Liro Forestry Solutions

PROJECT REPORT

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CAUSAL FACTORS IN HEAVY VEHICLE ACCIDENTS: A REVIEW

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SUMMARY

Public confidence in the safety of logging trucks has been eroded by the high incidence of accidents involving logging trucks and other road users. An international literature review was carried out to identify causal factors in logging truck accidents and provide recommendations for future research.

Analysis of the Land Transport Safety Authority (LTSA) crash database revealed that speed was responsible for more accidents than any other factor. It was cited as the primary cause of 64% of logging truck accidents and 46% of other commercial vehicle accidents.

The proportion of logging trucks that roll over during accidents is substantially higher than for other heavy vehicles. Of the logging truck accidents, 74% resulted in the truck rolling over compared with 35% for other commercial vehicles. There are two factors that cause a vehicle to roll over: **speed** and **vehicle stability**. The LTSA have shown that logging trucks travel at the same speeds as other heavy vehicles. Therefore, the higher proportion of rollovers for logging trucks may be explained by poor vehicle stability.

Static Roll Threshold (SRT) is a measure of truck stability. Baas & Latto (1997) found that 31% of logging trucks surveyed had a SRT below the internationally accepted standard of 0.35g. A joint study by the LTSA and Transport Engineering Research New Zealand (TERNZ) has found that while only 15% of all heavy vehicles have a SRT below 0.35g, they are responsible for 40% of the rollover or loss of control accidents. This evidence suggests that there is a need to identify those vehicles with low stability and either improve them or prohibit their operation.

There is also evidence to suggest that logging trucks are more likely to be operated in an unroadworthy state than other commercial vehicles. A recent Commercial Vehicle Investigation Unit (CVIU) random check resulted in 43% of logging trucks being taken off the road due to mechanical defect. Only 22% other heavy vehicles stopped were taken off the road.

Overseas literature has focussed heavily on the role of fatigue in commercial vehicle accidents. Two of the key findings from overseas literature were:

1. The most important variable in determining whether a driver will suffer from fatigue is time of day.
2. Drivers are unable to accurately assess their own levels of fatigue.

However, there is significant debate as to the proportion of accidents in which fatigue is a contributing factor. Estimates range from 0.5% in parts of the UK up to 40% in the US. Our own analysis showed that fatigue contributed to 9% of logging truck accidents in New Zealand. These estimates vary depending on the data used to derive the value. It is widely believed that police accident reports under-estimate the role of fatigue because of difficulty in assessing the physiological state of the drivers at the time of the accident.

This study has identified two approaches to improve logging truck accident rates. One is to improve vehicle design, the other to improve driver and company attitudes towards safety. TERNZ has already researched means of improving design but there is difficulty in implementing design changes due to the scale of investment in the present fleet.

It is recommended that safety initiatives such as those in Canada be explored. For instance, trucking companies could be assessed based on accident rates, level of driver training and compliance with legislation. It is hoped that this, coupled with on-going driver education, will reduce driver speeds.

There is also a strong need to educate drivers and police about the effects, causes and symptoms of fatigue. Research into methods of objectively determining driver fatigue is recommended.

ACKNOWLEDGEMENTS

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1.1 The Effects of Logging Truck Accidents

Logging truck accidents may result in loss of life, injury, property damage or any combination of these outcomes. Studies have shown that in multiple-vehicle collisions involving a heavy vehicle, the person most often killed or injured tends to be the driver or passenger of the car involved. FORS (1997) found that in fatal multiple-vehicle collisions involving articulated trucks, 38% of the deaths were the car driver, 21% the car passenger and 16% the articulated truck driver. Results were similar for rigid trucks where 36% of fatalities were the car driver, 12% the car passenger and 16% the rigid truck driver.

The social cost of logging truck accidents is $230/km compared with $60/km for other types of heavy vehicle[1]. This is due to the higher incidence of accidents and also the type of accident that results. Most often logging truck accidents result in the vehicle rolling over. In 1997, the social cost for all motor vehicle accidents in New Zealand was 3 billion dollars (http://www.ltsa.govt.nz/research/index.html).

1.2 Frequency of Logging Truck Accidents

In 1998, 648 heavy vehicle-related accidents resulted in an injury and an additional 77 resulted in fatalities in New Zealand. The number of heavy vehicle related fatalities equates to 2.1 per 100,000 population. The number of injuries in 1998 was 17.7 per 100,000 population.

Table 1: Injury and Fatality Accident Rates for Heavy Goods Vehicles

	Fatality	Injury
	Accidents per 100,000 population	
Australia	2.3	11.5
NZ	2.1	17.7
Canada	2.0	41.1
USA	1.8	32.9

Both Canada and the US have lower fatality rates with 2.0 per 100,000 population (CRASH, 1999) and 1.8 per 100,000 population respectively (NHTSA, 1998).

Australia has slightly higher fatality rates. In 1995, the fatality rate per 100,000 population was 2.3. However, the number of heavy vehicle related injury accidents is lower than New Zealand's at 11.5 per 100,000 population. These values are from three years prior to the previous statistics. Given the trend of decreasing accidents, this may be an over-estimate of the current accident rate in Australia.

In the US, large trucks account for 8.7% of fatal motor vehicle accidents and 2.4% of injury accidents. In Canada, heavy vehicles contribute to 8% of all traffic deaths and 7% of all traffic injuries.

