of surveys throughout Australia undertaken for the Federal Office of Road Safety (FORS), and speed data supplied by the Roads and Traffic Authority.

Detailed information over the whole of the review period was not available. Some individual site information was available back to 1985, but such information was rare.

Difficulties with data comparisons

Comparisons of the various surveys is complicated by the significant variations in the reporting of speeds. Reporting varied between:

2 lane roads versus all roads

all trucks versus truck types (rigid, articulated)

day/night split versus no split.

Buses were separately reported in the FORS surveys but numbers were small, less than 100 as a total sample over all sites.

Of equal or greater importance is the caution that must be exercised in drawing detailed conclusions from data for which a wide variety of circumstances exist. For example, the FORS surveys included variations due to:

. type of road (in NSW, 50% of sites were 4 lane divided, in Victoria virtually all 4 lane divided, only 2 other sites throughout Australia were 4 lane divided)

type of equipment used (amphometer, radar, etc)

road conditions, including surface roughness and weather

time of day

direction of travel

sample size

The survey design would have taken account of many of the variables, but such difficulties should be borne in mind throughout this section.

Truck Speeds, 1978 to 1987, Australia

Fitzgerald (1989) reported on a study of the effect of the increase on January 1, 1987 in the heavy vehicle speed limit from 80 to 90 km/h. The study analysed speed differentials between cars and trucks from one survey taken before the increase (October 1986) and two surveys after the increase (April and October 1987).

The report also quoted from earlier surveys in 1978 and 1983 undertaken by the Federal Office of Road Safety. These 1978 and 1983 surveys are shown in Table 4.7 together with the three additional speed surveys from the FORS study.

Within the limitations of the data, it appears that:

- truck speeds throughout Australia generally increased between 1978 and 1986 without an increase in speed limits

- truck speeds in New South Wales were, together with Western Australia, the highest in Australia

- all measures of truck speeds in Queensland, where the truck speed limit remained at 90 km/h, increased in line with increases in other States after the speed limits increased on 1 January 1987.

Table 4.7 Mean free speeds, trucks, 1978 to 1987
2 lane roads (km/h)

	speed limit 80 km/h			> 90 km/h	
	1978	1983	1986 Oct	1987 Apr	1987 Oct
NSW	83	84	94	96	98
Vic	78	87	86	89	90
Qld (3)	83	82	84	88	87
WA	na	84	97	95	98
SA	81	81	85	86	90

na not available

Notes:

1. Methodology used in early surveys may not be consistent with later surveys
2. Trucks presumed to include rigid and articulated vehicles
3. Speed limit changed on 1 January 1987 from 80 km/h to 90 km/h except in Queensland where the limit was already 90 km/h. It is also possible that the speed limit in Victoria in 1978 was only 65 km/h, as it is not known when the surveys were taken

Source: FORS 1985, Fitzgerald 1989

Articulated vehicle speeds, 1986 to 1988, Australia

In an attempt to determine if NSW speed survey results were biased because of the inclusion of 4 lane divided roads, specific site data was extracted and is reproduced in Table 4.8. Without the option of a rigorous analysis, it was concluded that no apparent bias existed. Only 20% of total articulated vehicles were sampled at the two sites giving highest speeds (Goulburn and Mt White).

Table 4.8 Articulated vehicle speeds by site, 1986-1988

Location	Mean free speed			
	Oct 86	Apr 87	Oct 87	Oct 88
2 lane undivided roads				
New England Hwy, Tamworth	103	102	104	109 N
				107 S
New England Hwy, Singleton	89	90	92	102 N
				99 S
Hume Hwy, Gundagai	97	99	100	103 N
	96	100	97	102 S
				98 N
				94 S
Newell Hwy, Forbes	104	102	98	101 N
	106	96	104	98 S
				104 N
				102 S
4 lane divided roads				
Hume Hwy, Berrima	88	91	96	97 N
	94	98	94	98 S
	88			98 N
				103 S
Hume Fwy, Menangle	94	100	100	98 N
	97	97	98	102 S
				106 N
				97 S
Hume Hwy, Goulburn	105	107	107	114 N
				106 S
Newcastle Fwy, Mt White	101	103	92	113 N
	96			95 S

N is northbound direction, S is southbound direction

Notes: 1. Sample sizes varied from 8 vehicles to 223 vehicles 2. Some surveys were at night, others during the day

Source: Fitzgerald 1989, Intstat 1989

Tables 4.9 and 4.10 are extracted from the FORS speed surveys undertaken in conjunction with the changes in speed limits for heavy vehicles (Fitzgerald 1989 and

Intstat 1989). As Intstat did not report separately in two lane roads, the Tables represent results for all roads.

Examination of these Tables leads to the following conclusions in relation to articulated vehicle speeds:

a. Speeds have increased throughout Australia since 1986

The data shows consistent increases in speed, particularly shown by Table 4.10 where percentages exceeding various speeds increased with each survey.

b. Articulated trucks in NSW travel faster than articulated trucks in other States

With the notable exception of Western Australia, where speeds are too similar to draw firm conclusions, there is evidence that articulated trucks in NSW travel about 10 km/h faster than articulated vehicles in other States. Not only are mean free speeds higher by about 10 km/h but the percentages of articulated trucks in NSW exceeding 110 km/h and 100 km/h are similar to the percentages exceeding 100 km/h and 90 km/h respectively in other States.

c. Articulated trucks travel faster than rigid trucks

Although only mean speeds are included in the comparisons in this report, other data in Fitzgerald and Intstat support this conclusion.

d. Actual rural speeds do not correlate well with speed limits

Given the speed limit increases, the percentage exceeding the speed limit plus 10 km/h (to allow for perceived tolerance) dropped substantially. The NSW figures are:

- speed limit 80 km/h: 79% exceeded 90 km/h
- speed limit 90 km/h: about 45% are exceeding 100 km/h
- speed limit 100 km/h: 22% are exceeding 110 km/h

In addition, mean free speed has increased 4 km/h for a 20 km/h increase in speed limit. This pattern is consistent across all States.

Table 4.9 Mean free speeds by vehicle class 86/87/88 all roads (km/h)

	Buses				Articulated				Rigid			
	Oct 86	Apr 87	Oct 87	Oct 88	Oct 86	Apr 87	Oct 87	Oct 88	Oct 86	Apr 87	Oct 87	Oct 88
NSW	100	101	100	105	97	99	100	103	89	90	90	94
Vic	87	91	91	na	86	88	91	na	88	88	90	na
Qld	93	94	94	97	89	91	91	93	87	87	88	87
WA	102	102	100	102	97	95	99	100	94	96	96	96
SA	94	97	96	na	87	90	94	na	87	86	87	na
Tas	80	80	78	85	87	85	85	89	83	81	80	80
ACT	83	87	82	82	85	85	80	92	84	85	83	87

na not available Source: Fitzgerald 1989, Intstat 1989

Table 4.10 Free speeds of articulated vehicles 86/87/88 all roads (km/h)

	% > 90 km/h				% > 100 km/h				% > 110 km/h			
	Oct 86	Apr 87	Oct 87	Oct 88	Oct 86	Apr 87	Oct 87	Oct 88	Oct 86	Apr 87	Oct 87	Oct 88
NSW	73	79	84	89	36	43	47	56	12	14	14	22
Vic	29	37	49	na	7	8	11	na	1	*	*	na
Qld	45	55	53	61	12	14	16	19	2	1	2	1
WA	72	67	77	79	37	33	40	47	14	13	14	17
SA	31	42	55	na	13	17	22	na	4	4	8	na
Tas	38	26	28	32	10	9	4	12	2	0	0	6
ACT	26	28	22	51	6	5	5	23	0	3	0	5

na not available Source: Fitzgerald 1989, Intstat 1989

In addition to the results of the FORS surveys, separate data for NSW supplied by RTA gives day/night and 2 lane/4 lane splits. Some of the 2 lane information is reproduced in Table 4.11, but 4 lane information is not given because little of the Pacific is 4 lane divided.

Conclusions which can be reached from these Tables are:

. articulated vehicles travel faster at night than during the day

. mean day free speeds increased more than mean night free speeds

. 85th percentile night speeds increased more than 85th percentile day speeds.

Table 4.11 Articulated vehicle speeds in NSW
2 lane roads (km/h)

speed limit 80 > 90 > 100

	Nov 86	Mar 87	Nov 87	Mar 88	Nov 88	Mar 89	Nov 89
Day							
Mean free speed	90	92	93	92	94	93	96
85th %ile	100	102	101	100	104	101	104
% exc 100 km/h	12	18	17	13	24	17	28
% exc 110 km/h	2	3	2	1	2	2	4
% exc 120 km/h	*	*	*	*	*	*	*
Night							
Mean free speed	99	100	101	99	103	102	103
85th %ile	108	109	112	110	112	112	114
% exc 100 km/h	39	48	55	40	62	54	61
% exc 110 km/h	13	13	17	14	19	17	22
% exc 120 km/h	2	1	1	1	2	2	5

* means less than 1%

Source: Information supplied by NSW RTA

Bus and coach speeds

Table 4.9 includes mean free speeds of buses (including coaches) throughout Australia, and Table 4.12 is additional data on bus speeds. Sample sizes are extremely low in each survey.

The conclusions reached about articulated truck speeds in NSW appear equally applicable to buses viz; actual speeds are higher than other States apart from Western Australia and speeds have increased since 1986.

Data presented in the reference material shows car speeds have increased since 1976, but not by the same amount as trucks.

Table 4.12 Free speeds of buses 86/87/88 (all roads) (km/h)

	% > 90 km/h				% > 100 km/h				% > 110 km/h			
	Oct 86	Apr 87	Oct 87	Oct 88	Oct 86	Apr 87	Oct 87	Oct 88	Oct 86	Apr 87	Oct 87	Oct 88
NSW	85	87	85	97	51	60	49	69	10	10	13	20
Vic	33	52	54	na	8	9	10	na	*	*	*	na
Qld	63	72	64	76	18	34	28	38	1	3	6	4
WA	87	89	90	82	55	63	45	59	24	26	10	24
SA	62	81	79	na	28	40	31	na	7	3	7	na
Tas	25	7	10	31	13	0	0	8	0	0	0	0
ACT	27	40	17	36	9	8	8	8	0	0	0	4

na not available

Source: Fitzgerald 1989, Intstat 1989

<u>Regression Analysis of Truck Speeds</u>

An analysis of mean vehicle speeds collected from speed surveys undertaken from November 1986 to November 1989 was conducted by the Roads and Traffic Authority. The results are presented in Table 4.13 below. The slopes of the regression lines show that the speed of articulated vehicles increased on both two and four lane roads during the day and on two lane roads only at night. The lack of a significant slope for four lane roads at night may be a ceiling effect, this is the type of location for which speeds were greatest before the speed limit increase.

It is possible, but less likely, that the change in the truck speed limit affected other vehicles. There has been some speculation that car drivers may have sped up in order to avoid being overtaken by trucks or to pass them. The analysis of mean speeds in Table 4.13 shows evidence of increased car speeds on four lane roads at night and probably during the day ($p<.07$). However, it must be noted that the speeds measured were free speeds and so may not be informative about the relative speeds of cars and trucks when in close proximity.

Table 4.13. Regression analysis of mean vehicle speeds November 1986 to November 1989. m=number of months since November 1986

Type of location	Regression line	Probability
Two lane day		
Cars	99.92 + 0.019m	0.5053
Rigid Trucks	84.23 + 0.141m	0.0870
Articulated Vehicles	90.68 + 0.123m	0.0062*
Two lane night		
Cars	103.83 + 0.067m	0.1682
Rigid Trucks	91.77 + 0.130m	0.0336*
Articulated Vehicles	98.81 + 0.124m	0.0127*
Four lane day		
Cars	106.92 + 0.126m	0.0665
Rigid Trucks	91.97 + 0.110m	0.0353*
Articulated Vehicles	93.80 + 0.189m	0.0038*
Four lane night		
Cars	105.02 + 0.130m	0.0254*
Rigid Trucks	92.65 + 0.145m	0.0563
Articulated Vehicles	101.34 + 0.079m	0.2776

Table 4.14 shows that the increases in the 85th percentile speeds appear to be smaller than those for the means. The speeds of articulated vehicles increased for two lane night and four lane day conditions.

Table 4.14. Regression analysis of 85th percentile of vehicle speeds November 1986 to November 1989. m=number of months since November 1986

Type of location	Regression line	Probability
Two lane day		
Cars	111.88 - 0.018m	0.5986
Rigid Trucks	93.79 + 0.163m	0.0346*
Articulated Vehicles	100.00 + 0.092m	0.1047
Two lane night		
Cars	116.70 + 0.051m	0.4304
Rigid Trucks	102.09 + 0.105m	0.2310
Articulated Vehicles	108.44 + 0.142m	0.0054*
Four lane day		
Cars	117.55 + 0.152m	0.0328*
Rigid Trucks	102.41 + 0.096m	0.0951
Articulated Vehicles	102.57 + 0.143m	0.0198*
Four lane night		
Cars	117.79 + 0.087m	0.1503
Rigid Trucks	104.45 + 0.122m	0.2794
Articulated Vehicles	113.85 + 0.020m	0.8153

COMPARISONS BETWEEN VARIOUS HIGHWAYS

A range of indices were calculated to determine both the trend and relationship of crashes on the Hume, Pacific, Newell and New England Highways. While no index could be regarded as absolute, the indices give a range of trends and comparisons for the purposes of the study.

Index 1 Fatal truck crashes per travel measure

The AADT averages used in Section 4.2 were divided into the number of crashes involving trucks for the year, then adjusted by the relative lengths between the different highways to give a measure of exposure. The resultant crash rate index is shown in Figure 4.8. The trend is generally downwards until 1988.

The fatal crash rate for the Pacific Highway is, using this index, either the worst or second worst in each year.

The trends are more clearly illustrated by Figure 4.9 where the changes in crashes are divided by the changes in traffic. For an index less than one, the crash rate is declining. With three exceptions, only for 1988 did the index exceed one on all highways.

Index 2 Fatal crashes involving articulated vehicles per 100,000 tonnes of interstate freight

Fatal crashes involving articulated vehicles is chosen rather than all fatal truck crashes because the index covers interstate freight.

The range of assumptions required in the data makes comparisons difficult, particularly the Pacific and New England Highways. Even so, the figures confirm the trends apparent in other work that the crash rates were declining prior to 1988. Figure 4.10 illustrates the yearly rates and Figure 4.11 the changes from the previous year.

Irrespective of the absolute ratios, the Pacific Highway is certainly worse than either the Newell or Hume Highways. The crash rate on the Hume could only decrease if Adelaide, Perth and Canberra freight was included, as would the Newell crash rate when Adelaide and Perth freight was considered. Therefore, the best light that could be put on this index is that the Pacific is, on average, three times worse that the Hume per 100,000 tonnes of interstate road freight moved.

CONCLUSIONS ON TRENDS 1982 TO 1988

Because of a shortage of data, or in some cases reliable data, firm conclusions could not be drawn on the full range of activities considered. In particular, reliable data prior to 1985 is scarce in many areas.

In most cases, however, the 1988 activity was greater than the trend. There is no evidence that activity in 1988 was lower than the trends from 1982 to 1987.

Economic activity

General economic activity remained steady, with GDP increasing about 11 or 12 percent since 1985/86. The figures for 1988/89 have not yet been released for many sectors, leaving the second half of 1988 unknown.

Travel activity

Traffic volumes over the period grew steadily at a rate of less than 5 percent. During 1988, however, traffic volumes on the Pacific, Newell and New England Highways increased at more than twice the previous growth rates. In particular, the New England Highway increased by 14 percent compared to the average annual growth of 1 percent.

Truck traffic on the Hume Highway since 1986 has increased about 14 percent per year.

Freight movements

Freight activity on the Hume Pacific and Newell Highways increased in 1984 and 1985 but was stagnant in 1986. In 1987 and 1988, freight activity on the Hume Highway increased more than 10 percent but the increase in 1988 was lower than in 1987. Negative growth on the Pacific and Newell Highways in 1987 was replaced with strong growth in 1988, particularly on the Pacific Highway.

Bus passengers

There is strong evidence that visits to Brisbane by bus passengers increased dramatically in 1988, leading to greatly increased bus and coach travel.

Vehicle speeds

Within the limitations of early data, it appears that truck speeds increased about 10 km/h from 1983 to 1986 while the speed limit was 80 km/h. From 1986 to 1988, mean free speeds again increased, but only about 5 km/h even though the speed limit increased by 20 km/h.

There is evidence that NSW trucks travel faster than trucks in other States except Western Australia even with the same speed limit, but the reasons for this are unknown. The trend continues.

In addition, trucks travel about 10 km/h faster at night than during the day, and these comparative speeds have not changed significantly since data became available in 1986.

With limited data, it appears that bus speeds followed the pattern of truck speeds, while car speeds exhibited a lower rate of increase than trucks.

Comparisons between highways

When indices comparing crash rates on four highways are examined, it is apparent that the trend in crashes/traffic and crashes/freight decreased between 1983 and 1987, but increased on all highways in 1988.

The Pacific Highway is, by all measures, generally worse for crashes than the Hume Highway.

4.5 SUPPLEMENTARY RESEARCH QUESTION - WAS THE WEATHER PATTERN IN 1988 SIGNIFICANTLY DIFFERENT TO THAT EXPERIENCED IN THE PERIOD 1982 TO 1987 AND IF SO CAN ANY RELATIONSHIP BE DRAWN BETWEEN THE CRASHES AND WEATHER PATTERN?

THE EFFECTS OF WET WEATHER ON CRASH PROBABILITY

A review of past research was undertaken to establish hypotheses to be tested against the NSW mass crash data data.

Two main ways in which wet weather affects crash probability have been identified:

(1) by reducing visibility - this is caused by obscuration due to heavy rain, spray and splash, and/or because of windscreen wipers not functioning properly or distracting the driver. The effect is greater when it is raining but may still have some effect when the road is very wet.

(2) by reducing traction - this results in increases in braking distance and reduction in manoeuvrability. A reduction in traction results from the road being wet and it may persist even when the rain has stopped.

The OECD Road Research Group (1976) considered these two factors. They concluded that "reduced visibility is nearly as important as decreased skid resistance as a factor in accidents in rain" (cited in Sandberg, 1980).

Reduced visibility

The factors involved in reduced visibility have been identified by Sandberg (1980).

> Reduced visibility in wet weather can arise from several sources. One is the impairment in visibility directly through the rain. Another is the visibility reduction due to the unfavorable changes in reflectivity and specularity in the presence of road lighting and vehicle headlights during wet weather. A third source is the generation of water splash from vehicles travelling at high speeds on a wet road. (p.194)

Splash is the water thrown forward and sideways from the tyre-road interface. The droplets are large and not caught in the air streams around the vehicle.

Spray is considered a greater problem. The small droplets are thrown by centrifugal action tangentially from the tyre treads and are caught by the air streams. Streams of spray may persist behind the vehicle for up to 200 m. Mortimer, Monaco and Crothers (1986) noted that the reduction in visibility due to spray was much greater when trucks were travelling at greater than 100 km/h.

Sandberg has listed the negative consequences of splash and spray on traffic safety

(a) Approaching traffic will face an impaired visibility through the spray before the approach.

(b) Approaching traffic will have a sudden and heavy shower on the windscreen. This may cause panic in some drivers not prepared for this and could result in a braking action giving loss of vehicle control. It may take several seconds until the windscreen wipers have been switched on.

(c) Vehicles behind the spray-producing vehicle get impaired visibility through the spray in the air as well as through the water-covered windscreen. The latter nuisance can, of course, be reduced by efficient windscreen wipers.

(d) Dirty headlights decrease drivers' night time visibility distances.

(e) Dirty headlights and rearlights decrease vehicle conspicuity.

(f) Rear windscreen and external rear mirrors get dirty, giving reduced rear visibility.

(g) Road signs get dirty and thus less visible. (Sandberg, 1980)

Intuitively, these negative consequences appear to contribute more to multiple-vehicle crashes than single vehicle crashes. The proportion of multiple to single vehicle crashes may not be greater during wet weather, however, if traffic volumes are lower in wet weather.

<u>Reduced traction</u>

Wet roads result in reduced traction and thus an increased crash risk. Reduced traction may contribute to both single and multiple vehicle crashes.

Reduced traction may contribute to crashes on curves during wet weather. The recent Victorian study of single vehicle rural accidents found a ratio of 85:62 of crashes on bends to crashes on straight roads, but this ratio increased to 17:5 when restricted to crashes in which it was raining (Carter, 1989). Only 8.2% of the total sample of crashes involved trucks, however.

The studies which have attempted to determine the contribution of wet weather to crashes have not focussed on trucks. Articulated vehicles, especially, may be more affected by reductions in traction than other vehicles. For this reason, estimates of the contribution of wet weather resulting from these studies are likely to underestimate the problem for truck crashes.

AN ANALYSIS OF THE ROLE OF WET WEATHER IN NSW HEAVY VEHICLE CRASHES

Choice of variable: Wet road versus raining

There are two variables coded in the mass data set which could be of relevance to determining the involvement of rain in heavy vehicle crashes.

The first is Surface Condition which has four levels:

3=wet 4=dry 5=snow or ice 9=unknown or not stated.

The second variable is Weather which has seven levels:

1=fine and sunny
2=raining
3=overcast
4=fog and mist
5=snow or sleet
6=other (eg hail)
9=unknown or not stated.

An analysis of the mass crash data for the years 1982-1988 showed that the road was wet in 19.5% of all heavy vehicle crashes and it was raining in 14.4% of all heavy vehicle crashes.

The surface condition was coded as "wet" in all but one crash in which the weather was coded as "raining". In contrast, the weather was coded as "raining" in only 73.76% of crashes in which the road was "wet". The weather was "fine and sunny" in 16.84% of wet road crashes and "overcast" in 7.11% of crashes. The remaining weather categories were cited in less than 2% of wet road crashes.

A question of interest is whether the trends in the two variables are similar. Figure 4.12 shows that the trends for "wet" and "raining" appear to be the same, whether number or percentage of crashes is examined.

"Wet" is the more inclusive variable. From a theoretical point of view, the increase in risk due to the visibility problems resulting from spray and splash and the vehicle control problems due to wet road may be more related to the road being wet than to it being raining at the time of the crash.

Involvement of rainfall in all versus fatal and serious injury accidents

The focus of this study is on fatal and serious injury crashes. Is the involvement of rain in these crashes similar to that in all crashes? Figure 4.13 shows the numbers and percentages of "wet road" crashes for all heavy vehicle crashes and fatal and serious injury crashes only.

The role of rainfall in crashes on the Hume and Pacific Highways

The road was coded as wet for 84/318 (26.4%) of Pacific Highway crashes and 84/325 (25.8%) of Hume Highway crashes. The weather was coded as raining for 59 (18.5%) of Pacific Highway crashes and 68 (20.9%) of Hume Highway crashes. The section which follows examines if wet weather crashes were affected by light conditions or vehicle type. Single vehicle crashes are also examined.

Wet weather and daylight-darkness. Some of the deteriorations in visibility in wet weather may increase crash risks more during darkness than during daylight. As Sandberg (1980) noted, dirty headlights caused by splash and spray decrease drivers' night-time visibility distances and dirty headlights and rearlights decrease vehicle conspicuity.

The numbers of heavy vehicle crashes recorded as occurring during daylight and darkness in which the road was wet or it was raining were compared. In Table 4.15, these numbers are expressed as percentages of all crashes occurring under that lighting condition. Crashes which were coded as dawn or dusk are not presented in the table.

Table 4.15 The percentages of daylight and darkness crashes in which the road was wet or it was raining.

	Daylight	Darkness
Wet road		
Pacific	22.9%	32.4%
Hume	24.1%	29.1%
Raining		
Pacific	16.9%	20.6%
Hume	21.1%	22.1%

The data in Table 4.15 suggests that wet roads, and rain to a lesser extent, are present in a larger percentage of crashes occurring in darkness than in those occurring during daylight. Tests of the difference between proportions (Ferguson, 1971) showed that none of the apparent differences were statistically significant at the 5% probability level. For the Pacific Highway, the difference between the percentage of crashes occurring in darkness in which the road was wet and the percentage during daylight was significant at the 10% probability level.

The role of wet weather in crashes involving each class of heavy vehicle. The percentages of articulated vehicle, rigid truck and bus crashes in which the road was wet or it was raining are presented in Table 4.16. The percentages of crashes in which the road was wet were greater for articulated vehicle crashes than rigid truck crashes for both the Pacific and Hume Highways (z=2.21, p<.05 and z=2.33, p<.05, respectively). These differences were significant only at the 10% probability level when crashes in which it was raining were analysed (z=1.90, z=1.70, for Pacific and Hume, respectively).

Table 4.16. Percentages of articulated vehicle, rigid truck and bus crashes in which the road was wet or it was raining on the Pacific and Hume Highways.

	Articulated vehicle	Rigid truck	Bus
Wet road			
Pacific	31.4%	20.5%	20.0%
Hume	30.0%	18.8%	37.5%
Raining			
Pacific	22.1%	13.9%	20.0%
Hume	23.5%	16.0%	37.5%

Care should be exercised in interpretation of the data describing involvement of wet weather in bus crashes on the Hume and Pacific Highways because the numbers are very small.

Wet weather and single vehicle crashes. Table 4.15 shows the percentages of crashes in which only one vehicle was involved for each of the classifications of Surface Condition and Weather. The numbers of crashes which were coded with Surface Condition as snow/ice or unknown/not stated or Weather as fog/mist, snow, other or unknown were small, therefore the proportions of these crashes which were single vehicle are zero or not reliable.

For the Pacific Highway, Table 4.17 shows that the proportion of crashes which were single vehicle was about 31% regardless of the Surface Condition or Weather. For the Hume Highway, the proportion of crashes which were single vehicle was higher when it was wet than when it was dry (z=3.17, p<.01) and higher when it was raining than when it was fine (z=3.93, p<.01).

Analysis of the data of Table 4.16 showed that the contribution of wet weather to crashes was greater for articulated than rigid trucks. Table 4.18 examines whether the contribution of wet weather to single vehicle crashes is greater for articulated than rigid trucks.

Table 4.17. Percentages of crashes which were single vehicle for each classification of Surface Condition and Weather

	Surface Condition		Weather	
	Wet	Dry	Fine	Raining
Pacific	31.0	31.0	30.8	30.5
Hume	42.9	24.6	24.1	47.1

Table 4.18. Percentages of crashes which were single vehicle for articulated vehicles and rigid trucks by Surface Condition and Weather

Surface Condition

	Wet		Dry	
	Rigid	Artic	Rigid	Artic
Pacific	25.8	33.3	26.1	34.8
Hume	33.3	48.2	16.2	30.0

Weather

	Fine		Raining	
	Rigid	Artic	Rigid	Artic
Pacific	25.4	35.3	19.1	36.8
Hume	16.8	29.2	34.8	54.6

Table 4.18 shows that the proportion of crashes which were single vehicle was greater for articulated than rigid trucks regardless of the Surface Condition or Weather.

BUREAU OF METEOROLOGY DATA

Daily rainfall measurements are collected at stations and condensed into districts. The district average rainfall is the average of rainfall received at selected stations in that district. Districts are areas for which the rainfall patterns (annual rainfall and seasonal rainfall incidence) are similar.

New South Wales is divided into 30 districts. There are 4 districts which fall along each of the Hume and Pacific Highways.

Rainfall data is available in its raw form in millimetres while decile values are often used to give an indication of rainfall variability over time. For example, if the annual (or monthly) rainfall for a district falls within deciles 4 and 7, the value is considered an "average" one. Drought criteria are based on decile analyses. Decile values do not therefore give an absolute indication of the actual rainfall. For example, as shown in Table 4.19, two almost identical monthly rainfalls (142 mm and 146 mm in station 59) are have different decile values because the expected rainfall patterns were different in these months.

Table 4.19 Monthly rainfall and decile values for districts covering the Pacific Highway, together with fatal articulated crashes, 1988

Month	Station 58		Station 59		Station 60		FAC
	mm	decile	mm	decile	mm	decile	
Jan	276	8-9	173	6	134	5-6	3
Feb	82	2-3	111	3-4	150	6-7	2
Mar	235	6-7	142	4	125	4-5	2
Apr	592	>9 *	472	<9	386	<9	2
May	32	1-2	39	2-3	43	1-2	1
Jun	122	6-7	105	6-7	78	4-5	4
Jul	193	8-9	146	8-9	148	8-9	1
Aug	58	6-7	9	<1	24	2-3	2
Sep	147	>9	113	8-9	114	7-8	0
Oct	11	<1	14	<1	31	1-2	2
Nov	64	3-4	67	4	96	5-6	0
Dec	192	8-9	208	7-8	142	7-8	3

Notes:

1. Decile 6 means that the rainfall was exactly on decile 6, decile 6-7 means that the rainfall fell between the 6th and 7th decile (one tenth points on the expected rainfall scale)

2. Station 58; Manning, from Casino to Murwillumbah
Station 59; Lower North Coast, West Kempsey to Coffs Harbour
Station 60; Manning, centred near Comboyne

3. FAC means fatal articulated vehicle crashes on the Pacific Highway

4. * means highest rainfall on record for that month

It is difficult to assume that drivers vary behaviour in accordance with normal monthly rainfall patterns, and therefore actual rainfall will be used in these comparisons.

It is apparent from Table 4.19 that there does not seem to be a relationship between rainfall and crashes in 1988. For example, April had extremely high rainfall but had only half the number of fatal articulated vehicle crashes as occurred in June which had average rainfall, and the same number as October which had minimal rain. Another comparison is the index: crashes per 100 mm rain. This index is given in Table 4.20 for the years 1982 to 1988. The average rainfall is the average of stations generally covering the highway concerned.

Table 4.20 Comparison of crashes in relation to rainfall

Year	Hume			Pacific		
	average rain	crashes	index*	average rain	crashes	index*
82	367	17	4.6	1350	25	1.9
83	908	13	1.4	1535	19	1.2
84	858	13	1.5	1454	16	1.0
85	732	14	1.9	1582	15	0.9
86	690	12	1.7	898	12	1.3
87	638	9	1.4	1237	10	0.8
88	799	17	2.1	1684	22	1.3

Notes:

1. * Index is ratio crashes/100 mm rain

2. Average rain is average of actual rain at stations

It is extremely difficult to draw conclusions on the basis of the information presented in Table 4.20. The only points worthy of note are, perhaps, that:

1986 and 1987 were the driest years on the Pacific Highway and produced the lowest number of fatal articulated vehicle crashes

. apart from a dry 1982, fatal crashes on the Hume Highway followed a similar pattern to the Pacific

. rainfall is higher on the Pacific Highway than the Hume Highway

SUMMARY AND CONCLUSIONS

The trends for 1982-1988 appeared similar whether the variables Surface Condition=Wet or Weather=Raining were analysed.

The incidence of wet roads and raining was similar for the Pacific and Hume Highways in 1988.

The apparent greater role of wet weather in crashes during darkness (versus daylight) was not found to be statistically significant.

Wet weather was more often involved in crashes of articulated vehicles than of rigid trucks. This may have resulted from losses of traction in wet conditions. This speculation is supported by the finding that the proportion of crashes that were single vehicle was higher when the road was wet or it was raining.

There does not seem to be a direct correlation between increased rainfall and increased numbers of fatal crashes.

4.6 DRIVER DISCUSSIONS

INTRODUCTION

Discussion sessions with a small selection of drivers were conducted, with the objective to :-

- determine driver views on how road safety and conditions had changed during the 1980's

- elicit suggestions and views on countermeasures.

The main criterion for selection of drivers for these discussions was at least 5 years experience driving interstate. Discussions were held at the transport operator's premises. Companies selected for driver discussions covered three different freight markets. Both owner drivers and company drivers were included.

Format was informal and only broadly structured in order to focus the discussions on relevant issues. In two instances group discussions were held, in the remainder discussions were held with individual drivers.

The discussions are reported in two broad categories of road safety issues and countermeasures.

ROAD, TRAFFIC AND SAFETY ISSUES

Drivers were asked how conditions has changed over the last ten years but to give particular emphasis to recent changes.

Truck speeds

Although more powerful engines and newer technology have allowed the faster trucks to travel faster, the general interstate truck speeds have not changed significantly in the last ten years. Trip times have reduced, however, as trucks lose less speed up hills and some roadworks have reduced road distances. Some drivers claimed the days of the fast truck were finished.

Road conditions

Roads have generally become more dangerous because they are rougher, there are more potholes and the surface stones have polished, in places to a glass like finish. In these conditions it is easy to lose a vehicle, particularly in power jackknife when there is oil on the surface. The Roads and Traffic Authority seemed to do re-surfacing works only after serious crashes.

Sections of the Hume have obviously improved where new divided roads have been opened, but the Pacific has deteriorated.

The Pacific Highway in the past has been preferred to the New England as the route to Brisbane because the distance is shorter and there is less climbing. However, poorer road conditions on the Pacific have caused a shift in heavy traffic to the New England, and the lack of experience on this road can cause problems.

There appears to be an increase, not only in numbers of trucks, but also in cars travelling at night. There has been a large increase in number of coaches on the road during the eighties.

Driver attitudes

Some owner drivers felt the company drivers caused more problems than owner drivers. Others drivers thought there was no difference in skills and attitude between owner or company drivers. The owner drivers felt that the company drivers do not generally have the same regard for fuel conservation and vehicle maintenance as owner drivers.

Improvements in driver attitudes have been noticeable in the last eighteen months. There is considerably less 'calling through' (to overtake) on double lines and blind corners. A lot of the 'cowboys' have gone. In particular, the bus crashes caused a sense that driving is more of a serious business among the less experienced.

There still remain, however, a few drivers with an ego problem who create safety concerns among drivers.

When faced with a car on the wrong side of the road, truck drivers are less likely than previously to move on to the road shoulder. In previous years, there was not the 'cowboy' stigma attached to heavy vehicle drivers by Police and the public. In recent years, however, because of that stigma, the truck driver is rarely believed as to the cause of the crash if there are no other witnesses, and a truck driver avoiding and crashing becomes involved in a single vehicle crash with the truck driver receiving the blame.

Car drivers have become more aggressive, and the recent reduction in speed limits for heavy vehicles in NSW has exacerbated the problem. Car drivers take more chances, cut in more often and pass in dangerous situations more often than before the reduction in speed limits.

<u>Training and driver experience</u>

It appears that there are more inexperienced truck drivers on the road over the last ten years. Such drivers do not know how to handle their truck, and are more likely to speed.

Experienced drivers are getting out of interstate work because of disillusionment with present conditions.

The drivers supported the graduated licence scheme whereby a young driver gained experience in small trucks in less demanding circumstances before moving up to larger, faster vehicles. Short periods of training were not seen as a substitute for experience.

Good reports on the specialised driver training courses in other States have been received. More than half of the drivers indicated that there appeared to be value in such courses even refresher courses for the experienced drivers. Some drivers felt the courses could be improved.

<u>Fatigue and driving hours</u>

On the main interstate runs, trip times were lower due to better gradeability of trucks and some shortening of routes.

There is still a problem with the operator who worked all day loading and unloading then spent all night at the wheel. This was seen as no different, however, to the car driver who worked all day and drove at night, particularly during 1988 when night driving to Expo by car drivers created particular problems. Other drivers referred to no limits on other workers such as crane drivers and doctors who worked very long hours.

There were insufficient roadside facilities for drivers. Drivers cannot stop in the middle of nowhere for refreshments. Drivers therefore exceeded driving hours in order to reach suitable stopping or refreshment facilities.

The driving hours regulations were felt to be too inflexible and did not allow for the variations in drivers and road conditions. Poor road conditions created more stress and therefore fatigue. The individual body response varied from day to day, such as, for example, after a few days break from driving a few hours of night driving could make the driver felt tired because the body had modified its patterns. On some days, the driver needed to rest before his five hours was up, on others he could drive for longer.

Delivery schedules

Some drivers claimed that just-in-time (JIT) manufacturing was the forgotten cause of inappropriate delivery schedules. Just-in-time manufacturing relies on low levels of stock at the manufacturing plant, with materials being delivered 'just-in-time' for the manufacturing process.

Because of lack of buffer stock, some manufacturers are putting their own economic concerns before road safety issues. In a 'panic' to keep the plant open, deliveries were required as soon as physically possible. As such work was regular it was hard to ignore, particularly with the increase in this method of manufacturing over the last decade.

Some companies now would not unload if time elapsed was below a minimum (eg 10 hours Melbourne/Sydney). This was seen as a measure to reduce incentive to speed.

Enforcement

Enforcement had been variable over the last ten years. However, there was a general feeling that common sense had gone out of the window in NSW in the last six months. The crackdown on truck drivers had included harassment, breaches for ridiculously minor offences, an increase in 'phantoms' (breaches where none occurred) and targetting of individual drivers.

One driver alleged breaches had taken place for minimal offences such as ;

excess speed (91 km/h in a 90 km/h zone)

travelling too closely (58m instead of 60m)

overlength (17.53m instead of 17.50m).

'Operation Co-operation' on the Pacific had been a good example of police and drivers working together and improving self regulation among drivers, and received strong support. There was general scepticism as to reasons why the planned four month operation was called off after only ten weeks.

The drivers felt that there should be some recognition of the distances travelled and present police attitude to truck drivers in the points demerit system. Owner/drivers could not afford to defend a 'phantom' but they were still only allowed the same number of points as a car driver who travelled minimal distance each year.

Drivers recognised the need for enforcement but felt commonsense was an important ingredient. Breaching on good straight sections, particularly downhill, was seen a revenue raising when there were places where speed was more dangerous.

ATTITUDE TO POSSIBLE COUNTERMEASURES

Drivers were asked their opinions on countermeasures recently introduced or under examination and also asked to nominate other possible countermeasures.

Speed limiters

Drivers did not oppose speed limiters provided the equipment was set at a reasonable maximum speed, say 110 or 115 km/h. The reason for opposing the 100 km/h setting on speed limiters included;

. why were truck drivers the only vehicle not allowed a tolerance on the speed limit

. difficulties arose in overtaking any vehicle travelling in the region of 80 to 85 km/h (eg car/ caravan combination)

. gradeability was reduced (speed on grades still dropped off by the same amount)

. there was no real incentive to retro-fit speed limiters set to 100 km/h as States with a 100 km/h speed limit allowed tolerances above the limit

. incentives to try to disable speed limiters arose from a low speed limit

. drivers would tend to drive faster where it would be inappropriate (such as on low speed curves) to make up time

Speed limits

The 90 km/h speed limit for trucks not fitted with speed limiters was strongly opposed because;

. car drivers caught up more frequently, following queues became longer and car drivers took more risks in overtaking.

. where speed limited trucks could travel at 100 km/h, more overtaking of lower speed trucks occurred. Cars became sandwiched between the overtaking trucks, leading to safety problems.

. the actual speed of the truck was the safety issue; so why are some trucks (with speed limiters) allowed to travel at 100 km/h when otherwise identical trucks (without speed limiters) are only allowed to travel at 90 km/h.

Tachographs/trip recorders

It was generally felt that these devices were a good fleet management tool but of no use for owner/drivers. They could not aid road safety as it was only record keeping. Breaching on historical records for minor transgressions of driving hours, where no problems had occurred, would be seen as revenue raising.

Police would not be able to read a tachograph card without the aid of specialised equipment, with particular problems occurring at night. It required training and skill to read cards and detect fiddling (which is easily done), skills and training unlikely to be present in the general traffic police.

Drivers felt the Police should not have the power to open tachograph enclosures. Some expressed concern that police may take the card either as evidence or to prevent counter evidence being presented.

Seat belts

Drivers did not support the use of seat belts in trucks because;

they were not suitable for use with suspension seats

. the drivers believed it was possible to throw themselves across the cabin to avoid being crushed by an approaching truck, which would not be possible if restrained by a seat belt.

Roads and road conditions

Road conditions must be improved, and known problem areas such as the Cullerin ranges section of the Hume should be improved first, not last. The Pacific was obviously a priority.

Improved passing facilities (overtaking lanes) were seen as low cost high value improvements. Better signposting of roadworks, particularly detours, was urgently needed. Education of car drivers about truck capabilities and limitations was important. Car caravan combinations should be tackled as a particular problem. Strengthening the graduated licence scheme and improving driver training facilities was a high priority with some drivers. General support for a national driving licence was evident.

Improved relations between drivers and enforcement officers would reduce aggressiveness and stress. Stress was increased by concern that their livelihood would be threatened by additional points for trivial offences.

OTHER ISSUES

Truck performance and mechanical issues

These experienced drivers all felt they knew the capabilities of their trucks, and drove according to these capabilities.

Industry entry/financial issues

The drivers believed that present truck financing methods made it too easy to enter the industry without sufficient financial knowledge and/or work. Inexperienced and/or company drivers did not know the hidden costs of operating trucks such as blown tyres, broken windscreens and similar un-programed equipment replacements. Entrants committed repayments on weeks with good returns without allowing for downturns. Poor owner/driver payments also contributed to many industry problems.

Some drivers commented that rail pricing for freight that is most appropriately carried by road tended to keep road freight rates too low.

National truck laws

Drivers were critical of the different laws in different States, particularly the variety of permits for maximum mass. Variations were seen only as parochial and not related to logic or reason.

Figure 4.1 Total Kilometres of travel, Australia, by articulated vehicles (Source ABS SMVU)

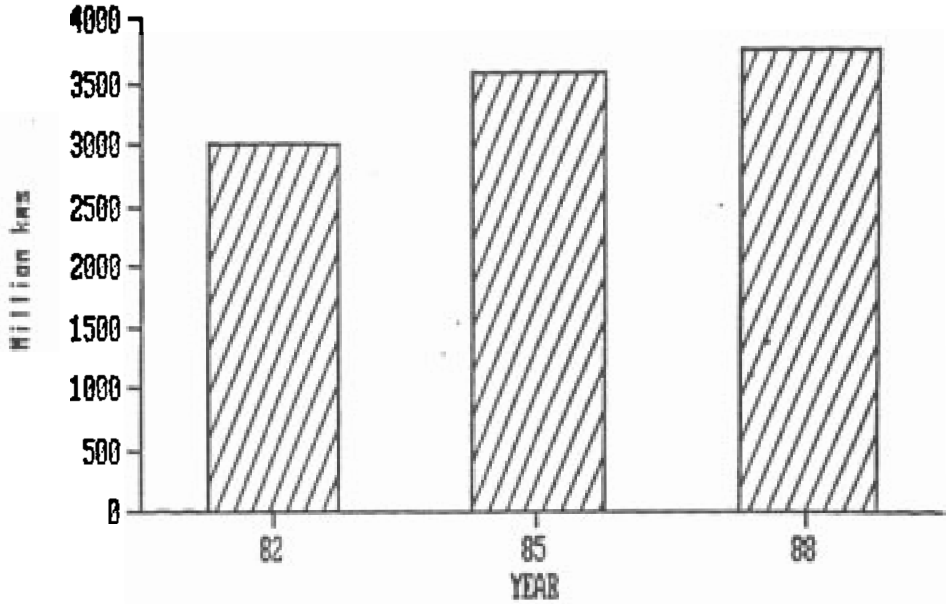


Figure 4.2 Total tonne-kilometres of travel, Australia by articulated vehicles (Source ABS SMVU)

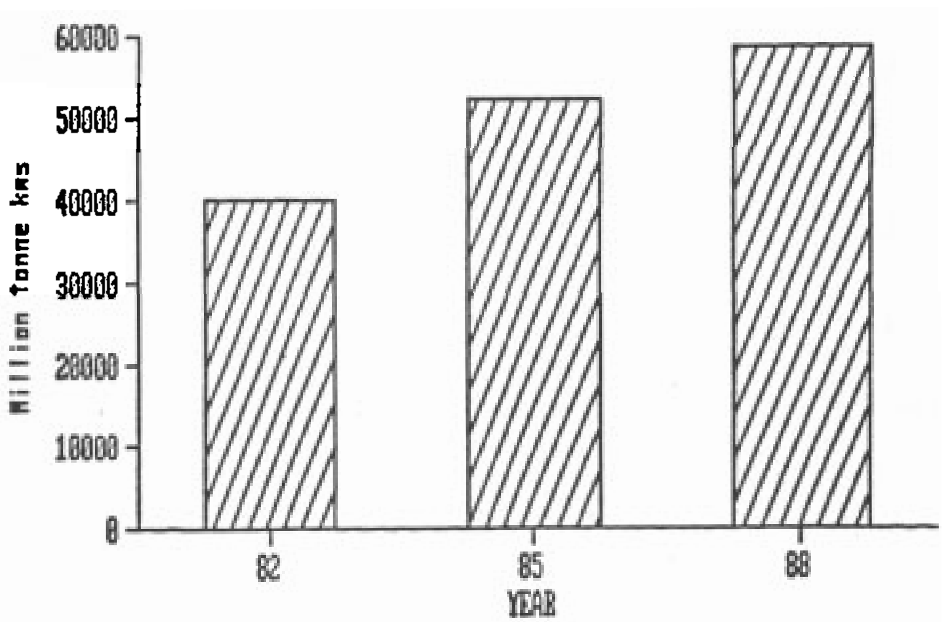


Figure 4.3 Traffic flows over the period 1982 to 1988 for the average AADT at selected sites on NSW highways

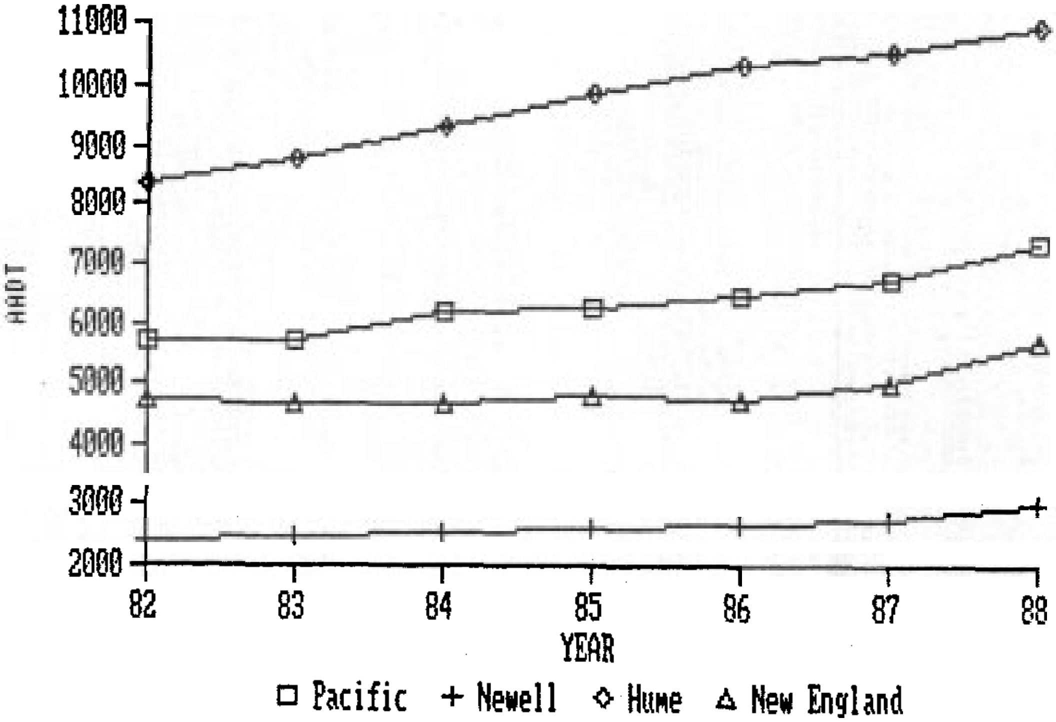


Figure 4.4 Truck flows through checking station at Marulan, Hume Highway.

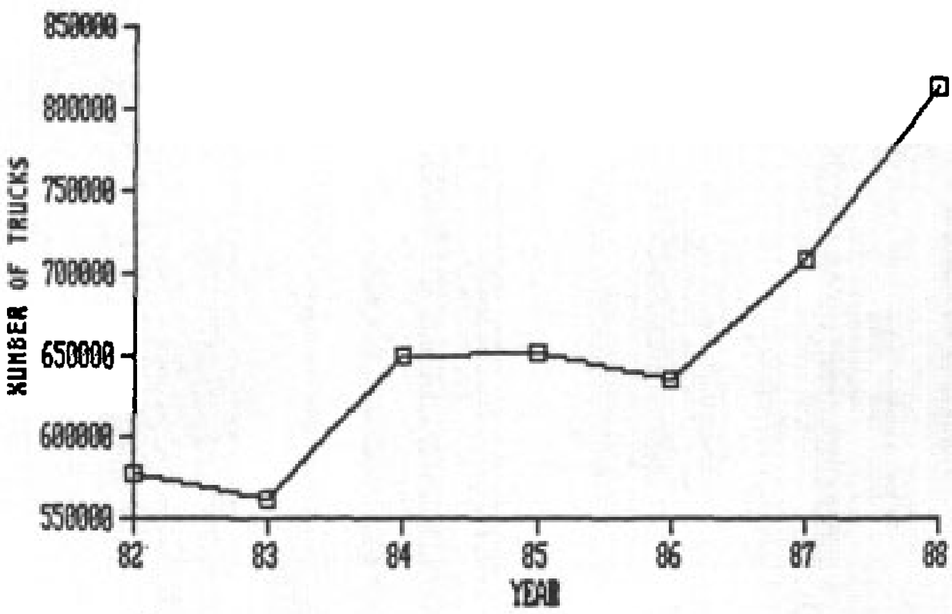


Figure 4.5 Quarterly interstate road freight with an origin or destination of Sydney (Source ABS - raw data)

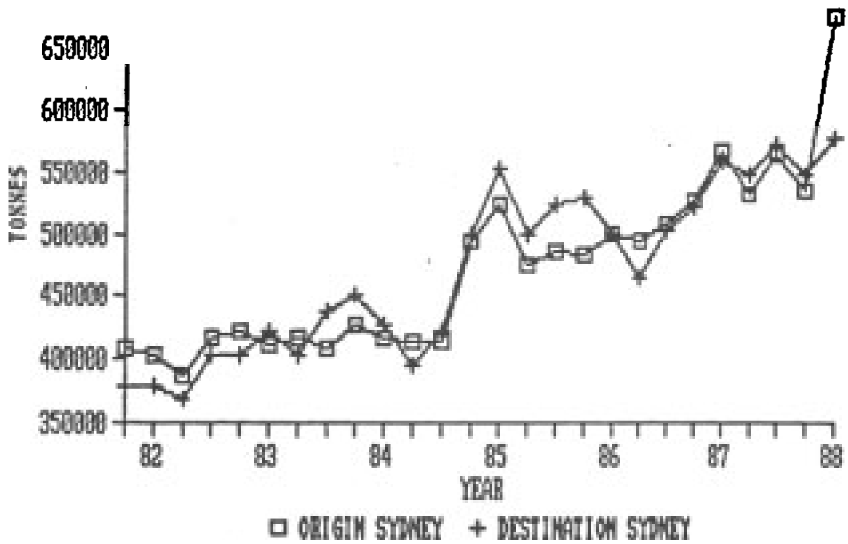


Figure 4.6 Quarterly interstate road freight between the ports of Sydney and Brisbane and Sydney and Melbourne in both raw and modified forms (Source ABS).

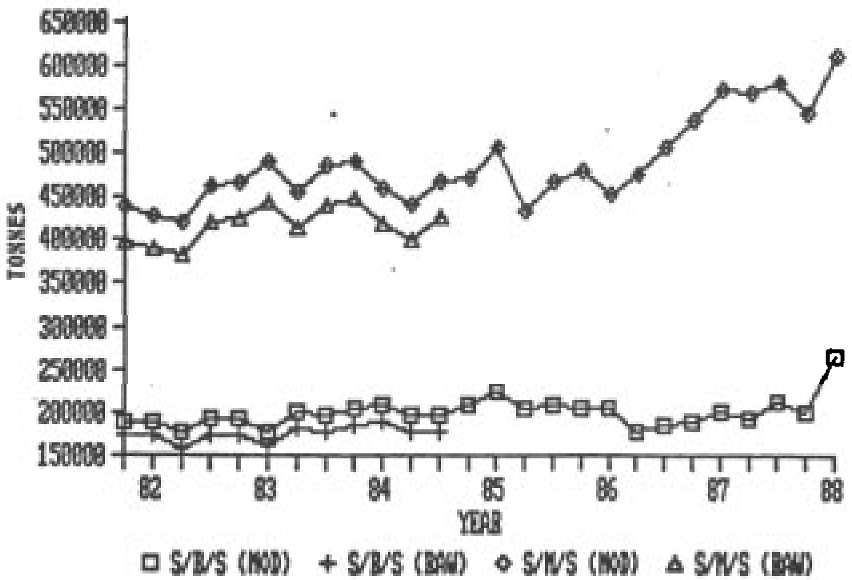


Figure 4.7 Changes from previous year in interstate freight on the Pacific, Newell and Hume Highways (tonnes)

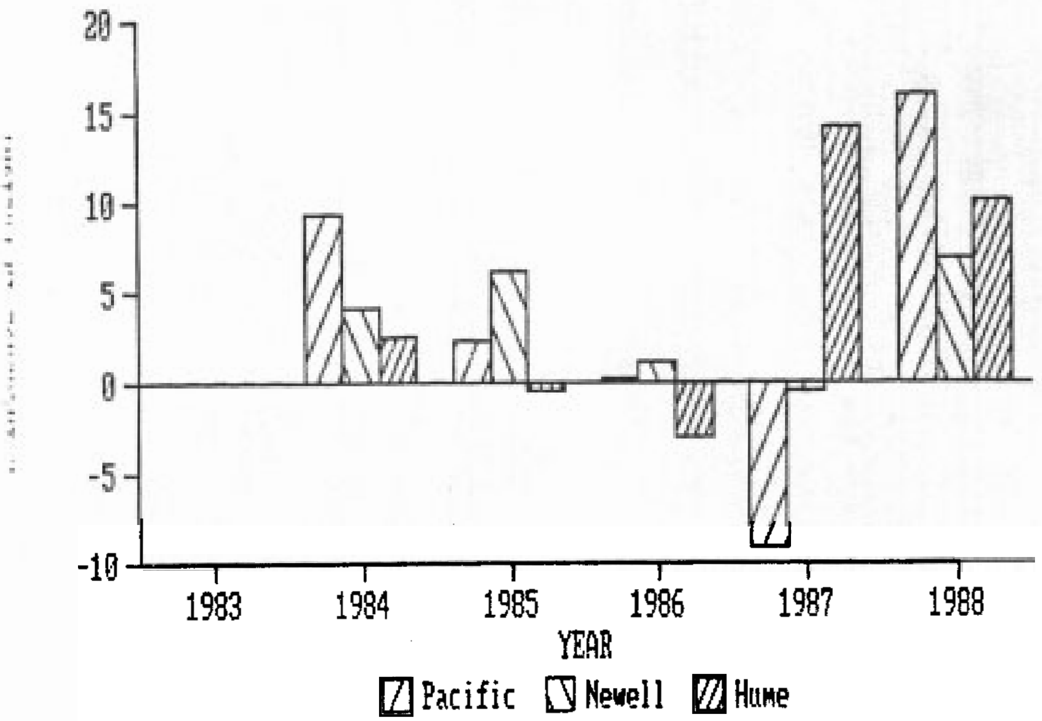


Figure 4.8 Ratio of fatal crashes involving trucks to a measure of exposure on the Pacific, Newell, Hume and New England Highways

Figure 4.9 Ratio of changes in number of fatal crashes involving trucks to the change in AADT for selected sites on NSW Highways

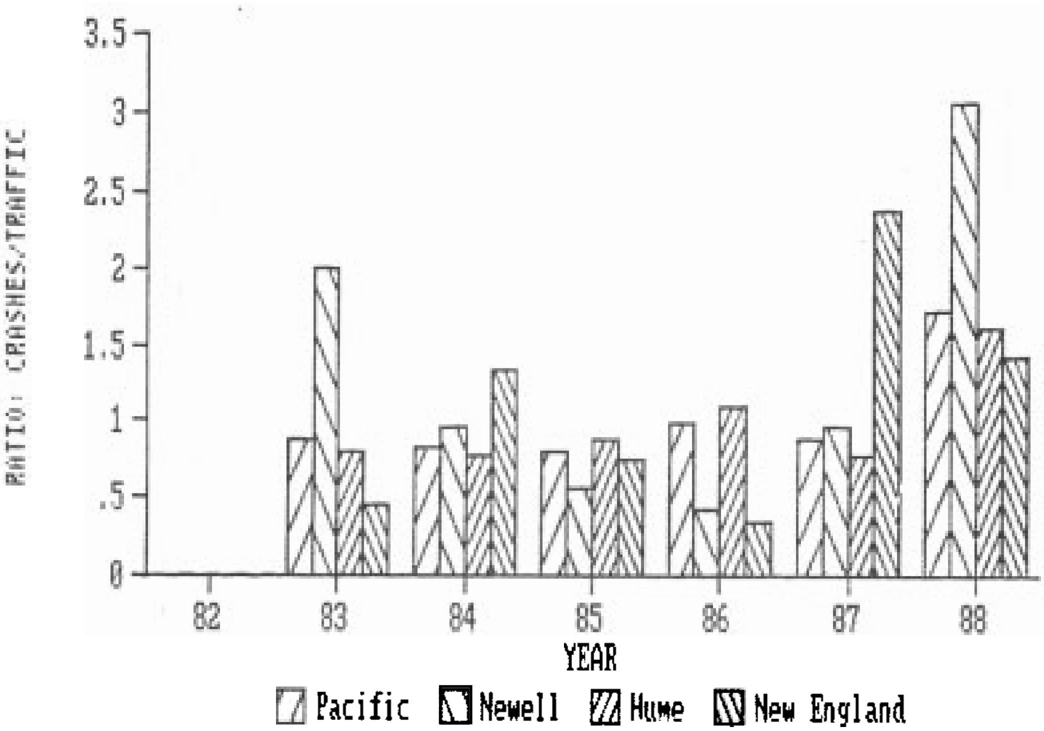


Figure 4.10 Ratio of fatal crashes involving articulated vehicles per 100,000 tonnes of interstate road freight on the selected NSW highways

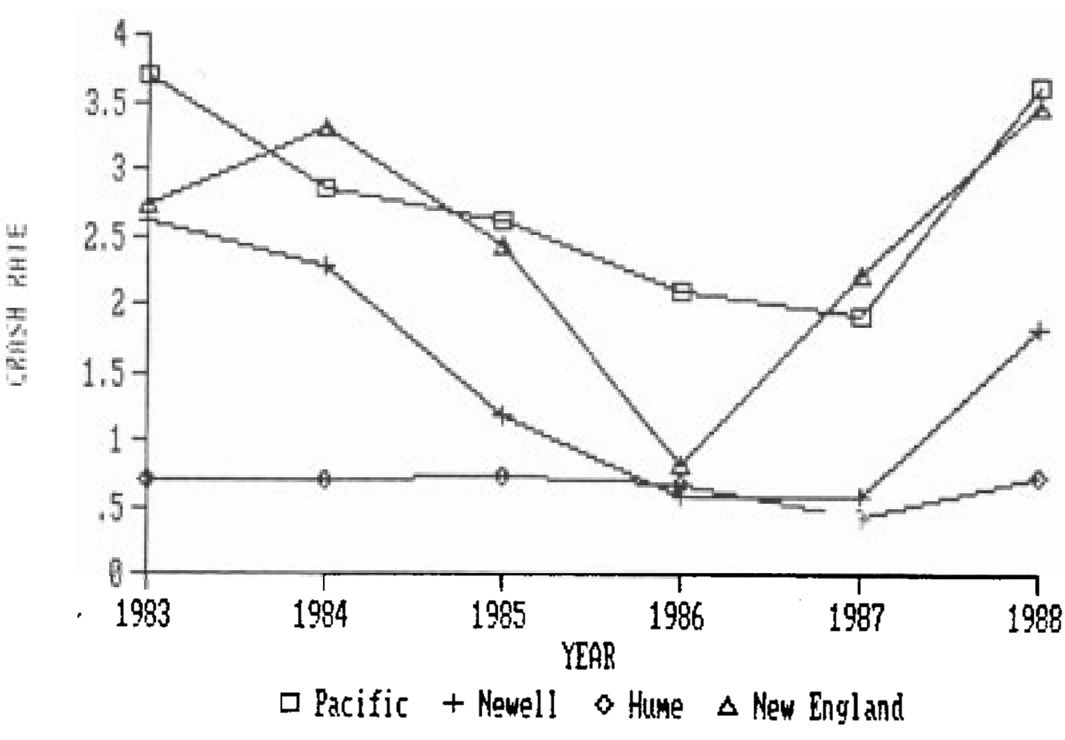


Figure 4.11 Ratio of changes in number of fatal crashes involving articulated trucks to the change in freight for selected sites on NSW Highways

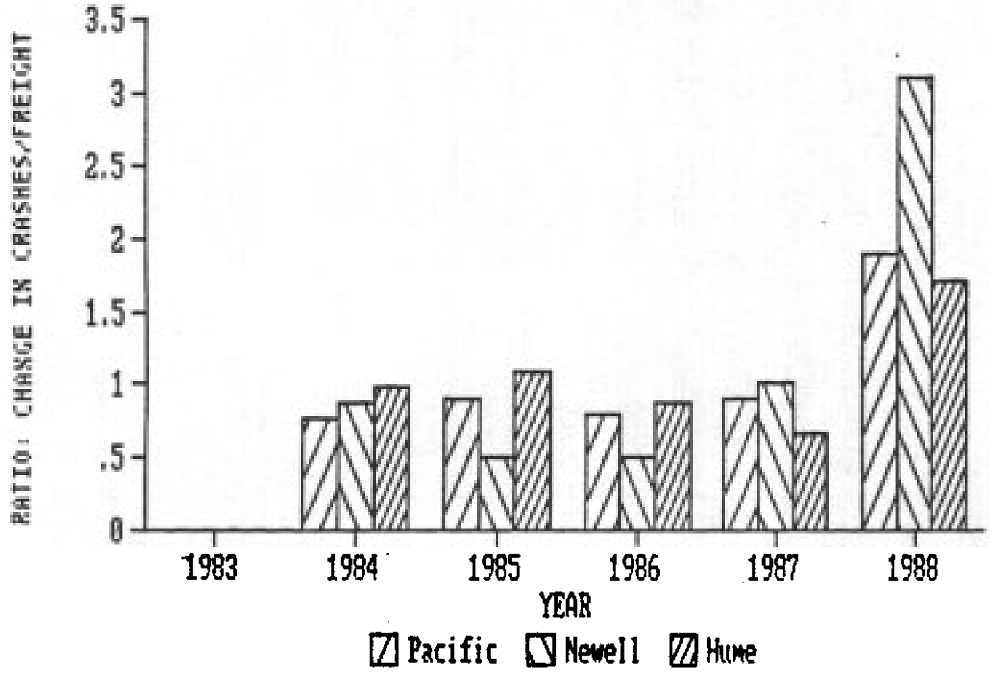


Figure 4.12 Number and percentage of NSW crashes coded as "wet road" and "raining" in 1982-1988

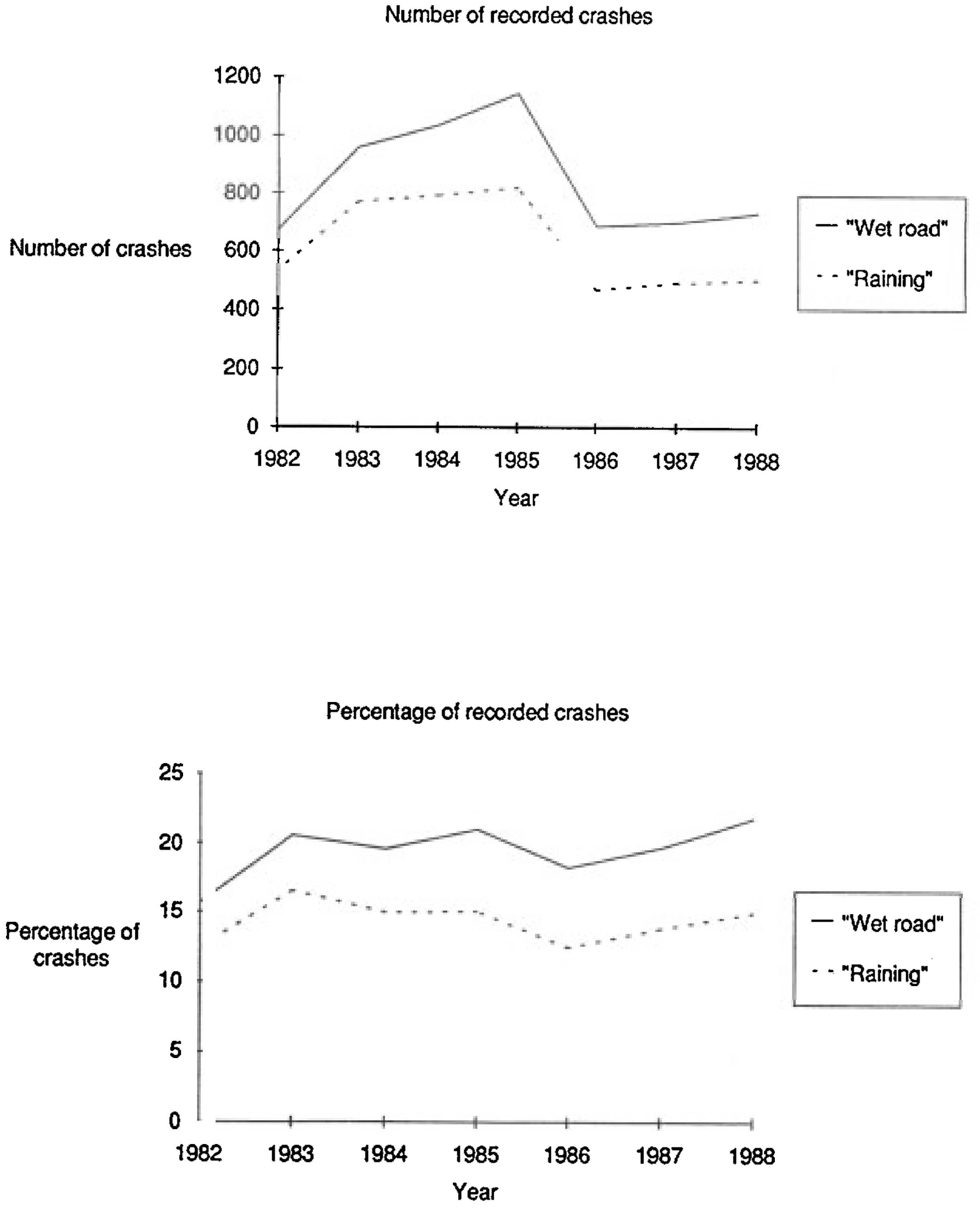
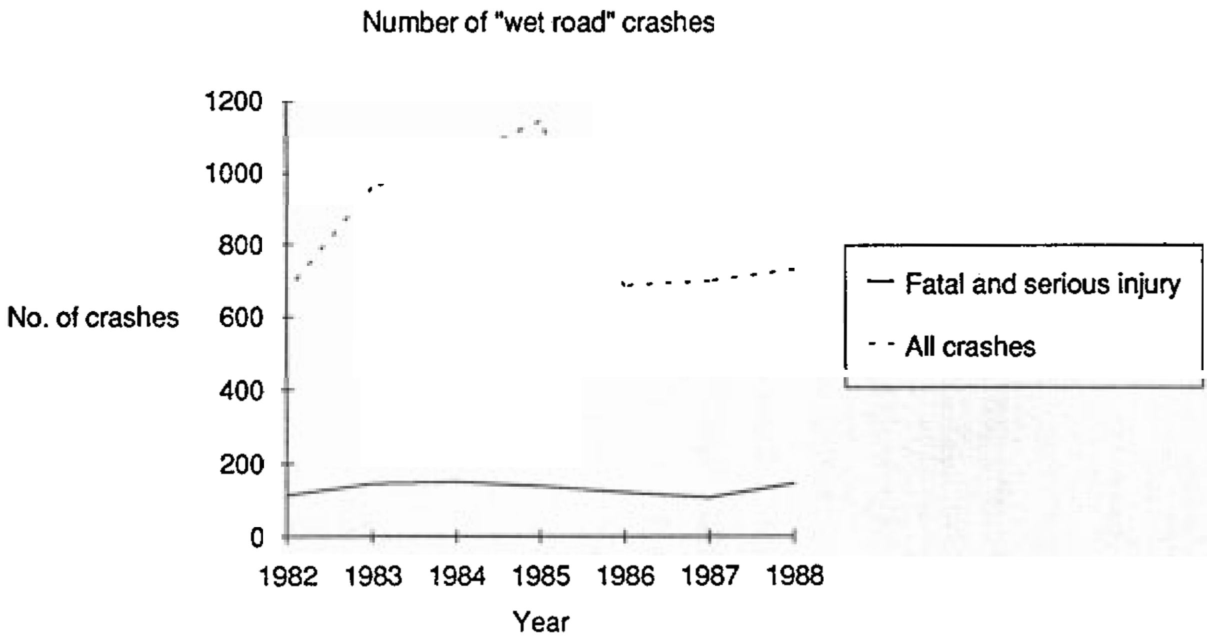
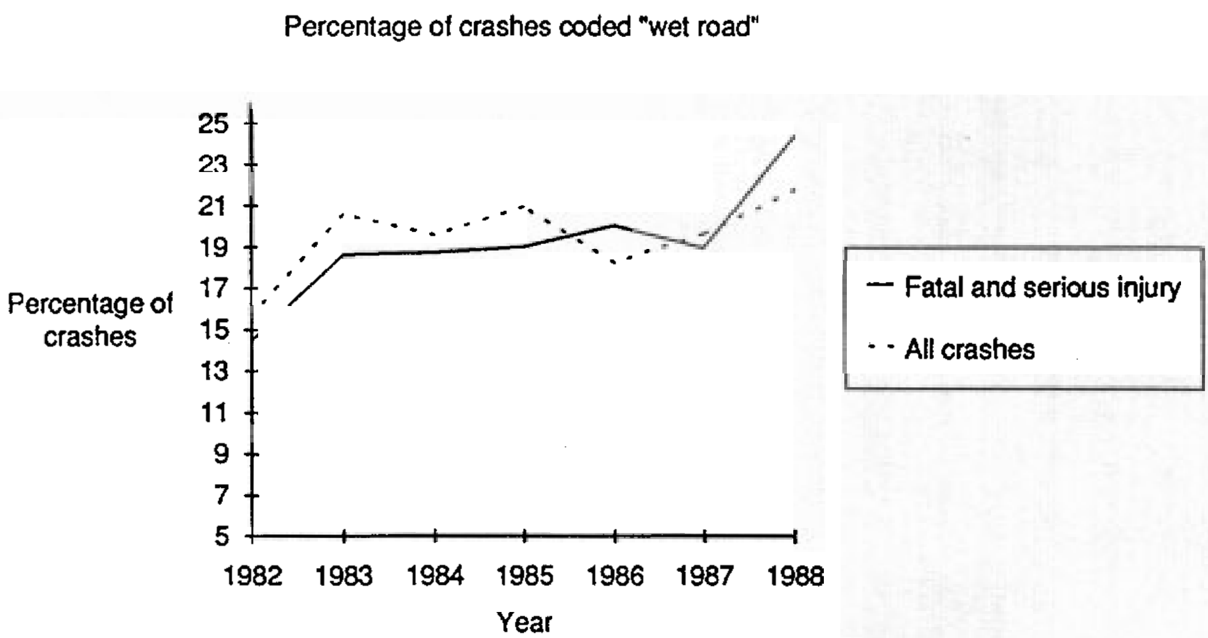


Figure 4.13 Number and percentage of crashes coded as "wet road" crashes in all heavy vehicle crashes and fatal and serious injury crashes only





5. COUNTERMEASURES TO NSW TRUCK CRASHES

5.1. INTRODUCTION

In this section, we outline the range of measures which have been proposed to tackle the problem of heavy vehicle crashes, both in Australia and overseas. Based on this knowledge of the range of possible countermeasures, it is then possible to consider their application in reducing the consequences of truck crashes in NSW, and this is done in the latter part of this section.

Over the years, a great number of suggestions have been put forward from a number of sources. This chapter attempts to describe these, and to relate the observed crash patterns to the countermeasures which may be used to prevent that crash (or its consequences) from occurring.

5.2 OVERVIEW OF HEAVY VEHICLE CRASH COUNTERMEASURES

If the results of this project are to lead to worthwhile reforms or changes, the support of the road freight industry (or important sections of it) is likely to be essential. Thus, we have paid particular regard in the following discussion to what the industry has had to say recently about heavy vehicle safety. The industry, moreover, is closer to the problems, and has a view about practicalities of implementation, which mean that its views should be taken seriously. However, in addition to this, the results of previous studies such as the National Road Freight Industry Inquiry (1984) and the Traffic Authority of NSW (1982) Joint Working Party on Heavy Vehicle Safety are of importance because they tend to take a somewhat broader view than the industry itself, including views about such aspects as regulation and industry structure. Finally, the results of research studies both here and overseas are relevant.

Thus, the countermeasures discussed in this chapter follow a structure loosely based upon that adopted by the Road Transport Industry Forum in its recent Heavy Vehicle Road Safety Summit held in Sydney on 19 February, 1990. This comprised five "essential elements":

- vehicle design and specification
- vehicle drivers: education, training and retraining
- vehicle speeds (behaviour)
- vehicle environment - our roads
- community and market expectations: demands and impact

We have restructured this a little, firstly to include as a further separate heading that of industry management and regulation (as suggested in the paper presented at the Summit by Camkin (1990)), and secondly to broaden some of the factors included under these headings (e.g. to discuss vehicle factors more generally - e.g. maintenance - rather than just their design and specification). Thus our discussion is structured as follows:

1. Vehicles
2. Drivers
3. Vehicle Speeds (Behaviour)
4. The Road
5. Other road users and the community
6. Management, regulation and enforcement

It is acknowledged that there is some overlap between many factors discussed under different heads, e.g. the use of log books may be considered as either a driver factor (2), a management factor (6), or an enforcement factor (6). Similarly, while vehicle maintenance is included as a vehicle factor in (1), responsibility for ensuring that the vehicle is maintained is a management factor (6).

Further, it needs to be said that each of the countermeasures discussed below represent ideas which could be implemented, or existing practice which could be improved. Implementation of any of these ideas, or indeed analysis of the suggestions themself, requires further consideration. In some cases there is doubt about the efficacy of the countermeasure; i.e. there are doubts that it will work at all. In other cases, improvements may be very slight, and/or come at a high price, e.g. in terms of reduced payload, reduced driver productivity, or reduced vehicle efficiency.

In all cases, therefore, implementation of any of these suggestions should be based either upon demonstrated effectiveness, or should await the results of further work to assess their cost-effectiveness. In some cases, it may be appropriate to facilitate the introduction of worthwhile countermeasures by offering commensurate tradeoffs which benefit those who introduce them, e.g. the recent proposal that higher speed limits might be available only to vehicles with speed limiters.

VEHICLES

Attention to heavy vehicles is likely to be a very cost-effective strategy. Articulated vehicles in particular are significantly over-involved in fatal crashes per vehicle, hence there is scope for spending more on improvements to reduce the probability of a crash or protection in a crash. Countermeasures based upon heavy vehicles are as follows.

Brakes

Brakes are important not only for the obvious reason that it is necessary to be able to decelerate a moving vehicle, to rest if need be, but also because braking affects vehicle stability; poorly matched brakes can produce jackknifing for example.

Specific proposals involving truck braking include:

- requirement to fit anti-lock braking systems
- compatibility between prime mover and trailer, including the availability and use of equipment to test such compatibility,
- brake inspection and maintenance,
- auxiliary and failsafe braking systems.

Tyres

It is generally believed that tyre standards and performance have improved considerably in recent years, and the main issue is with the condition of tyres in use, including re-caps. This is therefore primarily a maintenance issue (see below).

Side and Rear Under-run Protection

Given that the height of a trailer or rigid truck deck is often at about the height of the head of a person seated in a passenger car, many collisions have the potential to result in serious head injury or death. A possible way of reducing the severity of such crashes is through the provision of under-run protection guards. Rear under-run protection may be more valuable than side under-run protection given the relative frequency of the two crash types. Such devices, whether at the side or rear, should be of the right height, and be properly designed by structural engineers.

Bull Bars and Improved Front End Design

In collisions between cars and the front of heavy vehicles, most of the crash energy is dissipated through deformation of the car structure. Further, heavy vehicles often over-ride the car, resulting in intrusion of the heavy vehicle into the passenger space. Bull-bars intensify the former effect, and may possibly lessen the second. They are considered by some to be beneficial to heavy vehicles because they offer protection to the vehicle and its occupants in the event of collision, and lessen the possibility of loss of steering control in a collision with animals or other vehicles. However, this may be at the expense of the occupants of other vehicles which are involved in a collision with the heavy vehicle.

While there have been proposals to ban the use of bull bars except where the heavy vehicle uses an unfenced road, a more widely accepted approach is to make it less aggressive, and of more benefit, by incorporating a bumper, at about the height of a car bumper. An extension of this principle, which is in the development stage in Europe, is for the front end of the truck or bus to incorporate energy-absorbing devices and altered stiffness distribution. This may be of potential value in crashes at higher relative speed. (Bloch, Cesari and Biard, 1987). Finally, it may be possible to incorporate a "nose-cone" to deflect an oncoming car.

Conspicuity.

Heavy vehicles are often poorly delineated at night, both when parked and when moving in the traffic stream. The use of more running lights, reflectorisation, and improved marker and signal lights could be helpful in many circumstances.

Crashworthiness of the Truck Cabin.

Increased cab strength makes the cab better able to withstand crashes, especially rollovers. This may be regarded as an aspect of occupational health and safety as much as a road safety issue. Rollover protection devices and crash-resistant cabs are used in some countries. At present, Australian Design Rules do not feature such aspects as steering column intrusion or energy absorbing requirements for heavy vehicles, nor seat to floor anchorage requirements. However, as Jiggins (1987) has noted, it is unlikely that Australia would unilaterally introduce a Design Rule related to cab strength, because of the small size of the domestic market.

Ergonomics of Truck Cabin Design.

Poorly designed truck cabin layout can have safety implications in terms of such aspects as poor vision from the drivers seat; poor instrument layout, poor seat design (which may result in driver injury or fatigue), etc. Again, the design of truck cabins may be regarded as much as an occupational health and safety matter as a road safety matter.

Truck Seat Belts.

Truck seats often have large travel (e.g. with air suspension) for ride comfort. This causes discomfort and inconvenience to the wearer of a seat belt in a truck. Moreover, truck cabin controls are often poorly laid out (see above) so that a belted driver may find the control and navigation task more difficult. It is also relevant to acknowledge that there is a common perception among truck drivers that they are better off in a crash situation if they can get out of the driver's seat (either being "thrown clear" of the vehicle or jumping into another part of the cab) - a perception which is almost certainly erroneous. Improved seat belt wearing rates amongst truck drivers thus requires both better belt technology and a sustained education and information campaign. Various options for alternative mounting arrangements and retractor settings are potentially available, but are not yet mandatory.

Engine and Vehicle Specifications.

The specification of engines and gear trains which are better suited to the tasks to be undertaken by the truck will not only have potential safety benefits (e.g. by limiting the maximum speed), but also have benefits in terms of fuel usage. Reportedly, many trucks are geared more for maximum speed than for any other reason, and a campaign by safety authorities (and maybe truck manufacturers and the industry as well) to change perceptions may be needed here.

Poorly specified vehicles and components impact on vehicle handling and controllability. Particular features which have safety implications include height of the centre of gravity, suspension matching, fifth wheel and other couplings, tyres (particularly wide singles), spray suppression equipment, and brakes (including linings). Engine and drive train specifications have implications for speed and gradeability. Satisfactory driver feedback devices have yet to be developed.

Mechanical Inspections.

A high standard of maintenance is necessary to ensure continued roadworthiness of heavy vehicles; that is not in dispute. Where there is disagreement however is how that may be ensured. Responsible operators will of course look after their equipment; the question is how best to ensure that the less responsible do likewise. There is evidence (e.g. McDonald and McDonald, 1983) that vehicle defects are more likely to be a contributory cause in crashes involving trucks than those involving cars, although there is generally a low contribution of vehicle defects to causation of crashes (Lees, 1987).

Inspections may be either periodic (e.g. annual), random (e.g. roadside checks), or both. The National Transport Federation (1989) and the Road Transport Industry Forum's 5-point National Road Safety Program (1990) both call for compulsory annual checks (for vehicles 3 years and older in the latter case). However, other industry groups (e.g. the Victorian Road Transport Association, 1989) have opposed them on the grounds that they are ineffective.

Random checks, like any other form of violation detection, rely more upon the perceived probability of being detected than upon anything else, so need to be based upon a concerted and visible effort. The recent availability of the NSW Roads and Traffic Authority's truckalyser should make this type of program more cost-effective.

Load Stability and Load Security.

Unstable or insecure loads, overloaded trucks, and inadequate procedures for the carriage of dangerous goods all contribute to the road safety problem. Although there is an industry "Code of Safe Loading", and regulations covering various aspects of loading (especially related to dangerous goods), these are not as well used and enforced as they could be. Attention to training, information dissemination, and enforcement are required.

DRIVERS

Traini_ _ and Retraining.

As workers required to possess and exercise considerable skill, heavy vehicle drivers need access to adequate training opportunities, and to opportunities for re-training in the course of their career. There are still many drivers who have had no formal training, but have simply "grown up" in the industry. While this may be adequate in terms of the essential skills of driving a heavy vehicle, and possibly mechanical maintenance as well, current thinking is that a driver needs more than that (Jiggins, 1987; Evans, 1990). This would include not only the above, but also such aspects as defensive driving techniques, driver attitude, stress management, safe loading practices, vehicle coupling, roadside repairs, and maybe elementary first aid.

Recent American research (Beilock, 1989) which has compared the crash records of truck drivers with formal driver training with those who have had no such training indicates no statistically significant difference between the two groups. However, there were indications that periodic retraining was efficacious; "of those with at least 5 years driving experience, 29 per cent who did not receive periodic training had at least one accident in the past five years, versus 21 per cent for those who had received periodic training".

It has also been proposed that training programs should include management and financial aspects, so that drivers better understand the road, business and community context of the industry in which they work. For owner-drivers, these skills could affect the way in which they run their business, including the loads that they accept and the prices that they work for.

While there does not appear to be any hard evidence that driver training programs contribute to road safety, the industry perception is that operational (including safety) costs are reduced by the use of specialised driver training programs. However, in this regard it is difficult to distinguish between the effects of selection and training. The recent Road Transport Industry Forum 5-point National Road Safety Program incorporated a training and re-training element. The latter was proposed to be particularly available to drivers who have accumulated demerit points, and these points would be retrieved by undergoing such courses.

Drivers Licences.

There is currently in place a graduated driver licensing system. Proposals to enhance this include such aspects as linking the various State record systems to prevent a driver having a licence in more than one State (this proposal has been extended into a call for a national driver licencing system), the inclusion of medical tests when a licence is renewed, and for stricter criteria and testing than is currently the case.

There is evidence of the effectiveness of the demerit points system and the associated sanction of licence suspension in reducing crash involvement. However, unfortunately there is no clear evidence of the extent to which driver licensing and compulsory retraining has an effect on crash involvement (Haque, 1987)

Specific Skills.

Apart from the above, certain drivers are required to possess and practice specific skills peculiar to the industry in which they work. The main example here is for drivers carrying hazardous goods; under the Australian Code for the Transport of Dangerous Goods by Road and Rail, truck drivers are required to be trained to appreciate the hazards of the goods conveyed and their responsibilities under the code. This requirement has been extended into proposals for a "product licensing system", under which only drivers with the appropriate "ticket" could move designated categories of dangerous goods.

Fatigue.

Fatigue is considered by many to be a major factor in truck crashes. In this regard, it is relevant to note that fatigue can affect a car driver as well as a truck driver, but the methods of countering fatigue are mostly targeted at the truck driver, presumably because that is a more identifiable target, and because they drive more and are therefore more likely to be affected.

This is also related to the problem of drugs, with truck drivers reputed to be prone to the use of stimulants to stay awake (see below).

Fatigue is a complex issue, related not only to hours behind the wheel, but also such aspects as broken shifts, use of rest periods, quality and length of rest periods, quality of operating conditions (including boredom), as well as being subject to the effects of biological rhythms, food, dehydration, comfort, etc.

Possible solutions could involve education, improved vehicle design to reduce onset of fatigue, incorporation of in-cab fatigue detection devices which alert the driver, improved road design (especially delineation and rumble strips or ridged edge-lining), and more effective enforcement of driving hours legislation, possibly using modern technology to replace the log book (see below) (Vulcan, 1987; Haworth, 1990).

Alcohol and Drugs.

Alcohol is a smaller problem with heavy vehicle crashes than for car or pedestrian crashes, although of course heavy vehicle drivers are subject to the same BAC limits as all other drivers; the involvement of alcohol in truck crashes is about half that in car crashes. Low levels of alcohol (even below 0.05) act as a depressant and increase drowsiness. Low levels may be present from drinking the night before. There have been calls for a lower BAC limit for heavy vehicle drivers in the US (Transportation Research Board, 1987), and there is a proposal before the Australian Transport Advisory Council for a zero BAC level for heavy vehicle drivers.

Drugs, especially stimulants, are however thought to be widely used by long distance truck drivers. This is likely to have adverse safety consequences, e.g. hallucinations, greater risk-taking, etc. (Although it is sometimes suggested that in view of the long hours worked by truck drivers, the use of stimulants has safety benefits in preventing fatigue, there is no evidence that we are aware of to support the argument that drug use is on balance beneficial. In any case, it is considered undesirable on social and ethical grounds that any section of the workforce should be encouraged to engage in drug-taking as a matter of course.)

At present, there is no program to routinely test for the presence of such drugs, either for enforcement or statistical purposes, so there is little factual information to guide safety programs in this area.

Similarly, there is no practicable means to establish the presence and quantity of stimulants in a driver in an roadside environment, so enforcement is difficult if not impossible. Better industry conduct, through such aspects as control of driver hours, quality regulation and/or industry self-regulation is generally thought to be the practical way forward.

SPEEDS

Speed Limits

There is clear evidence of the effect of speed on the severity of a crash. The energy to be dissipated in a crash is proportional to the square of the impact speed; for example, an impact speed of 130 km/h involves more than twice the energy of one at 90 km/h. Moreover, in many crashes (other than head-on) the impact speed is well below the travel speed. This may explain why the drop in speed limit in the USA to 55 mph showed significant reductions in fatalities, and vice versa with the increase to 65 mph (Anon, 1988).

There is however conflicting evidence on the effect of differential speed limits for heavy vehicles on road safety. Briefly put, one argument is that it is not the speed of vehicles in a traffic stream which is important for safety, but the distribution of speeds. That is, if some vehicles are travelling significantly slower than the general traffic flow, they constitute a "moving road block" which represent a hazard to other road users. Statistical analysis of crash rates in the US tends to support this view (Federal Office of Road Safety, 1985). The implication of this argument is that heavy vehicle speed limits should be no different from that of general traffic; it was this argument that led to the elimination of the speed limit differential in 1988.

The other argument is that car drivers do not like to follow behind trucks, and that car drivers will attempt to overtake a truck travelling at the speed limit. This argument rejects the speed differential argument cited above, and quotes such results as the effect in the US of some States increasing car speed limits but not truck speed limits, compared to others where both were increased; the difference in the comparative crash rates was not statistically significant (National Highway Traffic and Safety Administration, 1989; Camkin, 1990; Chang and Paniati, 1990).

In addition, trucks generally have poorer maximum braking capability than other vehicles, so that trucks need to be travelling more slowly to stop in an emergency within a given distance. However, under non-emergency braking situations, there is no incompatibility between the braking characteristics of heavy and light vehicles (Jarvis, 1989). This factor is predominantly of concern in urban areas where traffic densities are higher.

Overlying all this is the question of whether speed limits have much effect on heavy vehicle (or car) speeds anyway. In a study undertaken for the Federal Office of Road Safety by Siromath (1988), the potential presence of police was cited as the second most important factor affecting truck speeds in the daytime, and the third at night. (Weather was the most important in both instances, with traffic density being the second most important factor at night and the third in daytime.) Speed limits per se were not mentioned. This study concluded (op cit, p 120) that it "did not provide evidence that current speed or preferred speed limit is substantially influenced by the current speed limit. The evidence suggested that factors associated with the given routes of travel are more important."

It is probably true to say that heavy vehicle speed limits are essentially an issue on rural roads, since traffic conditions primarily determine traffic speeds in urban conditions. Nevertheless, on the braking argument, heavy vehicle speed limits in the past have been less than car speed limits in urban areas.

Speed Limiters

While the road freight industry may express a strong wish for truck speed limits to be the same as car speed limits, the industry (as distinct perhaps from certain operators or drivers) has come out strongly in favour of speed limiters, which would prevent vehicles fitted with the device from exceeding a set speed (National Transport Federation, 1989; Evans, 1990). This is not the place to discuss the way in which these operate, but essentially they are of two types - geared speed limiters, where the engine governor and drive line gearing and tyre size are selected such that at the designated maximum speed the engine governor begins to cut off fuel, and road speed limiters which detect road speed from a speedometer-like device, and either cut off fuel or initiates normal governor cut off at the designated maximum speed. (A good description of the two devices is given in Victorian Road Transport Association, 1989). It is important to note that the latter type is available as an add-on, i.e. can be retrofitted to existing vehicles.

The advantage of speed limiters is that they effectively eliminate grossly excessive speeds on the open road; generally the engine governor will allow a small over-run, while vehicle speeds can increase on a long downgrade, but this will take a long time to build up and there would be few instances or circumstances where speeds would be more than 5-8% in excess of the set maximum.

Other advantages of the universal fitting of speed limiters to long distance trucks and coaches are that schedules would be set on a more realistic basis, not one that required speed limits to be broken; that they would enforce more economical operation; that operators who drive at legal speeds would not be at a commercial disadvantage; and that they are essentially tamper proof (National Transport Federation, 1989).

However, speed limiters in their present form would not be effective in situations where the speed limit was less than the set maximum. Since this includes towns and other built-up areas, and roads with poor alignment, some argue that the value of speed limiters is lost because they do nothing to reduce speed in some of the more hazardous locations on the highway. Technology exists which would enable an on-board device to detect the speed zone and adjust the speed limiter setting, but this would need further development (Howie, 1989).

Dr' ' Hours and Responsibility for Schedules

Although the driver is basically responsible for time spent at the wheel and the speed of travel of a vehicle, this may be influenced by other parties. Of particular concern is the need to meet delivery schedules, which may be set either by the vehicle owner or forwarder (e.g. to be at the destination early in order to obtain a return load) or by the consignee or consignor (e.g. as part of a "just in time" delivery schedule to a manufacturer). Tight schedules were mentioned as a safety factor by a moderate number of respondents in the survey of truck drivers and operators by Siromath (1988).

This raises the general question of responsibility for schedules, and the major deficiency in the current licensing and regulatory system that there is no sanction whatever upon those who set schedules that require drivers to break the law to achieve them. This is one of the prime arguments for a form of operator licensing.

Advanced technology, in the form of electronic devices with driver-specific modules which would record the identity of each driver on a tachograph or similar device could replace log books.

THE ROAD

Road Standard

Road standard clearly has a major effect on crash rates. Divided roads have a crash rate several times better than undivided roads, due to the spatial separation of opposing traffic streams, and the generally higher geometric standard to which such roads are built. Freeways, with complete control of access and absence of at-grade intersections are the safest form of road (Lay, 1986, p 564)

However, divided roads are expensive to build, and their economic justification lies in the user cost savings which they generate. These savings are in terms of reductions in travel time, reductions in vehicle operating costs, and reductions in crash costs. The crash savings are generally quite small in relation to the others (Lay, 1984, p 46). (This of course begs the question as to whether current evaluation methods adequately value the cost of road crashes; there is a school of thought that they are significantly under-valued (Andreassen, Thoresen and Wigan, 1988), and if this were to be "corrected", safety would have a greater influence on road evaluation. It would also presumably affect other safety programs as well, such as enforcement, education, vehicle design, etc.) It should also be noted that road projects may show very high benefit:cost ratios, so that some projects may in fact be justified on the basis of accident savings alone, with the other benefits as a "bonus".

Since divided roads cannot be provided everywhere, much attention must focus on the design standard of two lane roads. Although there are design guides for such roads (e.g. Austroads, 1989), the particular needs of heavy vehicles on roads with high heavy vehicle volumes, especially at night, may not always be fully recognised. Such aspects include sight distance requirements, daytime and night time delineation, lane width, shoulder width, culvert end walls, guard fencing, warning and direction signs, and verges. More work needs to be done to isolate the significance of some of these factors (see for example Siromath, 1988, p 63 and 93 and Linklater,1977, p 3), although recent American research (Joshua and Garber, 1990) has suggested that vertical alignment (as measured by the sum of the grade changes per unit length of road) is the most siginificant geometric variable affecting truck involvement in crashes.

The National Road Freight Industry Inquiry (1984, p 142) described the following road conditions as contributing to lack of safety: lack of overtaking lanes and overtaking opportunities, insufficient dual carriageways, poor pavement quality, lack of advisory speed signs, too few guard rails, inadequate rest areas, poorly placed hazard warning signs, narrow unmarked and unsealed road shoulders.

The industry is of course highly supportive of improved roads, especially divided roads, but has had little to contribute to date on specific safety-related programs and priorities within the road budget, although the Road Transport Industry Forum's 5-point National Road Safety Program refers to "better targeted road funding in consultation with industry".

Road Maintenance

Better standards of maintenance may contribute significantly to safety, again especially on roads used by heavy vehicles. All of the road design and traffic engineering features mentioned above require maintenance (especially delineation and warning devices and road pavements and shoulders), and keeping them in good order should be a basic responsibility of a road authority. In their surveys of truck driver attitudes, Siromath (1988) found the following road conditions affected driver speed, and it would be reasonable to suppose that they affected safety as well: road surface, rough road, potholes, rough roads, narrow roads, narrow bridges, roadworks corners and bends. As mentioned above, the National Road Freight Industry also drew attention to the problems of poor pavement quality.

Traffic Engineering Treatments and Black Spot Programs

Traffic engineering treatments involve the application of traffic engineering works to existing sites, including traffic control, minor road improvements, delineation, guard fencing, improved sight distances, intersection improvements, warning and direction, signing, speed zoning, rumble strips, skid prevention, and (in urban areas) street lighting, traffic signals, etc.

Black spot programs are an application of these treatments (and in some cases, more substantial road reconstruction or realignment), focussing upon road segments which have a high frequency of recorded crashes. Well-targeted black spot programs are highly cost-effective, with a claimed benefit of one life saved per year for every $500,000 spent (NSW Road Transport Association, 1989).

Black spot programs are particularly effective at intersections where the site is constrained, and the crash record shows a number of crashes of similar form which can be reduced or eliminated by redesign of the intersection or its control (e.g. traffic signal turn phases). Their application in rural areas is less definitive, since the "black spot" may be a length of road several kilometres in length. Nevertheless, the development of road safety programs in these areas is possible (Corben and Cunningham, 1989), and heavy vehicles will benefit. Perhaps more attention should be given to the particular benefits to heavy vehicles from such programs, because existing treatments do not always recognise this (e.g. inadequate guard fencing - National Road Freight Industry Inquiry, 1984, p 143).

Pro-active safety programs, which aim to recognise the factors which cause a site to become a black spot so that such sites might be treated before they develop a bad crash record, should also be encouraged (Ogden and Howie, 1989).

The industry has expressed support for an expanded black spot program aimed at all vehicles, and has noted that this extends to focusing enforcement at such sites (National Transport Federation, 1989).

The National Association of Australian State Road Authorities (1988) has published a review of traffic engineering factors in relation to road crashes. The Roads and Traffic Authority has developed a Handbook of Safety Practice (Department of Main Roads, 1986), and has extensive guidelines for the application of particular traffic engineering treatments (Department of Main Roads, 1978). However, it is necessary that these practices be implemented, and applied in a consistent and prioritised manner; a recent report suggested that this was not always the case with the application of guidelines concerning the issue of permits, and it may be that a similar situation exists for the application of road and traffic guidelines (Joint Standing Committee on Road Safety, 1990).

Overtaking Lanes

Although this is a specific design feature which has been mentioned in the discussion on road design above, it is worth a particular mention because of the potential benefits which overtaking lanes can provide. Hoban (1989) has shown that in moderate traffic, judiciously placed overtaking lanes comprising around 10% of the length of a road can provide much of the benefits in terms of level of service of full duplication. While the specific safety benefits, and especially heavy vehicle-related safety benefits, have not been established, it stands to reason that they would be significant. Giving traffic the opportunity to overtake slower vehicles, and allowing bunches to break up are both important from a safety viewpoint. The overtaking referred to includes both cars overtaking heavy vehicles, and heavy vehicles overtaking slow moving cars and caravans.

Truck Stops and Rest Areas

This is another specific road design feature, considered to have special benefit for heavy vehicles because of the contribution which such facilities can make to the fatigue problem. The opportunity for a heavy vehicle driver to safely pull off the road for a rest, to check loads, attend to mechanical problems, etc is considered to be important. These areas include both roadside areas provided by the road authority (some of which could have toilet and other basic facilities), and commercial facilities which typically include fuel and maintenance, toilets and showers, heavy vehicle parking, heavy vehicle servicing, and in some cases sleeping accommodation.

With the publicly provided facilities, some thought needs to be given their location; although no definitive analysis has been done, observation indicates that drivers prefer such facilities at the crest of a hill, since both deceleration and acceleration is aided; the informal "rest area" at the Big Cut on the Tumblong Section of the Hume Highway in NSW is a case in point.

Roadworks

One of the particular features of roads commonly mentioned by the industry and drivers is roadworks (e.g. Siromath, 1988). Adequate advance warning, clear traffic control, clear and unambiguous delineation, safety practices adopted by road gangs, and suitable detours are some of the relevant aspects. It is important to note that the needs of heavy vehicles and heavy vehicle drivers in each of these areas may be different from the needs of cars. However, it would appear that these needs are not always adequately recognised. This is ironic, and potentially a significant problem, because much road maintenance and reconstruction is directed at roads with heavy vehicle volumes since it is heavy vehicles which are primarily responsible for road wear.

Traffic Management for Heavy vehicles

Implicit in much of what has been said above is that the particular needs of heavy vehicles are not always adequately taken into account in road design and traffic management practices. This has effects on the road freight sector, including safety effects. There is much which can be done to facilitate the movement of heavy vehicles, especially in urban areas, and to reduce their impact upon other road users and the community.

Advanced Technology Highways

Finally, it is relevant to note that there are technological possibilities on the horizon which will likely find widespread introduction in the years ahead, which will benefit safety. These include such developments as intelligent vehicle-highway systems, which may in time lead to automatic control of vehicles on roads; improved systems for weighing vehicles in motion which will allow better control and enforcement of overloading; devices for monitoring the location of vehicles which has implications for schedule-keeping and security; and on-board devices such as radar-controlled braking, proximity detectors, fatigue detectors, driver modules for control of driver hours, alcohol interlock devices, etc. (It might be noted that some of these may see service quite soon; in particular, ignition interlocks have been fitted to vehicles of convicted drivers in several US states for about 2 years, and they will be fitted to the vehicles of all Victorian drivers relicenced after a second 0.20 BAC conviction, starting in October, 1990.)

Rumble Strips

Rumble strips are grooves or raised ridges placed on the shoulder of the roadway to alert a car driver that the vehicle is leaving the lane, through noise or vibration. They may be placed on the centre line, on lane lines, or on edge lines. Raised reflective pavement markers give a tactile sensation when a wheel runs over them. They are not considered effective for heavy vehicles since the noise and vibration which they impart would probably not be detected.

Commercial products are now available for application to both centre and edge lines. A series of thermoplastic ridges are applied to the road by a special applicator. The markings are highly reflective and because they are fairly thick (e.g. 3 mm), the lines are easily visible above road water on rainy days.

THE COMMUNITY

Community Attitudes

The road freight task does not take place in isolation from the rest of the community, and the community is very interested in aspects of heavy vehicle safety. Indeed, it is probably fair to say that heavy vehicle safety is of current concern, and has stimulated industry action, because of community concerns about heavy vehicle involvement in crashes. However, if that concern is to be channelled and used to lead to a better road environment, it is important that it be informed input, based upon sound and rational analysis and presentation of facts. Both industry and government have an important role here, and the recent responses of industry associations is an important development.

Other Road Users

Roads are for the common use of a range of vehicular and non-vehicular traffic, and all have a responsibility towards road safety improvement. The road freight industry is critical of motorists' lack of driving skills, and inability to understand, or to share the road fairly, with large vehicles. Car drivers are generally not aware of the particular needs of heavier, larger, longer, etc vehicles. Particular complaints include cars disregarding a heavy vehicle's braking space, cars attempting to overtake heavy vehicles in hazardous circumstances (especially at night and in the wet), cars overtaking on the left of a left turning heavy vehicle, urban buses pulling out from a bus bay into the path of a moving truck or coach, failure of other drivers to put their lights on low beam, driver behaviour at roundabouts, and problems with caravans (Axia, 1986).

The industry sees this as an important part of a road safety program, and has called for improved driver education in these matters.

One particular problem which has been highlighted is that of caravans, where poor overtaking skills and lack of control of caravan movement on the open road creates problems for heavy vehicle drivers (and other road users also for that matter). The National Road Freight Industry Inquiry recommended that drivers should be tested and issued with a licence before they are allowed to tow a caravan.

MANAGEMENT, REGULATION AND ENFORCEMENT

National Uniformity

The road freight industry has put the need for national uniformity of regulations near the top of its agenda for reform. It has done so on the grounds not only of safety, but also for economic and operational reasons. In the conclusions to the recent Heavy Vehicle Road Safety Summit, the industry called for the Federal Government to create a regulatory environment with a single set of rules applying nationwide. In return, the industry undertook to support moves for higher standards in such areas as licensing, driver health, control of hours of work, vehicle inspections, speed (through the use of speed limiters) and accountability for the conduct of sub-contractors (Evans, 1990).

However, it could be argued that national uniformity is a means to an end, rather than an end in itself, and that the real purpose should be made explicit. Camkin (1990) has pointed out that uniform regulations should apply to uniform conditions, not uniformity for its own sake. Thus, it is probably reasonable to argue that factors which are difficult or impossible to change as a vehicle moves from State to State or area to area should be uniform - e.g. vehicle design, loading, mass and dimension limits, driver licence requirements, driver hours and log books, traffic rules, etc - but that more transient factors such as speed limits, vehicle taxes, fuel taxes, etc might legitimately vary from place to place.

However, even though progress has been made in recent years, there are still many areas of non-uniformity (R.A. Pearson and Associates, 1988). This has led to the argument that the Federal Government should take over responsibility for regulation in this area. For example, Cameron McNamara (1984, p 4-7) have stated three arguments for Federal intervention:

- the need for national uniformity,

- the failure of the States to agree on the simplest of measures relating to matters of road safety, and

- the limitation of State powers.

They go on (p 4-30) to argue that the Commonwealth has adequate powers under Section 51 of the Constitution to legislate with respect to safety related regulation of the freight industry (although this conclusion may need revision in the light of the recent High Court decision concerning the establishment of Commonwealth control on corporations (8/2/90)).

The National Road Freight Industry Inquiry called for uniform national regulations within an Operators Licensing Framework (see below), but stopped short of advocating a Federal system. The Federal Interstate Registration Scheme also arose from recommendations of the Inquiry.

Responsibility for Safe Practice and Quality Regulation

There is an emerging indication that at least the more responsible companies within the transport and freight forwarding industry are prepared to acknowledge a responsibility towards the practices adopted by sub-contractors. This might include such aspects as ensuring that a sub-contractor driver has a valid licence; ensuring that there is no drug usage and that blood alcohol limits are adhered to; ensuring that vehicles are fitted with speed limiters (when these become compulsory); checking vehicle condition before a trip, including brakes, tyres, etc; checking log books before departure and upon arrival; and that trip schedules are reasonable and do not require a driver to break speed limits.

One contentious aspect of these proposals is that employers and possibly freight forwarders may need to have access to a driver's record, to assess the demerit points; this would likely have industrial and civil liberties implications.

This raises the more general question of quality regulation of the industry. There has been a clear trend in Australia and overseas over the last decade or more for less quantity regulation and more quality regulation; the former governs what an industry does (e.g. limits on routes, areas served, rates charged, etc), while the latter concentrates on how the industry conducts itself (especially in the area of road safety, but also environmental and other factors) (Cameron McNamara, 1984; Ogden, 1980)

A major deficiency of the regulatory framework in Australia at the moment is that the only participant in the road freight industry who has to demonstrate competence and be licensed is the truck driver. Yet many aspects of safety are outside the driver's control. These include vehicle maintenance (there are stories of drivers approaching police and asking to be put off the road because the vehicle that they are required to drive is so unroadworthy!), vehicle loading, load security, delivery schedules, etc.

The National Road Freight Industry Inquiry recommended the establishment of a national Operators Licensing system, under which owner drivers, fleet operators, freight forwarders, agents and brokers would be required to obtain an operator licence if they operated vehicles with a GVM of 14 t or more and which travelled more than 100 km from loading point to unloading point (May, Mills and Scully, 1984, p 189).

To go with this, a standard industry trip document was recommended, which listed pertinent information about the trip, the commodity, and the goods carried, and which importantly indicated the party responsible for the various aspects of delivery (i.e. the driver and the shipper).

The essence of this system from a safety viewpoint is that, while the licences would be available as of right in the first instance (mainly to satisfy Section 92 requirements), an Operator Licence would not be renewed if the person concerned had established a poor record of citations in relation to such aspects as speeding, overloading, vehicle condition, dangerous goods transgressions, etc. The experience elsewhere (e.g. Britain - see Ogden, 1980) is that this is an effective sanction which contributes to improved performance of the industry.

Chow (1988) and Hensher, Battelino and Young (1989) have examined the relationship between the underlying economic conditions in the industry and on-road behaviour of drivers, and both have concluded that there is a link. This affects such aspects as driving hours, schedules and loading delays, fatigue, speeding, loading, etc. All of these matters, and the accountability for transgressions, could be the subject of a quality licensing system.

Industry Self Regulation

This is related to the above. The question is whether a licensing system of the sort described should be introduced as a regulatory measure by government (and no government has moved to adopt the National Road Freight Industry Inquiry's recommendations), or whether this should form the basis of an industry self-regulation scheme.

The industry has shown signs in recent times of moving towards a system of self-regulation (Evans, 1990; Finemore, 1990, Anon, 1990). While details are understandably rather fuzzy, the essence of the proposal seems to be that a company would need to be a member of one of the industry associations (Australian Road Transport Association, Long Distance Road Transport Association, National Transport Federation, or Australian Livestock Transporters Association, which jointly comprise the Road Transport Industry Forum). It would then subscribe to an industry code of conduct, which might include the sorts of things recommended by the National Road Freight Industry Inquiry concerning training, driver accreditation, health standards, hours of driving, log books, vehicle condition, drugs and alcohol, etc. The sanction would appear to be that transgressions of the code could lead to expulsion from the Association.

Whether this would occur in practice, and what effect it would have if it did, must remain open questions at this time. Indeed, there is scepticism about the proposal from within the industry; a leading industry figure was quoted in a recent "Staysafe" report (Joint Standing Committee on Road Safety, 1990) as follows:

> "Self regulation is a joke .... I don't think it started from us however. I think it started from probably the Federal Government when there was concern, however expressed from different quarters about truck safety and nobody knew what to do so they said pass the ball, let's go into self-regulation. What does that mean? .... If you find out tell me. I drew up a code of safety conduct for ARTF which wasn't accepted because it was too short, it said 'obey the law' ".

Nevertheless, the clear indication in all of this is that the industry recognises the need to "lift its game", and recognises that some sanction must be placed upon the actions of what is generally regarded to be a small proportion of the industry which is giving it a poor public image.

<u>Tachographs</u>

A tachograph is a device which typically records vehicle speed, distance travelled, and elapsed time. On mechanical devices, these data are recorded on a circular chart that records relevant information from a number of stylii; on modern computer-based devices, the data are recorded electronically. Tachographs are in wide use throughout industry as a management tool, though the older mechanical types represent superseded technology, and are being replaced in many fleets with more sophisticated computer equipment (Noske, 1989).

Their relevance to road safety is in two areas - management responsibility and enforcement. In relation to the first, the argument is that tachograph records provide information to management about what has happened to the truck on a particular trip, in terms of such aspects as speeds, rest and other breaks, time of arrival, etc. By monitoring these aspects, so the argument runs, the manager can better control and manage the truck fleet, and driver behaviour is affected because the driver knows that the manager will be aware of these transgressions.

The proposal to extend the use of tachographs to an enforcement tool is controversial. On the one hand, some argue (as the National Road Freight Industry Inquiry did) that they are not only a useful concomitant of a licensing system whereby all operators are required to keep records, but that such records should be available to licensing and enforcement agencies in order to make drivers and owners more accountable. In an enforcement context, evidence of speeds immediately before the vehicle was intercepted would be available, while in a crash situation, the tachograph would indicate vehicle speed at the time of the crash.

On the other hand, it is argued that they do not themselves prevent excess speed, but only enable speed to be determined after the event (e.g. after a crash, or upon subsequent inspection); they are not tamper proof; it is difficult if not impossible to determine exactly the location of a vehicle in relation to speed zones; keeping tachograph records and relating them to specific drivers is an "administrative nightmare", and would be expensive to install and maintain. It could be added that the use of tachograph records as a device for enforcement may detract from their use as a management tool since there would be a major incentive to tamper with them. The industry is opposed to the use of tachographs for enforcement purposes for these reasons (Evans, 1990).

Finally, it is important to note that at present, data (for prosecution or research purposes) on speeds of vehicles involved in crashes is extremely sparse and unreliable. The wider use of tachographs provides one of the few opportunities to fill this important information gap.

Enforcement Practices and Priorities

The necessity for enforcement is readily acknowledged; all of the legal requirements related to industry conduct and performance need a degree of enforcement, and the associated sanction if an offence is detected.

There is clear evidence that if there is a visible police presence along a section of road, excessive speeds and crashes reduce along it (Leggett, 1988).

In general, the effectiveness of enforcement relies more upon the probability of being caught than upon the amount of the fine (Axup, 1982). Enforcement priorities should therefore be directed where they are most effective. At present, there is a perception that enforcement is more related to revenue collection than to road safety, and that it impinges especially heavily upon the heavy vehicle driver (especially the points demerit system) (Axia, 1986; Siromath, 1988, Linklater, 1977).

An interesting experiment in enforcement strategy took place in the Port Macquarie Police District in 1989. This experiment, known as "Operation Cooperation" attempted to gain industry and driver cooperation with police in achieving mutual goals related to safer roads. Because this Operation has not been documented elsewhere, a review of the Operation and its effects are presented in an Appendix to this Chapter.

Enforcement cannot be applied uniformly or everywhere at all times, so there clearly has to be priorities in enforcement. The National Road Freight Industry Inquiry (1984, ch 7) recommended that enforcement be targeted upon critical safety and overloading areas. The National Transport Federation (1989) similarly has called for enforcement effort to be targeted to built up areas and black spots - for all motorists, not just heavy vehicles. They align this call with their advocacy of speed limiters, on the grounds that the speed limiter will remove the need for police presence to check speeds.

There are also technological developments which aid enforcement, or reduce the need for it. Examples include speed cameras, red light cameras, and on-board devices to prevent an alcohol-impaired driver from starting a vehicle. The potential for driver specific modules which would need to be connected before a heavy vehicle could be started has been mentioned above as a means of controlling driver hours, instead of log books (Howie, 1989).

Management Training

The National Road Freight Industry recommended non-compulsory management training to be available, especially to prospective entrants to the industry. These would focus upon financial and management skills, and highlight the potential hardships faced by new entrants. They recommended that they should be offered through the TAFE system, and have the status of a formal qualification. More recently, Camkin (1990), the National Transport Federation (1989), and the Road Transport Industry Forum (1990) have made similar calls.

Use of Rail

Although road and rail for the most part serve essentially different markets, there are certain areas of overlap, where they are in direct competition. Factors affecting freight mode choice are complex (Ogden and Rattray, 1982), but relate to both price and service factors. However, if more freight could be encouraged to move by rail rather than road, there would be fewer trucks on the road, ceteris paribus, and thus fewer opportunities for trucks to be involved in crashes. Although data for NSW are not available, Victorian data (Ogden, 1988) have shown that rail freight is safer than road freight. Similar arguments apply for rail and coach passenger operations, except that the safety benefits are much less clear; although the two multi-fatality crashes involving coaches in NSW in October and December 1989 will no doubt have changed the picture, the long term history is that coach operations are comparable in safety to rail operations, and may be the safest form of land transport (Byun, McShane and Cantilly, 1979; Ogden, 1988).

Actions to encourage rail use include regulatory instruments (which cannot be applied to interstate operations because the provisions of Section 92 of the Australian Constitution) and pricing instruments, which would have the effect of making road freight more expensive. (However, it should be noted that any increase in road freight rates would likely also produce an increase in rail freight rates, as the rail industry attempts to reduce its deficits. It is likely though at least part of any increase in rail freight rates would be directed towards investment aimed at providing a better, more reliable service, which is possibly more important that prices in attracting market share). Indeed, it is probably fair to say that it is generally agreed that mode use should be left to the market, and that public policy should be aimed at ensuring that each mode covers its full costs (including external costs, such as the cost of crashes), so that users are presented with the correct price signals; this is the position taken in the recent InterState Commission (1990) report, and also had support in the Rail Industry Council (1990) report.

Regulations on Vehicle Mass, Dimensions and Configuration

Maximum allowable mass and dimensions are set taking into account the tradeoffs between infrastructure costs, operating costs, and safety (National Association of Australian State Road Authorities, 1985). As examples, an increase in width would allow significantly increased stability, a longer vehicle lowers the centre of gravity for the same load, and increased payloads mean fewer vehicles for the same task. (Although this may be offset to an extent if there was a shift of freight from rail to road as a result of the more competitive road operation, this is generally regarded as being a relatively minor effect (Conroy and Affleck, 1988; InterState Commission, 1990, Appendix XIV)

Each of these changes would have other implications. Different vehicle configurations (B-doubles, articulated vehicles, truck and trailer combinations, rigid vehicles) are in use and each exhibits different responses to driver input. In particular, the B-double has now established a reputation for safety and its wider use is likely to have a beneficial effect on safety. For example, the Joint Standing Committee on Road Safety, (1990) prefaced its report on B-doubles as follows: "In the current climate of concern about heavy vehicle crashes, it is surprising that more has not been made of a readily available opportunity to greatly reduce truck disasters. The opportunity is a new breed of truck, the B-doubles, 106 of which are now approved to ply selected NSW roads."

5.3 ANALYSIS OF COUNTERMEASURES TO NSW TRUCK CRASHES

In Section 5.2 we discussed the range of countermeasures which are potentially available to reduce the incidence or severity of crashes involving heavy commercial vehicles. In this chapter, we consider these as they apply to each of the fatal crashes investigated on the Hume and Pacific Highways, i.e. all fatal crashes involving a truck or a coach on those highways in 1988 and 1989 (see Section 2).

A comprehensive list of potential countermeasures or responses to crashes involving trucks and coaches is as follows (each item is described in Section 5.2):

Vehicles

- brake matching
- anti-lock braking systems
- lower centre of gravity (to make rollover less likely)
- annual vehicle inspection
- random vehicle inspection
- improved tyre maintenance
- proximity detector braking
- improved visibility from driver's seat
- side under-run protection
- rear under-run protection
- removal of bullbars
- lower front bumpers
- reduced front end stiffness
- energy absorbing nose cone
- more conspicuous vehicle
- improved cab crashworthiness
- fitting and wearing of seat belts
- compatible engine/transmission specification
- improved load security

Truck and Coach Drivers

- training: defensive driving
- training: driving attitude
- training: stress management
- driver licensing, demerit system, and compulsory retraining
- selection criteria
- medical tests
- fatigue detection
- driver education about fatigue
- control of hours and drug taking
- perception of vehicle performance capability

Speeds

- speed limits
- speed zones
- on-board speed limiters
- tachographs (for speed control)
- drivers' speed perception

Roads and Traffic

- divided road
- improved sight distance
- improved delineation
- greater lane width
- culverts: end walls and ditches
- provision of guard fencing
- warning and direction signs
- pavement quality
- advisory speed signs
- rest areas
- improved road shoulders
- bridge widening
- enhanced roadwork practices
- improved skid resistance
- "black spot" programs
- traffic management
- rumble strips
- escape ramps
- arrester beds
- education of road engineers

Other Road Users

- car overtaking practices
- drivers' distance perception
- drivers' speed perception
- car crashworthiness
- fatigue detection
- driver education and training

Management and Regulation of the Industry

increased truck payload limits
safety practices in management (including use of tachographs)
operator demerit system
industry code of conduct
operator management training

Research

crash reporting
crash investigation

Enforcement

"Operation Cooperation"
targeting of "black spots"
electronic detection of speeds, alcohol

Use of rail where possible

It will be recalled (see Section 2) that Strand 1 of this study was largely concerned with a detailed analysis of each of the 83 fatal crashes involving a truck or a coach which occurred on the Hume or Pacific Highways in NSW in 1988-89. Thus, the research team had accumulated a good deal of information about the immediate circumstances surrounding each crash. Based upon this knowledge, each crash was considered in turn, and all of the above countermeasures were examined in the context of that crash. In essence, an assessment was made as to whether each countermeasure, had it been present, would have been likely to have prevented the crash from occurring, or reduced the severity of the outcome.

Obviously, such an assessment is a subjective surmise, since it is clearly impossible to say with certainty what might have happened had circumstances been different. Moreover, such judgements can only be based upon the information to hand, which, while extensive, can never be complete. However, this approach had the merit that it considered a wide range of potential countermeasures related to the road user, the road and the broader institutional and legal structure, and not (as is often the case) focussing upon a single driver-related "error".

Notwithstanding this point, it is also acknowledged that information about factors not immediately related to the crash are only rarely known in any detail. Thus countermeasures which are remote from the circumstances of the crash itself were assessed differently. Rather than using the approach outlined in the previous paragraph, an assessment was made as to whether the factor was relevant to the crash. For example, if truck speed, fatigue, truck maintenance, etc was a factor in the crash, it may be that a form of operator's license would be of benefit; it could not be said that it would have prevented that particular crash from occurring, but it may be relevant in that case. Similarly, if the truck was engaged on local delivery, use of rail was considered not relevant, but if it was on an inter-capital trip, rail use was relevant. As a further example, extra police enforcement may have contributed to a different outcome, but there is no way of knowing for sure whether it would have done so.

This consideration means that all the factors listed above under management and regulation of the industry, research, enforcement (except for Operation Cooperation - see below), and use of rail, together with the "other road user" factors of driver training and driver education, were assessed as being relevant only, and not as being specific countermeasures considered likely to have prevented the crash from occurring or reducing its severity.

For this reason, the applicability of these factors is likely to be an over-estimate of the potential influence of these factors. This is also the case for some driver and vehicle factors where the incidence is known, but its effect is not; for example, the countermeasure of seat belts in trucks is assessed on the basis of a truck occupant being ejected from the truck, but it is possible that in some cases the outcome would have been the same even if the occupant had stayed within the truck.

It may be that the most meaningful way to interpret the analysis for these factors is to look at the converse, i.e. the extent to which that factor would not have affected the outcome. For example, rather than to say that rail use was relevant to about half of crashes, it is probably more useful to say that at best, rail could only have affected half of the cases, since the half for which it is relevant is an upper limit.

Conversely, for many of the other countermeasures, the applicability is likely to be an under-estimate. That is, where we were confident, on the basis of information to hand, that a factor was relevant, it has been included. It is probable that there were other factors present about which we have no information, or where the information which we have is insufficient for us to make a judgement. This particularly applies to driver and vehicle factors, where we often do not have information about such items as vehicle speed, hours of driving, or the incidence of drug use. It is important to note therefore that for these factors, our analysis is likely to be a lower bound of the extent to which the particular countermeasure is applicable.

Finally, it should be noted that in some cases it was impossible with confidence to separate the effect of individual factors, and it was necessary to combine them for analysis purposes. For example, where truck speed was a factor, a form of speed monitoring (e.g. tachograph) or speed inhibitor (e.g. speed limiter) would be applicable, but for our purposes, it is not possible to distinguish the effect of one from the other. (There may of course be other good reasons to separate them for other purposes.) Thus, the following countermeasures were amalgamated for analysis:

- all factors listed under management and regulation of the industry

- brake matching and anti-lock braking systems,

- other road users: driver training and education,

- speed limiters, and heavy vehicle driver speed perception

- reduced truck front stiffness and energy absorbing nose cone.

Table 5.1 lists the countermeasures, showing the number of crashes for which each was considered to be applicable. (The total number of crashes was 83, and of course more than one countermeasure was possible for each crash.)

TABLE 5.1. COUNTERMEASURE FREQUENCY

divided road	61*
rail use	42*
increased truck payload limits	42*
reduced truck front end stiffness	40*
road user education and training (other than truck driver)	33*
traffic engineering black spot treatment	27
improved road delineation	25*
electronic enforcement of speed and alcohol	24*
operator licensing; management and regulation of the industry	23*
improved road shoulders	22
driver licensing; demerit system; compulsory retraining	21
truck cab crashworthiness	20*
fitting and wearing of seat belts in trucks	19
police enforcement at known black spots	19*
truck and coach driver defensive driving training	18*
speed limiters and/or tachographs; speed perception	18*
rumble strips on road centre or edge line	18*
fatigue detectors in heavy vehicles	16
improved car crashworthiness	15*
truck driver attitude training	14
traffic management and engineering	13*
brake matching and anti-lock braking systems	11
enforcement through "Operation Cooperation" program	11
fatigue detectors in cars	11
research on crash investigation	11
remove truck bullbars	10*
truck and coach driver education about fatigue	10
lower truck and coach front bumper	9*
lower truck centre of gravity (rollover)	9*
car driver speed perception	8
heavy vehicle driver selection criteria	7
education of road engineers	7*
improved sight distance on roads and intersections	7*
proximity detector braking on trucks and coaches	6*
control of driver hours (drugs)	5
provision or improvement of roadside guard fencing	5
enhanced roadwork practices	5*
pavement skid resistance	5
improved truck conspicuity	5*
improved truck load security	5

CONT. OVER

TABLE 5.1 (CONT.)

continued random truck mechanical inspection	4
road culverts	4
car driver distance perception	4
research on crash reporting	4*
car overtaking practices	4
provision of overtaking lanes	3
provision of rest areas	3
wider bridges	3
truck driver stress management training	3
truck driver perception of vehicle performance capability	3
annual truck mechanical inspection	2
improved tyre maintenance	2
improved pavement quality	2
improved visibility from truck driver's seat	2
truck side under-run protection	2
truck rear under-run protection	2
wider traffic lanes	1
better warning or direction signs	1
advisory speed signs (install or amend)	1
compatible engine/transmission specification	0
change to posted speed limits	0
escape ramps	0
arrester beds	0

* these are considered likely to be over-estimates; most of the others are considered to be likely to be under-estimates.

When considering each of the countermeasures listed in Table 5.1, it should be realised that in many cases the frequencies shown are only upper or lower bounds, and even these are only a crude estimate, based upon incomplete evidence. Furthermore, many of the countermeasures overlap, so that in general the potential effect of introducing two or more countermeasures would be less than the sum of the frequencies shown.

The following discussion reviews each countermeasure, explains the circumstances under which it was included as applicable to a particular crash, and discusses its relevance to this study.

Divided Road

As discussed in Section 2, one of the most frequent factors associated with fatal crashes involving heavy commercial vehicles on the Hume and Pacific Highways was that the road was undivided. Conversely, in many cases, a divided road would have contributed to the prevention of the crash, or (less frequently) its severity.

For this analysis, a divided road was considered as a countermeasure in the following cases:

- head-on collisions, with any vehicle being on the wrong side of the road,

- some rear end collisions involving a stationary turning vehicle, where it was considered that such a vehicle would have been in a turn lane, not in a through lane, had the road been divided, and

- some single vehicle run-off-the-road crashes where it was judged that the crash would not have happened if the road had been divided - in particular, if the vehicle left the road to the left, it was considered that a divided road would not have helped.

The analysis showed that 61 out of 83 (73 per cent) of crashes may have been prevented if the road had been divided at the location of the crash. This is likely to be an upper bound estimate, since in some cases the result may have been the same even if the road had been divided (e.g. an errant vehicle crossing the median into the path of another vehicle). However, the extent of over-estimation is considered likely to be small in this case. Thus, it follows that the single most effective factor likely to reduce heavy vehicle crashes on rural highways is the provision of a divided carriageway.

<u>Rail Use</u>

Rail use was one of the factors which were remote from the actual site and circumstance of the crash, and was assessed as being "relevant", rather than a countermeasure specifically related to the particular crash.

Rail use was judged to be relevant if one or more of the trucks involved in the crash appeared to be carrying inter-capital freight; this was only rarely explicitly stated, and often had to be assessed on the basis of the vehicle being registered as a Federal Interstate truck and/or was operating out of the state of its owner or driver.

The analysis suggested that rail use may have been relevant to as many as 42 (51 per cent) of the fatal crashes; as noted above, this should be regarded as an upper estimate of the extent to which rail use could have been an alternative to the use of roads in the crashes examined.

As noted, these factors which refer to the broader context rather than to the crash itself are perhaps more meaningfully interpreted by considering the converse situation; in this case, it means that the *greater use of rail is irrelevant in at least 49 per cent of crashes,* since these were assessed as involving trucks on trips for which rail was not a competitor. This is a valuable conclusion because it indicates that greater use of rail, while relevant to certain traffics, is not a panacea for road crashes (and rail of course is not without its own safety concerns).

Increased Truck Size and Weight (Payload) Limits

Increasing the truck payload limit is another road safety factor which is not directly and specifically related to the site and circumstances of the crash, and thus, like rail use, was assessed as being "relevant", rather than as a specific measure which, if present, might have prevented the crash or reduced its consequences.

Increased truck payload limits are however of importance to truck safety for two reasons. Firstly, greater limits mean fewer trucks on the road, ceteris paribus, for a given freight task, and there is a smaller exposure to potential crashes or conflicts. However, it is possible that this effect could be offset to some extent by a shift of freight from rail to road, if higher truck payloads made road freight more cost-competitive. Secondly, to the extent that increased payload strategies are implemented through the wider use of B-doubles, which are generally regarded as an inherently safer and more stable vehicle, road safety would be improved.

This factor was judged on the same basis as rail use above, namely if the truck involved in the crash appeared to be carrying inter-capital freight, as indicated on the basis of the its being registered as a Federal Interstate truck and/or operating out of the state of its owner or driver. As with rail this is obviously a matter of judgement and conjecture.

The analysis suggested that increased truck payload limits might have relevance to as many as 49 (51 per cent) of crashes; this must be considered as an upper limit however, for the reasons outlined above. In interpreting this figure, it must be realised that it is not saying that 51 per cent of crashes would have been eliminated by the use of trucks with higher payloads, but that this percentage of trucks may have been affected had higher payloads been available. (For example, if there was a 20 per cent increase in weight limits, there would be a maximum of around 10 per cent reduction in crashes).

Conversely, the use of more productive vehicles with greater payload is considered irrelevant to 49 per cent or more of crashes.

Reduced Front End Stiffness

As noted previously, many crashes involved head-on collisions between a car and a truck. In some of these cases, it was considered possible that a redesigned front end of the truck may have been of some assistance. This might include either an energy-absorbing feature which might be effective at low relative speeds in reducing the consequences (not the occurrence) of the crash, or a more radical design of a nose cone arrangement which would have the aim of deflecting an on-coming car if the impact was offset or the angle of impact was oblique.

Thus, for this analysis, head-on crashes were considered as possibilities for the application of this countermeasure, even though the nose cone suggestion is at this stage hypothetical. *The analysis suggested that 40 crashes could have been influenced by a reduced front end stiffness of the truck (48 per cent of the sample).* However, as noted, this factor relates to consequences, not occurrence, and therefore it would be unrealistic to conclude that all fatalities would have been prevented if it was present; it should therefore be regarded as an upper estimate.

Road User Education and Training (Other than Heavy Vehicle Driver)

Many of the crashes which were examined involved a road user (not the truck or coach driver) who made an error of judgement or mistake of some sort. These included such actions as excessive speed of car drivers; failure of car drivers, pedestrians or cyclists to keep a lookout for other vehicles; car drivers who made an inappropriate or incorrect driving action; etc. To the extent that these behaviours or states may be capable of being influenced by driver training or education, they were included in this category.

A *total of 33 (40 per cent of the sample) crashes involved car drivers, pedestrians or cyclists whose actions may have been potentially susceptible to improvement through education or training*. However, this estimate is an upper bound, as it is unknown how many, if any, of these actions would not have been different even if the road user had undergone such training or education.

As with other factors concerned with the broader context rather than the crash itself, it is instructive to consider the converse implications of this result. In this case, it means that more than 60 per cent of heavy vehicle crashes were unlikely to be influenced by training and education programs directed at car drivers, pedestrians and cyclists.

Traffic Engineering Black Spot Treatment

Treatment of black spots (i.e. sites where there has been a concentration of crashes) by traffic engineering works has been shown elsewhere to be highly cost effective as a crash countermeasure. This countermeasure was assessed in the present study by firstly considering whether the site was a black spot; this was done by consultation with RTA engineers, not by analysis of the accident data, since clearly these were insufficient to provide a statistically significant sample.

Black spot analysis has mostly been applied to intersections, where the location is unambiguous. Its application to a road segment is less precise, since it depends upon the length of the road and its standard. Thus, while the Hume Highway between Yass and Goulburn may be considered as a black spot for these purposes, for the most part, road segments considered as a black spot would be much shorter (e.g. the Pacific Highway near Tintenbar).

Having decided on the basis of RTA engineers' assessment of the intersection or road segment as a black spot, it was then necessary to discern that the particular crash was amenable to treatment by a form of minor road improvement (basically anything less than full duplication).

On this basis, *27 crashes were considered as being of such a nature that they may have been prevented had appropriate traffic management works been carried out. These represent 33 per cent of the total crashes;* it is relevant to point out that the Federal Government has recently decided to put additional funds into the treatment of black spots. This is likely to be an underestimate of the extent to which traffic engineering may contribute towards reduction of heavy vehicle crashes, as there will likely be additional sites which more detailed analysis reveals as being black spots.

Improved Road Delineation

Road delineation includes all devices, both formal and informal, which the driver uses to guide and control the vehicle within the traffic lane or intersection. Examples of poor delineation include: absence or poor maintenance of edge or centre lines; absence or non-replacement of raised reflective pavement markers on the lane or edge lines; lack of bridge width markers; absence or inappropriate use of chevron markers at bends; poor delineation during road works, etc.

For this analysis, where any of the above factors were present, and where they were judged as being potentially related to the sequence of events which resulted in the fatal crash, improved delineation was assessed as being a possible countermeasure.

The analysis suggested that improved delineation could have helped in 25 (30 per cent) of crashes. This is likely to be an upper bound estimate, as improved delineation would not necessarily have prevented every crash where delineation was deficient.

Electronic Enforcement of Speed or Alcohol

There is an increasing trend towards the use of technology as an enforcement device. For this category, we considered two such devices, namely speed cameras and ignition interlock devices which prevent an alcohol-impaired driver from starting a vehicle. Thus, where it appeared that a vehicle in the crash was travelling at a speed in excess of the speed limit, or there was evidence that one or more drivers was over the legal blood alcohol concentration, this countermeasure was considered relevant.

The analysis suggested that 24 crashes (29 per cent) may have been prevented by electronic means of enforcement of speed or alcohol. This is probably an over-estimate, as it is unlikely that devices such as speed cameras would have affected the speeds of all vehicles, and it may be that excessive speed was not a causal factor relevant to the crash in every case. The severity of several other crashes would probably have been reduced also, had speeds been lower, although the number is difficult to estimate.

Considering the converse of this result, it suggests that at least 71 per cent of truck and coach crashes would not have been susceptible to influence by electronic enforcement directed at speed or alcohol.

Operator Licensing; Management and Regulation of the Industry

This countermeasure includes a number of actions and proposals aimed at altering the way in which the industry is managed. It includes such aspects as industry self-regulation, operator licensing, operator demerit systems, management training, and other proposals aimed at enhancing the management of the industry in the pursuit of road safety. The recent National Road Safety Forum focussed upon these sorts of proposals (especially industry self regulation) to the virtual exclusion of other factors.

In addition, we have included the use of tachographs here, since these are properly regarded as a device for use by management in relation to the use of their vehicles, including such aspects as vehicle speeds, driver hours, etc.

For this analysis, any heavy vehicle or heavy vehicle driver factor which was potentially amenable to change through management practices was included here. Examples included excess speed, use of drugs, truck or coach driver fatigue, truck mechanical condition, truck loading, driving hours in excess of the legal limit, exceeding speed limits, etc. As discussed previously, this analysis is likely to over-estimate the significance of this countermeasure, as even the best industry performance would be unlikely to completely eliminate all of these sorts of factors.

The analysis suggested that as many as 23 crashes may have been prevented by some form of improved management or regulation of the industry, directed at enhanced road safety. This is 28 per cent of the total.

Conversely, and perhaps more meaningfully, this result implies that measures directed at management and regulation of the industry would have had no effect on 72 per cent or more of heavy vehicle crashes; this is perhaps an important conclusion in the light of recent debate about the extent and value of industry self-regulation.

Improved Road Shoulders

Road shoulders are pertinent to crashes in a number of ways, of which the main ones considered here are the provision of a space to avoid a collision, and a vehicle losing control when the left wheels leave the traffic lane.

Crashes in the former case included those where there was a rear end collision on a road with narrow shoulders which prevented the second (rear) vehicle from driving to the left of the first vehicle; or some head on collisions where the driver of the vehicle in the correct lane had sufficient time to avoid an oncoming vehicle, but was prevented from doing so by a narrow shoulder.

Crashes in the second category included both some run off the road crashes, where the driver was unable to regain control after straying from the traffic lane onto an inadequate shoulder, and some head-on crashes where the driver did regain control but over-compensated and moved to the wrong side of the road.

The analysis suggested that 22 crashes (27 per cent) may not have occurred had the road shoulders been wider or in better condition. This is possibly an under-estimate, as there were several head-on collisions where the above cause was not recorded but could have been present.

Driver Licensing; Demerit System; Compulsory Retraining

Driver competence is clearly of significance in road safety, especially in the case of large commercial vehicles which call for a higher level of skill. This category of countermeasure includes improved driver training, the use of the demerit system to remove unsafe drivers from the road system, and compulsory retraining before a de-licensed driver is permitted back on the road.

For this analysis, the extent of this countermeasure was assessed firstly on the basis of an apparent lack of skill by a heavy vehicle driver involved in the crash. Secondly, an assessment was made of whether a driver who carried out a particular action may have made a different action if that driver had undergone advanced skills training or retraining. Clearly these judgements are highly subjective, and the conclusions were only reached where there was fairly clear evidence. They must therefore be regarded a lower bound estimates of the extent to which improved truck or coach driver skills, training, and retraining are relevant to truck and coach crashes.

The analysis suggested that 21 crashes (25 per cent) may have been prevented, or had less severe consequences, if truck drivers had displayed a higher skill level. This may be compared with the above estimate of 33 crashes (40 per cent) where improved skill levels of other road users (not heavy vehicle drivers) were considered relevant; this comparison is especially cogent when it is realised that another road user was present in only 90 per cent of heavy vehicle crashes.

Truck Cab Crashworthiness

Truck cabs vary in crashworthiness, and as a result a truck driver whose truck is involved in a frontal collision or rollover is at some risk.

For this analysis, the countermeasure of improved truck cab crashworthiness was judged on the basis of whether the truck driver was killed or injured in a collision in which the cab was crushed.

On this basis, *improved cab crashworthiness may have contributed to a less severe (i.e. non-fatal) outcome in 20 crashes (24 per cent)*. This is likely to be an upper estimate, as in some cases where the cab was crushed, a more crashworthy cab may not have prevented a fatality.

Fitting and Wearing of Seat Belts in Trucks

Seat belts have been compulsorarily fitted in trucks for some years but, unlike cars, it is not compulsory for truck occupants to wear them. However, as with cars, in most cases it is less hazardous for a truck occupant to restrained inside the vehicle than to be ejected or thrown around inside the cab.

The contribution of this countermeasure was assessed on the basis of a truck occupant being ejected from the truck. *The analysis revealed that in 19 cases (23 per cent of crashes), seat belts may have contributed to a less severe outcome.* This is likely to be very much a lower bound estimate, as we have not included cases where the driver was not ejected. In these cases, seat belts would have helped restrain the occupant inside the truck, particularly if a belt system with upper torso restraint attached to the seat was used. This would probably at least double the number of cases where the outcome could be expected to be less severe.

Police Enforcement at Known Black Spots

Enforcement is aimed, inter alia, at changing driver behaviour. To the extent that it is possible to cover the whole road system, it contributes to enhanced safety, since there is clear evidence that if there is a visible police presence along a section of road, excessive speeds and crashes reduce along it. Since all road segments cannot be equally strongly enforced, we have considered whether a greater police presence at sites or road segments known to be black spots may have changed driver behaviour (especially speed) in such a way that the crash may not have occurred.

On this basis, *a total of 19 crashes (23 per cent) may have been prevented had there been a higher level of enforcement at known black spots.* This must be regarded as an upper limit, as enforcement may not modify the behaviour of every road user.

Conversely, this suggests that concentrated police enforcement of known black spots would not have affected 77 per cent or more of heavy vehicle crashes.

Truck and Coach Driver Defensive Driver Training

Defensive driving basically means that drivers anticipate conditions in the immediate future and drive accordingly. Truck and many coach drivers are in a good position to do this as their cab is higher off the ground and they have good visibility as a result; a good driver will take advantage of this and drive accordingly.

This factor was assessed on the basis that a heavy vehicle driver apparently did not drive defensively, i.e. the information suggested that had the driver been more alert, the crash or its consequences may not have happened. This is likely to be an over-estimate, as in some cases even a more alert driver would not have been able to prevent the crash from occurring.

The analysis suggested that 18 crashes (22 per cent) may have been prevented, or their consequences reduced, had the heavy vehicle driver practiced better defensive driving.

Speed Limiters and Speed Perception

These are aimed at reducing excess speed. Speed limiters are on board devices which constrain the vehicle from much exceeding a prescribed speed, while speed perception is a countermeasure which aims at alerting the driver to an excess speed situation.

Speed limiters were assessed as being applicable in 18 crashes (22 per cent) where the heavy vehicle was judged to be travelling at a speed greater than around 100 km/h and this was considered to be a contributing factor. Note that this is less than the number of crashes where excess vehicle speed was a contibuting factor (28 per cent); in many of the latter cases, the speed, while excessive for the conditions, was less than 100 km/h, and thus would not have been amenable to control by a speed limiter.

This estimate of 22 per cent is likely to be an upper limit, as some crashes would likely have occurred even at lower speeds. On the other hand, the severity of outcome and hence number of deaths would have been reduced in a number of the crashes had speed limiters been fitted.

Rumble Strips on Road Centre or Edge Line

Rumble strips are grooves or raised ridges on the shoulder of roadway to alert a car driver that the vehicle is leaving the lane, through noise or vibration. They may be placed on the centre line, on lane lines, or on edge lines. Raised reflective pavement markers give a tactile sensation when a wheel runs over them. They are not considered effective for heavy vehicles since the noise and vibration which they impart would probably not be detected. Commercial products are now available for application to both centre and edge lines. A series of thermoplastic ridges are applied to the road by a special applicator. The markings are highly reflective and because they are fairly thick (e.g. 3 mm), the lines are easily visible above road water on rainy days.

The use of rumble strips as a countermeasure was assessed in the case of light vehicles either crossing on to the incorrect side of the road, or running off the road, where it was considered that the driver had gone to sleep.

The analysis suggested that 18 crashes (22 per cent) may have been affected had a device of the above sort been present. This is probably an upper bound to their applicability, since there would be some crashes in which they would not be effective.

Fatigue Detectors in Heavy Vehicles

Fatigue detectors at this time are a potential device yet to be fully developed and evaluated, the essence of which is to detect driver fatigue, and make some response with the objective of awakening the driver and/or alerting the driver to this state.

The applicability of this countermeasure was assessed on the basis of whether the truck or coach driver was thought to have gone to sleep, causing the crash as a result. In only a few cases can we be sure that the driver had gone to sleep, but otherwise inexplicable driver behaviour (e.g. single vehicle run off road crashes) tends to be attributed to fatigue. As a result, it could be argued that the analysis is possibly an over-estimate, since other factors (e.g. the presence of other vehicles, mechanical failure, or load instability) may be a factor in some of these cases. On the other hand, fatigue may be present in cases other than a driver falling asleep, resulting in a late or inappropriate response to a driving situation. Since we have tended to adopt a narrow definition of fatigue (i.e. asleep), the wider effects of fatigue may be greater than those actually suggested by the analysis, so the analysis possibly gives a lower bound estimate.

The analysis suggested that 16 crashes (19 per cent) may have been prevented had the heavy vehicle been fitted with an effective on-board fatigue detection device.

Improved Car Crashworthiness

This factor is similar to the truck crashworthiness factor discussed above. However, it was assessed in this case by reference not only to a deformed car body, but also on the basis of collision speed and angle, since even the best car body could not be expected to provide survival space with a fast moving heavy vehicle; the impact energy is just too great.

Improved structural car crashworthiness may have contributed to a changed outcome in 15 crashes (18 per cent). This may be an upper bound estimate, since the actual outcome may have been equally severe even with better car structural strength, depending for example upon occupant seat belt wearing. On the other hand, if accompanied by improved truck front end design, it may be a lower bound.

One factor of particular note is that in a number of cases the car caught fire, due apparently to a ruptured petrol tank combined with the car being scraped along the road due to the energy involved at impact.

Truck Driver Attitude Training

Some crashes seemed to feature an aggressive attitude or behaviour on the part of the truck driver. Training programs have been developed to attempt to develop a more responsible attitude by drivers.

This factor was assessed in terms of evidence of truck driver aggressiveness, such as close following, convoying, dangerous overtaking, etc. As such, it is probably a lower bound, since there would probably be cases of such aggressive behaviour for which we have no evidence.

Attitude training, if it was effective in altering truck driver behaviour, may have affected 14 crashes (17 per cent).

Traffic Management and Engineering

The use of traffic engineering measures at black spots has been referred to above. This countermeasure is similar, but is not particularly related to a black spot program, but rather is concerned with re-design of a particular road feature that seemed to be associated with the crash (e.g. intersection layout, median design, street lighting, traffic signals). As such, it is probably an upper bound, since correction of these features may not have necessarily eliminated the crash.

The analysis suggested that 13 crashes (16 per cent) were amenable to redesign of traffic engineering and management features.

Brake Matching and Anti-lock Braking Systems

The braking systems on tractor-semi-trailers and truck-trailers may not be well-matched, and only rarely have anti-lock devices. They can pose particular problems with unladen trucks, where the brakes lock up more easily.

This factor was considered to be applicable where there was evidence of truck braking problems (skidding, jackknifing, etc). As such, it is probably a lower bound estimate, since there may have been other cases of brake malfunction for which no evidence was available. A *total of 11 crashes (13 per cent) were assessed as being likely to have been avoided had better truck brake matching or anti-skid brakes been fitted.*

There was some evidence of the practice of deliberately backing-off the front brakes, and this could be checked using the RTA Truckalyzer.

Enforcement through "Operation Cooperation"

"Operation Cooperation" was a heavy vehicle enforcement campaign which operated in the Port Macquarie Police District during part of 1989. It is described in detail in Appendix D, but the essence was that police concentrated upon the more serious breaches by truck and coach drivers, did not hassle them, and did not use unmarked vehicles. In return, truck and coach drivers and the industry agreed not to use CB radios and to cooperate with police in apprehending serious transgressors. It is generally regarded by the police who took part, and certainly by the industry and drivers who used that section of the Pacific Highway as a success. Its effect upon truck-related crashes also appeared to be positive.

Assessing the potential impact of "Operation Cooperation" upon other parts of the highway is difficult, and relies upon judgement as to whether the particular factors present in a particular crash may not have been present had the Operation been in force. Factors such as truck and coach speed, truck driver attitude, convoying, etc were considered.

Our assessment is that 11 crashes (13 per cent) might have been affected by a program along the lines of Operation Cooperation, but this might be regarded as a lower bound estimate, as we have no way of assessing what the long term effects of this form of enforcement might be upon heavy vehicle drivers.

Fatigue Detectors in Cars

Many of the head on crashes in the study involved a car being on the wrong side of the road, and for several of these there is a high probability that the car driver was fatigued. Therefore, as with the truck fatigue detectors discussed above, there is potential for a device of some sort which would aim at detecting the onset of driver fatigue, and initiating some response with the objective of awakening the driver and/or alerting the driver to this state.

As with trucks, the applicability of this countermeasure was assessed on the basis of whether the car driver was thought to have gone to sleep, causing the crash as a result. Again as before, this is likely to be a lower bound estimate of the extent to which car driver fatigue detectors may have prevented the crashes examined. *The analysis suggested that 11 crashes (13 per cent) were in this category.*

Research on Crash Investigation

This factor was less a countermeasure as such, than a potential contributor to increasing the level of knowledge about crashes and therefore potentially contributing to future safety.

It was assessed where, in our judgement, there was something unusual about the circumstances of the crash, but there was little or no follow up crash investigation to determine causal factors. As such, it is highly subjective, and therefore is probably a lower bound estimate of what more detailed crash investigations could contribute. *A total of 11 crashes (13 %) were in this category.*

Remove Truck Bullbars

Many trucks are fitted with bullbars to reduce the extent of cabin intrusion in the case of a frontal crash with animals, or other vehicles. However, it also has the effect of making the front of the truck much less collapsible, with the result that more of the impact energy in a crash with another vehicle is absorbed by the other vehicle, in some cases producing a worse outcome than would have resulted had both vehicles absorbed some of the impact energy.

This factor was assessed by considering crashes involving the front end of the truck where relative speeds were low (since at high relative speed the amount of energy is so great that absence of bullbars would make little difference). *A total of 10 crashes (12 per cent) were identified.* This is an upper bound estimate, since it is not certain that the absence of bullbars would in fact have led to fewer fatalities.

Truck and Coach Driver Education about Fatigue

Education can be effective in the long term in changing driver behaviour, and one of the aspects of education which may be amenable to an education program is truck or coach driver fatigue. This assessment is obviously highly subjective, since we are not always certain that fatigue was involved, let alone knowing what might have happened in the hypothetical case that a driver might have changed behaviour had they experienced an educational program. As such the estimate must be a lower bound, since the effects may be greater than that indicated by the few cases identified.

This factor was assessed on the basis that the driver was not only apparently fatigued, but had also behaved in such a way that fatigue was a likely consequence, especially that they had driven for many hours without an adequate break. *A total of 10 crashes (12 per cent) were in this category.*

Lower Truck and Coach Front Bumpers

One of the important differences between cars and heavy vehicles is the difference in the height of the bumper. Since heavy vehicles usually have higher bumpers than cars, in a collision involving the front of the heavy vehicle, there is a greater likelihood that the car cabin will be intruded. Lowering the heavy vehicle bumper may mean that more of the impact energy is absorbed by the chassis of the car and less by the cabin.

This factor was assessed by considering crashes involving a car and the front end of a truck or coach, where the relative speed at impact was low (since at high relative speeds the impact energy is so great that severe distortion of the car cabin is likely). A total of 9 crashes (11 per cent) were identified; this is likely to be an upper estimate since in some of those cases the crash would probably still have been fatal even with compatible bumper heights.

Lower Truck Centre of Gravity

Trucks are inherently less stable than cars, due to their higher centre of gravity amongst other factors. Therefore, lowering the centre of gravity, or other related measures, the truck may be effective in some cases in preventing truck instability, especially truck rollover.

The analysis indicated that as many as 9 crashes (11 per cent) involved truck roll over which may have been prevented had trucks had a lower centre of gravity, or similar related measures to improve stability. This must be an upper estimate, since in some cases it is likely that the roll over would have occurred even with a lower centre of gravity.

Car Driver Speed Perception

As noted above, this countermeasure is aimed at affecting the perception of a driver of his or her speed. To the extent that excess speed for the conditions is a factor, it may be that some form of speed perception device could have been helpful at specific locations or environments.

Eight crashes (10 per cent) were identified where car driver speed was excessive for the conditions, but the driver may have had inadequate warning or been given misleading visual cues from the road environment at those sites. This is likely to be upper bound estimate of the potential of such a device, as it would not be effective in every case.

Driver Selection Criteria

To the extent that heavy vehicle driver skills and attitudes are relevant, driver selection is a factor to be considered. However, this factor is difficult to assess, since there is no way of assessing with confidence that it would have made any difference. Therefore, it has only been designated here in cases where there is clear evidence of inappropriate behaviour on the part of the heavy vehicle driver. It may be that the actual effect would be greater than that indicated because this is a relatively restricted criterion, and there may be other cases of poor driver skill or attitude than we were able to identify from the evidence available. *Our analysis indicated that 7 crashes (8 per cent) may have been affected by this factor.* In addition, some of the 14 crashes listed under truck driver attitude training could probably have been prevented through driver selection criteria.

Road Engineer Education

In some cases, it appears that the road itself or associated traffic management facilities were inappropriate, did not take account of the specific needs of heavy vehicles, or where the installation appeared not to recognise the significance of traffic devices (e.g. delineation devices) in road safety. These factors are amenable to targeted education programs aimed at those responsible for management and maintenance of the road and roadside.

This factor was considered relevant where we assessed that a shortcoming of this sort appeared to be present. A *total of 7 crashes (8 per cent) were identified*; this is likely to be an upper estimate, since the crash may have occurred even with better traffic design, etc.

Improved Sight Distance at Roads or Intersections

Restricted sight distance appeared likely to be a factor in a few crashes, particularly at intersections in urban areas. Improved sight distance or better traffic control could therefore have contributed to preventing the crash from occurring. However, this is likely to be an upper estimate, since it would probably not have prevented every such crash. *Seven crashes (8 per cent) were in this category.* (Although this is a small number, and is considered to be an upper estimate, this does not mean that sight distance is unimportant - rather it means that in most cases the design or traffic control features are considered adequate.)

Proximity Detection Braking on Trucks and Coaches

This is a potential countermeasure yet to be fully developed and evaluated, based upon some notion of truck or coach brakes being activated, or the driver alerted, when the vehicle is closing rapidly upon a stationary or slow moving vehicle. In the crash sample, there were a number of cases where it appeared that the driver misjudged the speed of a vehicle ahead, and a device such as this may have been helpful.

A *total of 6 crashes (7 per cent) were of this sort.* This however is probably an upper estimate of the effectiveness of a device of this sort, since it presumably would not or could not prevent every such crash from occurring.

Control of Driver Hours (Drugs)

Driver hours are relevant to heavy vehicle safety, principally because of the potential contribution to fatigue. Current methods of enforcement of this factor rely upon the use of log books, which are generally held to be widely misused, and in any case do not take account of other factors pertinent to driver hours, such as the need for flexibility, hours spent working but not driving, day and night driving, etc.

Unfortunately, in the present study there was very little information about the number of hours of driving of most truck or coach drivers in the crashes examined. Where there was evidence of excessive hours, it was recorded as such; this occurred in only 5 crashes (6 per cent). However, it is virtually certain that this is a lower bound estimate, as there is widespread evidence from other sources of excessive driving hours.

Provision or Improvement of Guard Fencing

Guard fencing is a proven safety feature, and *in 5 cases (6 per cent) we considered that the provision of guard fencing, or the improvement of existing guard fencing, could have been helpful.* This is likely to be a lower bound estimate, as guardrail serves several functions, one of which is to provide improved delineation, and therefore it may have contributed indirectly to preventing other crashes as well.

Enhanced Roadwork Practices

A number of crashes occurred at roadwork sites (5 crashes - 6 per cent). In some cases, it is likely that improved roadwork practices (e.g. advance warning, traffic control) may have contributed to eliminating the crash or reducing its consequences. However, this is an upper bound estimate, as better practice probably would not have affected every crash at roadwork sites.

Pavement Skid Resistance

In some cases, one or other vehicles in the crash lost control and skidded. In these cases, the provision of pavement with better friction properties was considered to be a relevant countermeasure. *Five crashes (6 per cent) were in this category*. This is probably a lower limit, as in some cases drivers may have been deterred from using their brakes to a greater extent (and thus skidding) because the road appeared to be shiny; in these cases, a better pavement may have helped prevent the crash.

Improved Truck Conspicuity

In 5 cases (6 per cent) cases, another vehicle ran into the rear of a heavy vehicle, and it could therefore be the case that improved rear end conspicuity may have helped. This is probably an upper limit however, since better conspicuity will not be helpful in every case of rear end collisions (e.g. if the offending driver is under the influence of alcohol).

Improved Truck Load Security

In some cases, the crash was apparently a result of load shift, and thus better load security, or changed practices (e.g. with the transport of empty bottles) may have prevented the crash. *Five crashes (6 per cent) were in this category*. This is probably a lower limit, as other crashes may have been attributable to this factor, but there is no evidence of such after the event.

Other Factors

The remaining factors listed in Table 1 were present in less than 5 crashes in the sample, and could therefore be considered as being relatively minor. However, it is significant that most of these remaining factors are assessed as being lower bound estimates, i.e. the actual importance could be higher than that indicated. In particular with factors such as vehicle mechanical inspections, roadside rest areas, overtaking lanes, improved pavement roughness, better road signs, or heavy vehicle driver stress management training, it is very difficult to say that they would have made a difference in any specific instance, but they may be important parts of an overall road safety program.

In addition, it should not be assumed that a low frequency means that the factor is not important; it may mean that it is adequate at the moment. For example, we did not identify any instances where posted speed limits were inappropriate, but it should not be assumed from this that speed limits are unimportant. Instead, as stated, existing practice is considered reasonable. Similarly, the low frequency of such road features as narrow lanes or inadequate warning signs is a reflection of the fact that in most cases these features were adjudged to be satisfactory at the crash sites, not that they are unimportant.

6. FINDINGS

The overall objectives of the study gave considerable weight to the *circumstances and contributing factors* in fatal and serious injury crashes involving heavy vehicles occurring in NSW. In addition to this overall objective, a number of the specific research questions raised in the project brief hinge on understanding the crash circumstances and contributing factors, both for the years 1988/89 and for previous and subsequent years. Although these issues have been considered in each strand of the study (see sections 2,3 and 4) within the context of each strand's research approach, there is a need to consolidate these findings in a broader context.

The study objectives also gave considerable weight to the *development of countermeasures*. The original brief allowed considerable flexibility in approach in this area and it was decided to adopt a largely "top-down" approach, where all known countermeasures were evaluated for relevance and effectiveness in the crashes investigated. This was supplemented by a "bottom-up" approach, where the circumstances of the crash suggest possible countermeasures, where appropriate.

In this section, findings are presented, firstly in relation to contributing factors, and secondly in relation to countermeasures.

6.1 NSW TRUCK CRASHES AND CONTRIBUTING FACTORS

OVERVIEW

The essence of the problem of severe heavy vehicle crashes in NSW, when disaggregated by year or highway, becomes somewhat elusive because the crash numbers are relatively small (i.e. a maximum of 25 fatal crashes on any one highway in any one year, and a maximum of 60 hospital admission crashes on any one highway in any one year). Thus relatively large fluctuations in percentage terms could be expected to occur from year to year.

This study concentrated on the Hume and Pacific Highways, which have each tended to have 8-12% of the State's fatal heavy vehicle crashes. They have had a somewhat lower percentage of the State's hospital admission heavy vehicle crashes (6-12% on the Pacific Highway and 5-9% on the Hume).

Both fatal and hospital admission articulated vehicle crashes showed a downward trend from 1982 to 1987, considered state-wide. In 1988, both types of crash increased, but the fatal crashes increased to an extent outside the expected trend. This increase occurred roughly equally on all highways. The increase was not evenly distributed throughout the year, but was particularly evident in the September quarter of 1988.

Coach crashes resulted in 67 of the 235 heavy vehicle fatalities in 1989. However, the small number of coach crashes prevented an analysis of trends for the years 1982 to 1989. A detailed examination showed that miscoding of long distance coaches as "Other Bus" has underestimated the number of coaches in fatal and hospital admission crashes in earlier studies.

In general, severe (i.e. fatal or hospital admission) truck crashes on the Hume and Pacific occur more in the higher speed zones, away from intersections, and in hours of darkness.

Between 1987 and 1988, two-vehicle crashes involving trucks in higher speed zones increased from 23 to 49. Most crashes occurred on undivided roads, and head-on crashes on undivided roads increased from 26 in 1987 to 48 in 1988.

In the case of multi-vehicle crashes, the truck was responsible in 32% of truck/car crashes and nil crashes between trucks and unprotected road users, and this did not change between 1987 and 1988.

Against this broad picture of the N.S.W. truck crash problem, total freight movements on the Pacific Highway between Sydney and Brisbane are estimated to represent 18% of total Australian interstate freight, while Sydney-Melbourne movements on the Hume Highway are estimated to represent 50% of total Australian interstate freight. ie. the Hume carries over 2.5 times the interstate freight carried on the Pacific. Traffic flows (including both cars and trucks) are approximately 60% higher on the Hume than the Pacific, although the Hume flow varies considerably along its length, while the Pacific tends to be more consistent. Although specific data on traffic composition were not available, it would appear that there is a considerably higher percentage of trucks on the Hume than the Pacific. While traffic flows on both highways increased steadily over the period 1982-1988, freight flows showed considerable fluctuations superimposed on a general upward trend, and Sydney-Brisbane freight increased by 16% from 1987 to 1988, while Sydney-Melbourne freight increased by 10%. It was noticeable that, for the December quarter of 1988, Sydney-Brisbane freight increased by 32% over 1987 levels. Traffic levels increased by 9% on the Pacific and 4% on the Hume between 1987 and 1988.

Truck speeds in N.S.W. are high in relation to most other states and showed strong increases over the years 1983 to 1987. It was not possible to compare speeds on the Hume and Pacific Highways.

When fatal truck accidents were related to traffic and freight levels, it was found that truck fatal crashes per unit traffic flow reduced over the years 1982 to 1987, and increased in 1988 for all N.S.W. highways, and similar trends occurred for truck fatal crashes per unit freight flow. It was noticeable that truck fatal crashes per unit freight flow were approximately 3 times higher on the Pacific than on the Hume.

In the opinion of truck drivers, several trends affecting truck safety were evident during the 'eighties: the speed capability of trucks increased, use of Just-In-Time transport increased, road conditions deteriorated, enforcement practices became counter-productive and less experienced drivers were employed.

CONSOLIDATED ANSWERS TO RESEARCH QUESTIONS

(I) WAS THE 1988 NSW FATAL ARTICULATED TRUCK CRASH PROBLEM SIGNIFICANTLY DIFFERENT FROM OTHER YEARS?

While these truck crashes did not differ significantly with respect to 1982-1984 levels, they did differ significantly from the 1982-87 trend, and were 111% above the predicted value (and were 40% above the 95%ile value) for 1988.

(II) WHY ARE THE PACIFIC AND HUME HIGHWAYS APPARENTLY A PROBLEM?

All major NSW highways showed an increase in truck fatal crashes from 1987 to 1988, and the Hume and Pacific Highways each account for 8-12% of the State's fatal truck crashes. However, the Pacific is the only highway with a clear-cut long-standing problem in terms of truck fatal crashes per unit traffic flow. This problem is even more marked in terms of truck fatal crashes per unit freight flow. Factors contributing to the general Pacific highway problem are considered to be:

. a predominantly undivided road of generally poor standard (including narrow shoulders and the presence of roadside objects)

. the incidence of poor horizontal and vertical road alignment

. a high incidence of night-time crashes

. wet road conditions

. the incidence of car drivers crashing head-on into trucks, often due to inattention, fatigue or poor visibility

. high truck speeds.

In relation to the Hume Highway, the Pacific was found to possess the characteristics of an immature truck route.

(III) WHY WERE TOTAL ARTICULATED TRUCK CRASHES LOWER IN 1988 THAN 1987, WHEN FATAL ARTICULATED TRUCK CRASHES WERE HIGHER IN 1988 THAN 1987?

The ratio of the number of fatal articulated vehicle crashes to the number of hospital admission crashes doubled from 1987 to 1988, indicating an increase in crash severity, and the total of fatal and hospital admission articulated vehicle crashes increased by 15% from 1987 to 1988. The major increase in articulated vehicle fatal crashes occurred in high speed zones, and very often involved two-vehicle crashes (with cars or unprotected road users). There was a large increase in head-on crashes on undivided roads in 1988, and in ran-off-the-road crashes on curves. While it was not possible to compare contributing factors to crashes between 1987 and 1988 (because Strand 1 covered 1988 and 1989), factors believed to be involved with the above classes of crash in 1988 (and which may have changed between 1987 and 1988) include the incidence of night-time crashes, inattention, fatigue, poor visibility and alcohol use on the part of car drivers and unprotected road users, high truck speeds, and truck driver inattention. These are considered to be the most likely factors affecting the increase in articulated vehicle fatal crashes in 1988.

(IV) HOW DOES THE HEAVY VEHICLE CRASH SITUATION IN 1989 COMPARE TO PREVIOUS YEARS?

There were fewer fatal articulated vehicle crashes in 1989 than in 1988 but more than in 1985-1987. There were fewer fatal rigid truck crashes but more fatal long distance coach crashes than in any of the years 1982 to 1988. Heavy vehicles were more involved as key vehicle in fatal crashes in 1989 than in 1987 and 1988.

(V) WHAT WERE THE CONTRIBUTING FACTORS AND CIRCUMSTANCES OF HEAVY VEHICLE FATAL CRASHES OCCURRING IN 1988 AND 1989?

This question was addressed in detail by Strand 1, and is answered for the Hume and Pacific Highways in section 2 of the report.

(VI) WERE HEAVY VEHICLES MORE INVOLVED AS "KEY VEHICLES" IN CRASHES IN 1988 THAN IN 1987 OR 1989?

In multi-vehicle crashes involving trucks, the incidence of the truck being judged responsible for the crash was relatively low in the period 1987-1989, ranging from 28% for rigid trucks in 1987 to 46% for rigid trucks in 1989. If anything, there appeared to be an increase in truck responsibility for crashes between 1988 and 1989. Strand

1 investigations did not show any notable difference in truck driver behavioural factors between 1988 and 1989.

(VII) DID ECONOMIC AND TRAVEL ACTIVITY IN 1988 DIFFER FROM THAT IN 1987? IF SO, HOW?

As detailed in Section 4 of the report, there was a large increase in Sydney-Brisbane and Sydney-Melbourne freight activity in 1988, and a significant increase in traffic flow on both the Hume and Pacific Highways.

In the December quarter of 1988, Sydney-Brisbane freight increased by 32% above 1987 levels.

(VIII) WHAT SPECIFIC COUNTERMEASURES ARE INDICATED BY THE OUTCOMES OF THE STUDY?

Specific countermeasures were evaluated in Strand 1, for their likely effectiveness against fatal crashes on the Pacific and Hume Highways, and these findings are detailed in section 6.2 of this report. While the implications of Strand 2 and 3 for countermeasures development are broad in nature, these aspects of the study would lend particular weight to measures likely to be effective in high speed zones, on undivided roads, in hours of darkness, involving head-on crashes, targetted at other road users as well as truck drivers, involving more effective enforcement and tending to render the Pacific Highway a more mature heavy truck route.

OUTLOOK

While the study does not provide any predictive capability, some insights may be offered into the outlook for truck fatal crashes in NSW.

The crash numbers on specific highways can be expected to fluctuate considerably from year to year and trends, by definition, can only be identified with considerable hindsight.

However, there is some evidence that very significant truck safety problems will persist, and perhaps intensify. The Pacific Highway is experiencing an unacceptably high truck crash rate and major steps are overdue to render the highway an effective road freight environment. Traffic and freight flows on the Pacific are still quite low, but can be expected to increase with intensified economic development in Southern Queensland. Although the New England Highway is ostensibly an alternative route to the Pacific, discussions with drivers indicated that the Pacific is preferred because the terrain is flatter.

On all NSW highways, the realities of long-distance travel for all types of road users will continue, and this will perpetuate the syndrome of the hours-of-darkness crash problem. There is evidence that, despite the downward trend of crashes in the mid-'eighties, road projects have not kept pace with the increased demands of traffic (both recreational and commercial), freight (both in terms of volume and Just-in-Time distortions), faster vehicles better isolated from the road environment, and inexperienced, overworked truck drivers.

There are already some positive elements at work, including the speed limiting of trucks and moves for more realistic enforcement practices (such as Operation Co-operation). However, unless there is a long-term commitment to implementing a much wider range of countermeasures (and the next section of this report describes and evaluates these in detail), the NSW heavy vehicle crash problem may deteriorate.

6.2 SPECIFIC COUNTERMEASURES TO NSW TRUCK CRASHES

These finding are based primarily upon the results of the analysis of the data on individual crashes (Section 2) and the consequent examination of the countermeasures applicable to each crash (Section 5). These were complemented in some cases by the results of the driver interviews (Section 4) and also other sources of information about truck and coach crashes reported in the review of countermeasures (Section 5).

The findings are presented in terms of the effects on the four basic components of the road traffic system, namely the road, the vehicle, the driver, and the environment within which the system operates. For our purposes, the driver component is considered in two parts, the heavy vehicle driver and the car driver, given that in many crashes involving a heavy vehicle, a car driver is involved.

The specific findings refer to the following elements:

Roads

divided roads
road shoulders
delineation
safety audit
overtaking lanes
rest areas
roadwork practices
culverts

Vehicles

speed limiters
heavy vehicle front end stiffness
cab crashworthiness
seat belts in trucks
fatigue detectors
truck brake matching and anti-lock
heavy vehicle mechanical inspection
truck loading

Heavy Vehicle Drivers

licensing, training and driver selection
use of drugs and alcohol
control of driver hours

Car Drivers

driver education
use of drugs and alcohol

Road System Environment

use of rail
increased truck payload limits
heavy vehicle speed limits
management and regulation of the industry (including tachographs)
speed and alcohol enforcement
"Operation Cooperation"

We conclude with a few comments about the methodology used in the study, especially the means of analysis, and the adequacy of the data sources.

ROADS

Divided Roads

There is no question that divided roads are much safer than undivided roads. Over 85 per cent of the crashes examined occurred on undivided roads, while our assessment is that *as many as 73 per cent of the crashes might not have occurred had the road been divided.*

The completion of the duplication of the Hume Highway, and provision of a divided road on the Pacific Highway, would therefore lead to very significant reductions in crashes on those highways.

Road Shoulders

On two-lane roads, the provision and maintenance of a good road shoulder is an important safety practice. Our analysis indicated that *27 per cent of crashes may not have occurred had the shoulder been wider or in better condition*.

The provision of wide (at least 1.8 m) shoulders over the full length of the highways could lead to a significant reduction in crashes, as a result firstly of reducing the incidence of drivers losing control if the vehicle's left wheels leave the sealed lane, and secondly by providing space to avoid a collision (e.g. rear end, some head-on). It might also be noted that sealed shoulders provide other benefits in terms of reduced shoulder maintenance costs, and reduced pavement damage.

Delineation

Based upon our field investigations, discussion with RTA engineers at the sites of crashes, and evaluation of crash countermeasures at specific crash sites, we conclude that the quality and consistency of delineation on the Hume and Pacific Highways leave much to be desired. We estimate that *as many as 30 per cent of the crashes investigated might have been prevented by better delineation*.

Since most of the information required by a driver for control, guidance and navigation is visual, good delineation of the road immediately ahead (up to 8 seconds) is vital. This is particularly so at night, when the ambient lighting is much less. On roads with high night-time truck volumes, such as the two highways under examination, the need is even greater, since there is a higher number of on-coming headlights, and the vehicles behind those headlights are wider and therefore closer to the opposing traffic.

The provision along the full length of both highways of high quality delineation, to a uniform standard, is likely to be a very cost effective safety measure. This would include edge and centre line marking; raised reflective pavement markers on lane lines, centre lines and edge lines; highly reflective post-mounted delineators; bridge width markers; chevron markers at curves, etc.

Raised reflective pavement markers on centre lines and edge lines also create a "rumble strip" which can be helpful in alerting a driver (especially a fatigued driver) to the fact that his or her vehicle is straying from the traffic lane. In this context, we note that the cost of a ridged thermoplastic edge line and centre line is only some $1600 per kilometre.

Needless to say, all of this delineation should be in accord with current standards. We note however that there are significant differences of practice between different parts of the State, reportedly a result of delegation of responsibility to RTA divisions. We suggest that there should be uniform statewide (and preferably nationwide) guidelines on the use and installation of delineation devices. (In particular, we note that the use of bridge and culvert width markers appears to be much less prevalent in NSW than in other states.)

Safety Audit

There are a number of traffic engineering measures and practices which, if more widely adopted, could be significant in reducing the number or severity of crashes on both highways. Our analysis suggested that *traffic engineering treatments at known black spots could have been effective in as many as 33 per cent of crashes; rumble strips could have been helpful in 22 per cent of crashes; while improvements to road features such as intersections, medians, street lighting, traffic signals, etc could have affected 16 per cent of crashes.*

A comprehensive safety audit, carried out along the full length of both highways would identify many opportunities for safety-oriented traffic engineering improvement, and assist in developing priorities for treatment. Many of these are likely to be quite low-cost (less than say $50,000 each). Examples include: sight distance at intersections; provision of turning lanes; protection of culverts; improved skid resistance pavements; bridge widening; replacement of rough pavements; provision of wider lanes; upgrading of warning signs; re-examination of the appropriateness of posted speed limits; redesign of intersections; provision of guard fencing at appropriate locations, provision of improved pedestrian and bicycle facilities; improved street lighting; provision or upgrading of traffic signal installations, etc.

As noted above in the discussion on delineation, it is important that any works resulting from an audit of this sort be carried out in accord with statewide guidelines, and be implemented on a consistent basis.

A safety audit is especially cogent at the present time, given the Federal Government's promise to make additional funds available for black spot treatment.

Overtaking Lanes

Some 6 per cent of the total fatal crashes involved overtaking, while a further 7 per cent involved two vehicles in close proximity. Overtaking lanes have been shown in research elsewhere to be highly effective in improving road user level of service (by allowing bunches to break up), and that they have safety benefits, especially where there are high truck flows.

The RTA has installed many overtaking lanes on both highways in recent years, and this is to be applauded. There are many other instances where an overtaking lane could be useful, and we suggest that the program of installing such lanes continue. As with other road and traffic programs, we suggest that the selection of sites for overtaking lanes be prioritised on a rational statewide basis, and that the design features (especially at the start and the end of the overtaking section) be consistent on a statewide (and preferably nationwide) basis.

Rest Areas

Although our analysis did not identify many crashes where the provision of a rest area might have been helpful, this does not mean that they are unimportant; rather, the particular means of analysis could not relate a specific crash to what might have happened had a rest area been present and a driver used it.

However, there is ample evidence that fatigue is an important factor in the crashes examined; 14 per cent of crashes may have involved a truck driver falling asleep, and a further 11 per cent involved a car driver falling asleep. Up to 60% of crashes could involve some element of fatigue. Therefore, an important part of an overall safety program is to attempt to counter this, and the provision of frequent, well-signed, well-maintained rest areas is likely to be a key part of such a program.

Our truck driver interviews indicated that drivers considered that there were too few roadside facilities, including both rest areas and commercial truck stops where they could stop for refreshments and a rest. This was one of the reasons given for exceeding driving hours - that stops were too far apart. In passing, we also note that in some of the rest areas which currently exist, the entry arrangements are not particularly satisfactory, with (for example) entrances provided where sight distance is poor; this aspect should be picked up in an overall safety audit.

Roadwork Practices

In up to 5% of crashes it is likely that improved road work practices (e.g. advance warning, improved traffic control, better delineation of the traffic lane through the roadwork site, etc) may have contributed to eliminating the crash or reducing its consequences.

A re-examination of current practice, and (probably more importantly) a training and education program aimed at increasing the safety awareness among those responsible for the various aspects of road works and associated traffic control would likely be quite useful. In our discussions with RTA engineers on site, this aspect was often raised as a matter of concern. It was also noted that this is a matter not only of road safety, but of occupational health and safety as it affects the maintenance or construction workforce.

Culverts

Although culverts were directly associated with only a few fatal crashes in our sample (improved culverts may have helped eliminate 5 per cent of the crashes) we strongly suspect that their indirect influence may have been greater than that. In our field inspections, we noticed a great many culverts with their end walls very close (in many cases within a metre or so) of the road pavement, and further that many of these were unprotected (e.g. with guard fencing) or unmarked with width markers or similar delineation devices. Putting these observations together with the comments made in the interviews with truck drivers to the effect that they will not deliberately drive off the pavement to avoid a crash for fear that they will collide with an unseen roadside object such as a culvert, makes us believe that the presence of unmarked culverts has produced a situation where truck drivers will not undertake avoiding action.

We therefore suggest that all culverts close to the edge of the road pavement should be clearly marked with width markers, and that particular attention is paid to culverts in the comprehensive safety audit recommended above.

VEHICLES

Speed Limiters

Our analysis suggested that 28 per cent of crashes involved excess truck speed, and 11 per cent involved excess car speed. *As many as 22 per cent of crashes were considered likely to have been prevented, or their severity reduced, had the heavy vehicle been fitted with a speed limiter.*

It is important to note that speed limiters will not be relevant to all crashes where excess speed is a factor, since some of these are at locations where the vehicle may be travelling at speeds less than that for which the speed limiter is set. This includes both travel in urban areas, and travel at rural sites where the road standard is such that a speed may be excessive for the conditions even though less than (say) 100 km/h. In our examination of fatal crash sites, a number occurred at locations with an advisory speed sign, i.e. where the advisory speed was less than 100 km/h.

Although speeds of vehicles actually involved in crashes are not known, we feel confident that speeds of 120 km/h or more are excessive, and need to be controlled. Our assessment is that a form of mechanical device, such as the speed limiter, is necessary and appropriate. Speed limiters are virtually tamper-proof, and our expectation is that the widespread adoption of speed limiters would lead to more realistic delivery schedules and less inclination by drivers to delay their departure times, since travel time could not be made up simply by driving faster. Importantly, the fitting of speed limiters has substantial industry support.

Further, we suggest that the speed to which the speed limiter is set should be at least 5 km/h in excess of the speed limit. This is to allow efficient operation of the engine at the posted speed limit, and to prevent a vehicle "running out of legs" on an overtaking manoeuvre, which is potentially unsafe. This suggestion does not contradict the purpose of the speed limiter, as it would still eliminate speeds way in excess of the speed limit. (See also Section 5.3 on speed limits and management and regulation of the industry.)

<u>Heavy Vehicle Front End Stiffness</u>

As mentioned above, 48 per cent of crashes were head on, and in many of these, a redesigned front end of the heavy vehicle, involving either a more energy absorbing front end or a device to deflect an on-coming vehicle, may have reduced the severity of the crash.

Such a countermeasure is clearly a long-term one, and should be preceded by extensive research into heavy vehicle front end design and the consequences of having a more energy absorbing structure or nose cone. We note that prototype energy-absorbing truck bumpers exist in Britain and that research is under way in France on the stiffness characteristics of the front of the truck. Therefore, given that most trucks on use in Australia are of overseas design, it would seem sensible to await the results of that research. However, some research work could be undertaken locally, especially in relation to bumper bars, and the regulation of the design and fitting of bull-bars.

<u>Cab Crashworthiness</u>

Our analysis suggested that improved cab crashworthiness may have contributed to a less severe (i.e. non-fatal) outcome in 24 per cent of crashes.

As with the previous point, this question needs to be tackled at an international level, but Australia should maintain a watch on international developments so as to be able to move (e.g. with Australian Design Rules) when the time is opportune.

Seat Belts in Trucks

Our analysis suggested that *as many as 23 per cent of crashes, a truck occupant may have been saved had he or she been wearing a seat belt*. Seat belts are a proven safety device, but are rarely worn by truck drivers. The reasons mainly have to do with the difficulty of wearing them with suspension seats, and the (mistaken) belief that it is better to be able to "jump clear" of the driver's seat in the event of an impending collision.

We note that there is an ADR in preparation for truck seat belts, which will address the concerns about the difficulty of wearing belts with suspension seats. This will likely be followed by regulations to make seat belt wearing compulsory in trucks. We suggest that when this happens, it is accompanied by an extensive education campaign aimed at convincing truck drivers of the benefits of seat belts.

Fatigue Detectors

Fatigue is an acknowledged problem for both car and truck drivers; our analysis found that some 14 per cent of crashes may have involved a truck driver falling asleep, with a further 11 per cent involving a car driver falling asleep. Based upon this, the fitting of some sort of on-board device aimed at detecting the incidence of fatigue, and initiating a response to wake the driver and/or alert the driver to the onset of fatigue could be very useful.

Such devices exist in the experimental stage, and we suggest that their development be monitored, with a view to assessing when and if their fitting in vehicles should be made compulsory. This device is potentially of value to all road vehicles, but perhaps has special relevance to trucks given the longer distances travelled and the higher use of trucks at night time.

Truck Brake Matching and Anti-lock

Although our analysis revealed heavy vehicle braking problems (e.g. skidding, jackknifing, etc) as a directly contributing factor in only 4 per cent of crashes, we assessed that improved heavy vehicle brakes could have prevented the crash or reduced its severity in 13 per cent of crashes.

This suggests that continuing with efforts to improve the compatibility of prime mover and trailer brakes through the ADR system is appropriate, together with the wider use of anti-lock technology.

In addition to these technological countermeasures, education and enforcement programs directed at preventing the backing-off of front brakes is advocated. Also, there is a need to improve drivers' perception of the braking performance of their vehicles so that they are able to fully use the vehicle's braking capabilities without unrealistic fears of vehicle instability.

Heavy Vehicle Mechanical Inspection

Our investigations did not reveal many instances of truck defects or badly maintained trucks. However, this may be due to the lack of information on this aspect from the data sources available for this study. Our work in this area is clearly not definitive, but we note that there is evidence from other sources suggesting that there is room for improvement in the mechanical condition of trucks using the roads.

For this reason, we support the more widespread use of random inspections, using devices such as the Truckalyser developed by the RTA NSW. To be effective however, such a program must be reasonably widespread, with several units in operation.

Truck Loading

Our analysis revealed 5 per cent of crashes as being related to truck load insecurity. However, we suspect that this may understate the incidence of this factor, as there is no data on loading or instability in many cases. Similarly, we have no data at all on truck laden mass, and therefore cannot comment on the effect of greater control of maximum loads on safety.

However, two comments are made, both of which arise from discussions with police and industry personnel contacted in the course of the study.

The first has to do with safety and load stability in carrying empty bottles. There is much anecdotal evidence that these can cause difficulties in transit. The problem is purported to arise from the shrink wrapping and associated temperature changes; the bottles expand and contract with temperature changes, causing the shrink wrapping to loosen, this then allows movement of individual bottles, some of which break, allowing greater movement and more breakages. This can lead to a situation where the whole load can suddenly and unexpectedly shift.

We therefore suggest that the question of load security in the transport of empty bottles be examined in detail, with a view to developing improved practice and perhaps stronger regulations concerning the transport of this commodity.

The second comment in relation to loading is the absence of a truck Checking Station for northbound trucks from Sydney. With the construction of the new freeway as far south as Hornsby, the Checking Station at Berowra is now by-passed, so a truck can travel from Sydney to the

Queensland border along the Pacific Highway without a check. While the effectiveness of checking stations in controlling overweight vehicles is less than total, it is suggested that consideration be given to placing a Checking Station or stations somewhere north of Sydney on the Pacific Highway.

HEAVY VEHICLE DRIVERS

Licensing, Training and Driver Selection

Issues related to the skill level of drivers, and how they may obtain and retain those skills are of obvious significance in road safety. This is especially so with the drivers of heavy commercial vehicles, because the skill requirement is greater, and drivers are on the road for longer.

Our analysis suggested that at least 25 per cent of crashes might have been avoided, or their severity reduced, if heavy vehicle drivers had displayed a higher skill level. This suggests that attention to be given to various aspects of driver training, retraining, licensing and selection. Associated with skills training could be aspects of attitude training, such as defensive driving techniques, stress management, attitudes towards such factors as seat belts and fatigue, etc.

Various proposals have been put forward over the years about driver training and related matters; it is beyond the scope of this study to comment upon what needs to be done in detail. Suffice it to say that our analysis suggests the need for action. We would also note that there is no heavy vehicle advanced driver training facility in NSW, comparable with the DECA facility in Shepparton, Victoria, or the Mt Cotton facility in Queensland. Our driver interviews showed substantial support for courses at such facilities, even for experienced drivers.

Use of Drugs and Alcohol

Our analysis indicated that alcohol use by drivers of heavy vehicles was a factor in 13 per cent of crashes. Perhaps more importantly, alcohol use by car drivers, pedestrians and cyclists is also an issue in crashes involving trucks, with 14 per cent of crashes having this as a factor. Programs, such as "booze buses", education, and general enforcement aimed at this problem are clearly relevant therefore to truck crashes.

Our analysis was not able to get very far with an assessment of the incidence of drug usage (stimulants) among heavy vehicle drivers. Unlike alcohol, no tests are performed either at the crash site or among hospitalised or deceased crash victims. Therefore, there is very little hard evidence about the extent of drug use or its effects.

We suggest that more information is needed about this aspect. Perhaps a pilot program of blood testing of persons involved in crashes involving a heavy vehicle may be a good starting point, if that was feasible. In any case, there is a need for better information to guide policy and enforcement in the area of drug use by heavy vehicle drivers.

Control of Driver Hours

As with the previous factor, the information obtained in the course of this study was not able to provide much insight into this aspect. However, as discussed in Section 2.4, heavy vehicle driver fatigue is clearly an important issue, featuring in at least 14 per cent of crashes, and control of hours of driving is clearly relevant to that.

Anecdotal evidence is that log books are a quite inadequate means of controlling driver hours. (This is indirectly supported by our study; in several cases where there ought to have log books to provide information about drivers, they either did not exist, or had not been filled in.) The wider use of tachographs is only a partial answer here, as it neither prevents excessive hours, nor necessarily provides accurate information about the driving hours of a particular individual. We therefore suggest that research be conducted in an attempt to find an improved method of controlling driver hours, perhaps through some form of electronic tachograph, electronic interlock on the truck, operator licensing, or in some other way.

Ideally, driver hour regulations should recognise that there are factors other than just the period of time at the wheel of a heavy vehicle that are important. Our driver interviews indicated that there is a need for flexibility in recognition that there were variations between drivers, and that regulations should take account of road conditions, hours spent on duty not driving, time spent driving a motor car, etc. Drivers also pointed out that there were individual body responses (for example, a driver coming back after a few days break may feel tired after just a few hours night driving, whereas later, after he had adjusted to the new work pattern, he could drive for longer without feeling tired. Including these factors in a regulatory framework is a challenge, but we suggest that it should be attempted; there is more to the driving hours question than simply the number of hours behind the wheel.

CAR DRIVERS

Our analysis indicated that 45 per cent of multi-vehicle truck crashes involved a car as the responsible agent in collision with a truck, and that in as much as 60 per cent of crashes, a road user other than the heavy vehicle driver made a mistake or error of judgement of some sort (including car drivers, pedestrians and cyclists).

This suggests that improved car driver education or training may be helpful. The principal areas of concern in the case of the crashes considered here include fatigue, inattention, and inappropriate speed.

These are general skills, not specifically related to trucks. In addition, there is some evidence from our driver interviews that car drivers sometimes behave inappropriately in the vicinity of trucks (and sometimes provoke truck drivers). Examples are cutting in ahead of a braking truck, reducing the truck's braking space; reducing speed on upgrades; careless overtaking (the more so since truck speed limits have been reduced) and driving very slowly for the conditions. (In this last respect, it is interesting to note that our analysis showed that 20 per cent of crashes were associated with a slowly moving or stationary car.)

Consideration of car driver education and training is beyond the scope of this report, but it is relevant to point out that this study has revealed particular aspects of car driver behaviour which may be amenable to attack through education programs.

Use of Drugs and Alcohol

As noted in Section 3.2, alcohol use by car and heavy vehicle drivers, pedestrians and cyclists is an issue in crashes involving trucks, with 27 per cent of crashes having this as a factor. Programs, such as "booze buses", education, and general enforcement aimed at this problem are clearly relevant therefore to truck crashes.

No evidence was forthcoming in the present study regarding drug use by car drivers, and further information is relevant here also.

ROAD SYSTEM ENVIRONMENT

Use of Rail

In general, there is not a great deal of overlap between rail markets and road markets, with each mode tending to dominate where it operates best. However, in the two particular corridors under examination here, there is a degree of overlap, and rail is a potential competitor with road for much of the longer distance (especially inter-capital) freight market. Our analysis suggested that as many as 51 per cent of the crashes involved trucks which appeared to be potentially competitive with rail. However, perhaps a more meaningful interpretation of this is that 49 per cent of crashes did not involve trucks which were competitive with rail.

Factors affecting mode choice are many and varied, and it certainly could not be argued that all inter-capital or long distance freight could or should move by rail. Similarly, it would be inappropriate to artificially intervene in this market with regulations aimed at encouraging rail use in the interests of road safety. In any case such intervention may be invalid for interstate movements under Section 92 of the Australian Constitution. Moreover, rail use for freight, while safer on a tonne km basis than road freight, is not without its own safety implications.

NSW Government policy is that freight mode use should be left to the market, with the proviso that each mode carries its full costs, so that shippers are presented with the correct price signals. The whole question of road and rail cost recovery is under current investigation within the NSW Ministry of Transport and the Australian Transport Advisory Council, and there have been recent reports by the InterState Commission (on road cost recovery) and the Rail Industry Council (on the future of the national rail system) on this issue. This whole question of cost recovery and rail use is therefore a cogent one, and it is not the task of this study to examine these issues. We would say, however, that cost allocation for all competing modes should include accident costs, with actual mode use being left to the market to determine. Such a policy may tend to produce an increased use of rail for long distance and inter-capital freight.

Increased Truck Payload Limits

Increased truck payload limits have two safety benefits. Firstly, they enable the road freight task to be accommodated on fewer vehicles, thus reducing the exposure of trucks and other road users to potential crashes or conflicts, all else being equal (i.e. assuming no mode shift or generation of extra freight demand). Second, to the extent that increased payload is achieved by the wider use of B-doubles, which are an inherently more stable vehicle than a conventional articulated truck, road safety is improved.

Our analysis suggests that this factor was relevant to up to 51 per cent of crashes, although again the converse is probably as important, namely that this factor is not relevant in 49 per cent (or more) of crashes. This certainly does not mean that 51 per cent of heavy vehicle crashes would have been prevented had B-doubles and other high-productivity vehicles been in use, but that this proportion of the traffic is potentially affected, and therefore that some of this traffic could be accommodated on fewer vehicles.

There is evidence that there are safety benefits to be gained from permitting the wider use of more productive vehicles, especially the B-double. B-double use is now permitted throughout much of New South Wales, but not on the Pacific Highway; this policy could well be re-assessed in the light of experience with the use of B-doubles elsewhere in the State. In the case of the Hume Highway, the use of B-doubles is constrained by the policy of the Victorian Government, which does not allow their use on the highway in Victoria. New South Wales could bring pressure to bear on Victoria to allow this vehicle to operate in Victoria, especially on the Hume Highway (which is generally of a good geometric standard). This pressure might, for example, include encouraging the Federal Government to permit B-doubles to use all roads on the National Highway system. Also, the recent ISC report on vehicle registration charges advocates a designated routes system for larger vehicles.

Heavy Vehicle Speed Limits

Our analysis has shown that 28 per cent of crashes were associated with excess speed by a heavy vehicle, evenly divided between night and day. In many cases this would be speed in excess of a posted speed limit.

Truck speed limits were increased in NSW in 1988, and reduced again (except in special circumstances on divided roads) in 1989. The latter reaction was largely in response to the increased incidence of truck crashes in NSW in 1988 and 1989.

Although there is evidence that measured truck speeds increased slightly following the relaxation of the speed limit in 1988 (see Section 4) our analysis was unable to establish any link between the increase in speed limits and the increase in crashes. However, our driver interviews have produced anecdotal evidence that the reintroduction of the general 90 km/h speed limit for trucks has led to problems, such as:

- more frequent overtaking of trucks by cars,
- increased incidence of bunching, and longer bunches,
- drivers taking more risks in overtaking,

- cars being "sandwiched" between trucks, especially between a truck without speed limiters in front and a truck with speed limiters behind (where the latter can travel at 100 km/h).

These problems are not unexpected, and are in fact a reversion to the conditions that applied pre-1988, which were the reasons why the speed limit was lifted at that time, i.e. the argument (supported by overseas evidence) that safer conditions prevailed if there was a common speed limit for all vehicles.

Our study has not been able to produce any substantial evidence to show that the increase in speed limits in 1988 produced the increase in truck crashes in NSW in 1988-89. However, the coincidence of these events is clear.

On the other hand, there is no evidence that other States (which also increased their truck speed limits in 1988) have had a significant problem with truck crashes since; indeed FORS statistics indicate that the aggregate change in other states was an 4 per cent reduction in articulated truck crashes in 1988 compared with 1987. In addition, we have anecdotal evidence that the reintroduction of the lower truck speed limit in NSW has led to a repeat of the undesirable and potentially unsafe driving practices that applied pre-1988, and we still have the overseas evidence that crashes are more associated with the dispersion of vehicle speeds rather than speed itself.

In the absence of compelling evidence to the contrary, we are inclined to conclude that the arguments that led to the removal of the speed limit differential in 1988 are still valid, and that the speed limit differential between cars and trucks should again be removed. However, we do believe that strong action is needed to reduce excessive truck speed.

A major data deficiency is the absence of information about the actual speeds of vehicles involved in crashes. One of the advantages of the wider use of tachographs is that it would shed some light on this area. However, we feel confident in saying that speeds of the order of 120 km/h are excessive, and must be controlled. Many of the fatal crashes investigated involved sub-standard sections of road where the section was signed with an advisory speed of 60-80 km/h; these roads are quite incompatible with truck (or car) speeds much in excess of 100 km/h, because the vehicles have to reduce speed to an unacceptable extent on these deficient sections. Even on those sections of the highway where the road geometry is of a higher standard, we would believe that truck speeds in excess of 120 km/h are inappropriate.

Management and Regulation of the Industry (including Tachographs)

This countermeasure aims to change the way in which the road freight task is carried out, by shifting the responsibility and accountability for safe practice from solely residing with the driver to other participants, such as owners, forwarders, shippers, etc. Although our study could not determine the effects of these changes, since they would be essentially hypothetical, we nevertheless surmised that *as many as 28 per cent of the crashes may have been influenced had the management of the industry been accountable*. Again, the converse of this is probably as significant, namely that 72 per cent of crashes would not have been affected by management and regulation.

This aspect has strong support from elements within the road freight industry, especially in the form of industry self-regulation with the aim of eliminating unsafe practices. However, this is not the only path to reform, and the proposal advanced by the 1984 National Road Freight Industry Inquiry, among others, for a form of Operators Licensing is also considered to have considerable merit. Under this proposal, all participants in the industry would be required to have an Operators Licence, which would be available initially as of right, but its renewal would be denied if there was evidence of extensive contravention of safety, loading and amenity regulations. A form of Operators Licensing has been in use in Britain since the 1970s, and is generally regarded as being successful in achieving these objectives.

Given the consensus for the need for reforms, the evidence from elsewhere that a form of Operators Licensing can be an effective safety measure, and our conclusion that a significant number of crashes were potentially amenable to treatment through changes associated with management and regulation of the industry, we conclude that the measure has considerable potential, and should be strongly advocated. However, just what form such reform might take is a matter beyond the scope of this study.

Nevertheless, to be effective, it should address such aspects as excess speed, use of drugs, driver hours, mechanical condition, truck loading and overloading, driver training and licensing, delivery schedules, carriage of dangerous goods, etc. In Britain, it is extended to cover environmental conditions such as noise of trucks, emissions, noise at depots, etc. In view of the range and importance of these factors, and the need to have an effective set of sanctions against those transgressing the regulations or "code of conduct", we are inclined to the view that a significant public sector regulatory structure would be needed, and that reliance on industry self-regulation is unlikely to be sufficient.

Tachographs may be an important concomitant of efficient and effective management and control of the industry. Tachograph records can provide information to management about what has happened to the truck on the road, in particular in relation to vehicle speed, rest breaks, etc. However, we have reservations however about making current generation tachographs compulsory, and more especially about the use of tachograph records for enforcement purposes. Such tachographs are not tamper-proof; reading and interpreting tachographs requires a degree of skill which it would be unreasonable to expect all police officers to possess. It is difficult, if not impossible, to use a tachograph record to determine precisely the location of a truck in relation to a specific speed zone; and they do not indicate unambiguously who was driving the truck at any particular time. Thus, in their present form, they are, in our view, of limited value as an enforcement device. However, improved technology could overcome most of these limitations. For example, devices which detect the speed zone that the vehicle is in have been developed.

It is also relevant to note that tachographs, as they become more widespread, will provide useful information about the actual speeds of vehicles involved in crashes, and this is probably the only way that such information will be obtained.

Speed and Alcohol Enforcement

Previous discussion has mentioned the role of both speed and alcohol. Police enforcement is and should continue to focus upon these aspects.

We note that in both cases, there are technological developments which have the potential to make enforcement more effective. Speed cameras, which eliminate the need for a visible police presence offer considerable potential as a safety device, especially if their use is concentrated upon black spot locations or road sections.

Ignition interlock devices, which prevent an alcohol-impaired driver from starting a vehicle, represent another technological possibility. Although not yet in common use, these devices exist, and offer potential as a safety tool.

Our analysis suggested that *electronic enforcement devices such as these had the potential to affect as many as 29 per cent of crashes*. As such, they could well be quite cost-effective, and are worthy of consideration by enforcement agencies.

<u>"Operation Cooperation"</u>

As noted in Appendix D, Operation Cooperation was an experimental enforcement campaign mounted in the Port Macquarie Police District in 1989. It appeared to be effective in reducing truck crashes, and certainly led to police and the industry working together to achieve common aims regarding the removal of irresponsible drivers and industry self-regulation generally. In our assessment, *enforcement using the principles involved in Operation Cooperation could have affected 13 per cent of the crashes.*

This form of enforcement has particular appeal because of the realisation in virtually every area of human endeavour aimed at behaviour modification that positive reinforcement of desirable behaviour is far more effective than negative punishment of undesirable behaviour.

In view of evidence of its effectiveness, the positive response of industry, and the clear evidence from behavioral sciences about the efficacy of these methods of behaviour modification, we strongly endorse "Operation Cooperation", and believe that a form of enforcement of this sort should be a key part of future enforcement practices directed at heavy vehicles. We suggest that the practices developed in Operation Cooperation be documented, and that these practices be refined and introduced generally.

METHODOLOGY

<u>Crash Analysis</u>

The methodology used in this study has been very valuable in providing insights into the factors associated with truck crashes, and the potential of a wide range of countermeasures. However, *the method has been of more value in relation to factors present in the immediate circumstances of the crash than to more remote factors.*

Specifically, factors present at the crash itself, such as road and traffic factors, weather, light conditions, etc are well assessed, as are such immediate factors as vehicle defects, driver actions or manoeuvres, presence of alcohol, hours of driving, vehicle stability, braking, etc, provided they are recorded in the data bank.

However, factors which are remote from the site and circumstance of the crash itself are less well covered. In particular, such factors as driver training, management and regulation of the industry, the effect of enforcement, use of alternative modes, are not directly addressed in this form of study because of the non-availability of information, or the non-relevance of the issue to each particular crash.

This is not to say that these sorts of factors cannot be, or have not been, included, but rather that they cannot be included directly. Thus while it may be possible, for example, to say that alcohol was present in a particular crash, it is not possible to say that, for example, operators licensing would have changed the circumstances of the crash. What we have done therefore is to examine the circumstances of each crash and identify whether factors which might have been affected by (say) operators licensing are present, and if so, then to say that operators licensing is relevant to that crash.

With this proviso that we can be much more certain about factors present in the crash itself than about factors not directly affecting the circumstances of the crash, we conclude that the approach used was valuable, and that we have confidence in the results.

Data Sources

Any post-facto evaluation of crashes is critically dependent upon the data sources available. Primary sources are of course the police reports, including the accident report itself (the P4 form) and the police telex. There are three aspects of this which give us cause for concern.

The first is that in many cases, *there is very little information about factors other than those related to the driver*. Many telexes for example will have a comment like "deceased at fault, no further action". This concentration on the human factor to the virtual exclusion of other factors makes analysis difficult. We understand that police training and perception is concerned with determining whether a law has been broken, and if so, to prosecute the transgressor. However, it is generally acknowledged that in many crashes there are a multitude of factors, and the crash occurs because of the simultaneous occurrence or presence of a range of driver, road, traffic and environmental factors. While acknowledging of course that the driver's role in the road traffic system is to control his or her vehicle in accord with the conditions prevailing, the fact remains that non-driver factors are often critical in determining the circumstances which lead to the crash. Consequently, alteration of these circumstances may prevent future crashes.

Concentration on driver or human factors means that very often we know little about non-driver factors. It is difficult therefore for the investigator to assess their contribution from the original police sources, and since these are in most cases the only sources available, this constrains the subsequent investigation. Even where there is subsequent police follow-up, e.g. by the Accident Investigation Squad, this focuses upon the establishment of a case for the prosecution of an accused person, rather than a thorough investigation of the crash circumstances. For example, vehicle defects may be investigated in some depth if that will aid a prosecution; if it will not, then vehicle factors are unlikely to be considered unless they are glaringly obvious. And, as mentioned, if there is no prosecution (especially if the person considered responsible is killed) there is no subsequent investigation in most cases.

In making these comments, we do not wish to be seen to be critical of the police, who have a difficult job to do and on our observation generally do it very well. Our comment is rather that their job is law enforcement, and that their duties and actions revolve around that; their job is not explicitly crash investigation in the wider sense. It is hardly surprising therefore that the data needs in the one area do not coincide with the needs in the other.

We suggest therefore that *there is a need for supplementary data sources to enable the more detailed analysis of heavy vehicle crashes*. The Road Safety Bureau has commenced a pilot program along these lines with its so-called "Level 2 Report", which is a form completed by the police, and including a wider range of information related to the driver, the vehicle, and the road and traffic circumstances. *The RSB Level 2 Report, if allied with data held by the RTA on such aspects as vehicle ownership, driving record, etc, is potentially very valuable, and we encourage its development*. In order to obtain more information about the driver and other road users, a follow-up data collection form would be needed, or there may need to be interviews of participants by a special study team.

Our second concern with data is the *time which elapses between the occurrence of the crash and the availability of the crash data;* at least 6 months seems to be the norm at the present time. This not only makes analysis difficult, but also introduces a large delay before ameliorative measures might be introduced.

Finally, an important omission from the data set is any information *about the speeds of vehicles involved in crashes, or presence of drugs* (other than alcohol). Tachographs may help with the former. With the latter, unless the appropriate tests are performed on crash victims and presented at a coronial enquiry, no information on this important parameter is available. We suggest that this deficiency needs to be addressed.

OVERVIEW OF COUNTERMEASURES

Countermeasures may affect either the *exposure* to crashes, the *risk* of experiencing a crash, or the *consequences* of being involved in a crash (Nilsson, 1990). In some cases, countermeasures may affect more than one of these components of road hazard. In considering the relative importance of the large number of countermeasures indentified in this study, and in considering areas where countermeasures may be lacking, it is useful to classify countermeasures on two axes: (i) whether they affect exposure, risk or consequence component of road hazard and (ii) whether they address the driver, vehicle, road or road system environment element of the road traffic system. Table 6.1 shows the potential contribution of the study's 59 countermeasures with respect to the above classifications (some of the countermeasures appear in several cells of this table).

TABLE 6.1 CLASSIFICATION OF COUNTERMEASURES

COMPONENT OF HAZARD	ROAD TRAFFIC SYSTEM ELEMENT ADDRESSED					
	Truck Driver	Car Driver	Truck	Car	Road	Road System Env.
Exposure					1	4
Risk	11	4	7	2	18	6
Consequence	2	1	9	1	4	3

This shows that the countermeasures tend to concentrate on the risk component of truck-related road hazard, with lesser attention to consequences, and little attention to exposure. Also, the road and truck elements are emphasized more than the remaining elements in the road traffic system. In particular, the countermeasures concentrate on road and truck driver measures to reduce risk. While it is natural that truck driver, truck and road countermeasures would receive high priority in a study such as this, Table 6.1 shows that car and car driver measures to reduce risk, and car, car driver and truck driver measures to reduce consequences are lacking and future research should seek further countermeasures in these areas.

Based on the countermeasures frequency listing developed in this section of the report, plus the foregoing classification of countermeasures, it is recommended that the following countermeasures be promoted in the interests of most effectively reducing the overall road hazard associated with truck crashes:

(i) *to reduce exposure*: -

divided roads
rail use
higher payload limits
crash research

(ii) *to reduce risk*: -

road user education and training
road black spot treatment programs
road delineation
electronic enforcement of speed and alcohol
operator licensing and demerit scheme
road shoulders
truck driver licensing
enforcement at black spots
truck driver defensive driver training
speed limiters
rumble strips
fatigue detectors for car drivers
truck driver attitude training
traffic management and engineering
truck brakes
Operation Co-operation
fatigue detectors for truck drivers
truck driver education about fatigue
lower truck COG (rollover)
car driver speed perception
truck driver selection
education of road engineers
sight distance
truck driver hours (drugs)
roadwork practices
truck conspicuity
truck mechanical inspection
car driver distance perception
car driver overtaking

(iii) *to reduce crash consequences*:

truck front end design
electronic enforcement of truck speed
road shoulders
truck cab crashworthiness
truck seat belt wearing
enforcement of speed at black spots
truck speed limiters
car crashworthiness
crash research

remove bullbars
lower truck bumper
proximity detector braking
guard fencing
truck load security
culverts
truck front and rear under-run

The most significant countermeasures, in terms of their specific likelihood of success plus potential for reducing overall truck road hazard plus contribution to a balanced countermeasure strategy are considered to be:

divided roads

truck front end design
truck speed limiters
road black spot treatment programs
electronic enforcement of speed and alcohol
road shoulders

enforcement at black spots
road delineation
truck cab crashworthiness
truck seat belt wearing
fatigue detectors for car and truck drivers

car crashworthiness
removal of bullbars and lower truck front bumpers, plus rear under-run protection
truck load security
culvert protection
road user education and training (including speed and distance perception)
operator and driver licensing and demerit scheme
truck driver defensive driving training

Provision of divided roads is an order of magnitude more significant than the remaining 17 countermeasures on the above short list.

In this study, the relevance of each of a list of countermeasures has been assessed for each particular crash and the totals were compiled. In order to fully prioritize these countermeasures for implementation purposes it will be necessary to estimate the likely effectiveness (in terms of crashes, deaths and injuries likely to be saved over the life of the countermeasure), to discount future benefits to present day values, and to consider the total benefits in relation to total costs.

This was not part of this study's brief, but may show that some of the less frequently relevant but lower cost countermeasures in this study have a high cost/benefit ratio. There is also the question of the feasibility of the various countermeasures listed and the accuracy with which their benefits and costs can be estimated. Some of the countermeasures are new and need further development: others are known and proven and may be applied immediately.

7. CONCLUSIONS

(i) NSW highways provide a significant part of the nation's interstate road freight routes. The Hume and Pacific Highways are estimated to perform 50% and 18% respectively of the nation's total interstate road freight task.

(ii) Traffic flow on the Hume Highway is some 60% higher than the Pacific and is believed to involve a higher percentage of trucks on the Hume Highway. Traffic flow is considerably more variable along the Hume than along the Pacific.

(iii) Both traffic and freight flows on NSW highways have grown significantly during the 'eighties, with freight flows showing considerable fluctuations superimposed on the upward trend.

(iv) The Hume and Pacific Highways are each the scene of 8-12% of the State's fatal truck crashes, and a somewhat lower percentage of the State's hospital admission truck crashes.

(v) The rate of fatal truck crashes per unit freight flow is approximately 3 times higher on the Pacific than the Hume. The crash rate on the Hume is reasonably typical of the crash rate on other NSW highways.

(vi) Trends of fatal truck crash rates (either in terms of traffic flow or freight flow) tended to reduce during the 'eighties until 1988, when a significant increase occurred. These trends were similar on all NSW highways, but differed from the Australian-wide situation which was more constant.

(vii) The number of NSW fatal truck crashes occurring in 1988 was above the predicted value based on the 1982-1987 downward trend.

(viii) In 1988, the major increase in truck crash types occurred in high speed zones, on undivided roads (involving head-on crashes with cars), involved unprotected road users, or involved ran-off-road crashes on curves. These problems were acute on the Pacific Highway because (a) it is a predominantly undivided road of poor standard (including narrow shoulders, presence of roadside objects, and a high incidence of poor horizontal and vertical road alignment), (b) there is a high incidence of night-time crashes, often in wet conditions, (c) car drivers on the wrong side of the road crash head-on into trucks (presumably due to inattention, fatigue and poor visibility) and (d) trucks throughout NSW tend to travel at relatively high speeds (ie. a significant proportion in excess of 120km/h).

(ix) Trucks were found to be responsible in about 45% of multi-vehicle fatal crashes involving trucks and in about 32% of truck-car crashes.

(x) In 1988, there was a large increase in interstate road freight flows originating or terminating in Sydney, and traffic flows increased significantly. However, conventional notions of the effects of these exposure indices on crash occurrence would not adequately explain the increase in fatal truck crashes throughout NSW in 1988. Other factors which were found to contribute to truck crashes in 1988, and which could potentially have changed from previous years, are: night-time travel (and poor lighting conditions), the behaviour patterns of road users in cars (involving inattention, fatigue and alcohol use), the behaviour of unprotected road users in a road freight environment (involving alcohol use and inattention), and the behaviour of truck drivers (involving excessive speeds and inattention).

(xi) Unless NSW adopts a long-range commitment to implementing a range of countermeasures to truck crashes, the NSW fatal truck crash problem is expected to be perceived to increase from time to time, and probably to show a general upward trend.

(xii) Major factors contributing to severe truck crashes in NSW were found to be: undivided roads, poor road alignment, light conditions (night-time), roadside objects, excess truck speed, poor road shoulders, slow car speed, truck instability, car driver inattention, truck drivers falling asleep, car driver alcohol use, truck driver alcohol use, car drivers falling asleep and excess car speed. Up to 60% of crashes could involve some element of driver fatigue, and up to 40% could involve excessive speed by truck or car drivers.

(xiii) Road alignment was found to be a particular problem on the Hume and Pacific Highways, especially on the Pacific Highway. Tight radius curves, especially in combination with abrupt grade changes, and compound or extended curves were found to threaten the controllability of both trucks and cars, contributing to severe crashes.

(xiv) Countermeasures having a high level of relevance plus specific mechanisms for reducing the fatal consequences of truck crashes are presented in Section 7 (Findings) and relate to roads, vehicles, heavy vehicle drivers, car drivers and the road system environment. While the roads countermeasures should be particularly targetted at the high-risk Pacific Highway, all other categories of countermeasures can be expected to have significant benefits throughout NSW (and extending to other States).

(xv) While all countermeasures in Section 7 deserve consideration for implementation, the most significant countermeasures are considered to be:

. Divided highways on major freight routes (this eliminates exposure to head-on crashes and poor road alignment)

. New technology in truck (structural) frontal redesign to deflect cars and absorb energy

. Fitment of speed limiters in trucks to prevent excessive speeds (i.e. greater than 120 km/h)

. Road improvements at known blackspots (including re-alignment)

. Use of the latest electronic technology for enforcement of alcohol limits (for both car and truck drivers) and for enforcement of speed limits (for both trucks and cars)

. Improved road shoulders (with respect to width and condition)

. Police enforcement of speed limits and non-hazardous driver behaviour at known black spots

. Improved road delineation with appropriate use and maintenance of refectorised devices, edge markers and adequate delineation during roadworks

. Use of current and new technology to provide truck cab strength during rollover and frontal impact

. Removal of impediments to truck drivers' wearing of seat belts.

. New technology to alert sleepy truck and car drivers

. New technology in car crashworthiness to maximize survival possibilities in offset frontal impacts with trucks

. Reduction of truck aggressivity through removal of bullbars, lower front bumpers, energy absorbing bumpers and under-run protection

. Elimination of insecure loading practices on trucks

. Marking and protection of culverts

. Programs to educate other road users with respect to appropriate driving behaviour in a road freight environment, including speed and distance perception

. Adoption by road freight operators of appropriate tools to eliminate hazardous truck operational practices and the introduction of an operator licensing and demerit system to enforce the use of such management tools

. Heavy vehicle driver defensive driving training

(xvi) The provision of divided highways is an outstanding countermeasure to truck crash hazard. Plans to reconstruct the Pacific and Hume Highways need to be accelerated. Priorities for reconstruction should take into account the current incidence of poor alignment (involving tight radius curves combined with abrupt grade changes, and compound and extended curves), traffic volumes and the percentage of trucks in the traffic stream, particularly at night.

(xvii) It is important that truck crash issues continue to be monitored, evaluated and researched. It is recommended that the methodological recommendations contained in Section 7 (Findings), and relating to crash analysis and data sources, are taken into account in evaluating the effectiveness of countermeasures and finding new countermeasures.