Of the fatal crashes involving trucks in this country between 1996 and 1998, 33% were the fault of the truck. Overall, trucks were therefore responsible for about 7% of all fatal road crashes (LTSA, 1999).

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While the New Zealand accident rates for all heavy goods vehicles (HGVs) is comparable to overseas, research has shown that in New Zealand, logging trucks are more likely to be involved in accidents than any other heavy goods vehicle.

The Land Transport Safety Authority (LTSA) has estimated from Police reports that two log trucks crash every week on public roads. Based on the distance log trucks travel, their crash rates are 3 to 4 times greater than the average for all heavy vehicle combinations (LTSA, 1999).

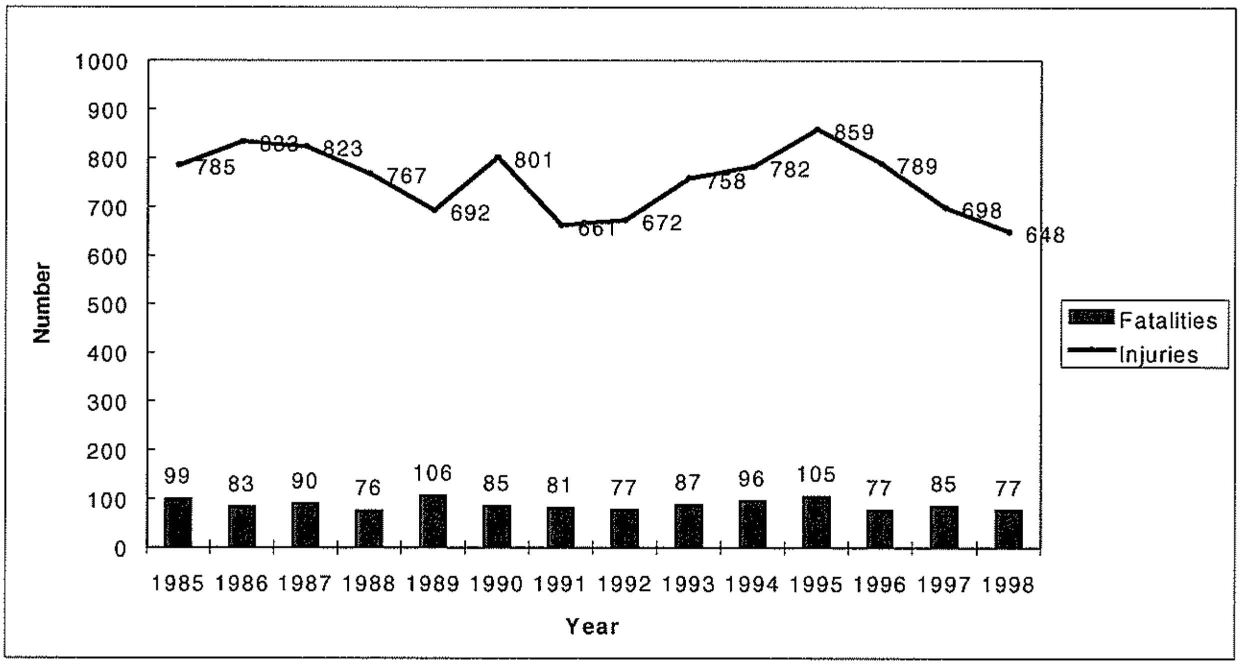
Of the 354 Commercial Vehicle Investigation Unit (CVIU) HGV reports available, 225 were for combination vehicles (towing one or more trailers). Of these, 31 were logging trucks or 13.4% of the combination vehicles. Nearly twice as many logging truck crashes are being reported than what would be expected based on their proportion of the fleet (Baas & Latto, 1997).

1.3 Trends in Heavy Vehicle Accidents

The number of heavy vehicle accidents is declining, but at a slower rate than for other motor vehicles. In 1985, 0.866 accidents occurred for every million km travelled compared with 0.355 in 1998. Similarly there has been a decline in the rate of fatal accidents. In 1985, 0.097 accidents occurred for every million km travelled compared with 0.0377 in 1998.

From 1995 to 1997 there was an 18% decrease in the number of fatalities from motor vehicle accidents and a 19% decrease in the number of injuries. During the same period there was a drop of 19% in both heavy vehicle-related fatalities and injuries. However, 1995 was a particularly dire year for heavy vehicle crashes and this statistic hides the actual rate of decline. During the period from 1994 to 1997 there was an 11% decrease in heavy vehicle related fatalities and a 12% decrease in the number of heavy vehicle related injuries. This is significantly lower than the rate of decline for all motor vehicles.

Figure 1: Fatality and Injury Trends in Heavy Vehicle Accidents



This is in contrast to Australia, where the decline in truck-related road trauma exceeds the general decline in fatalities and serious injuries for all types of vehicles. Articulated trucks experienced a decline in fatalities from 1990 to 1995 of 24%. Rigid truck fatalities declined 26% during the same period. For all motor vehicles the decline in fatalities over the same period was 14% (FORS, 1997).

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The proportion of logging trucks that roll over during accidents is substantially higher than for other heavy vehicles. Of the logging truck accidents, 74% resulted in the truck rolling over compared with 35% for other commercial vehicles. There are two factors that cause a vehicle to roll over: **speed** and **vehicle stability**. The LTSA have shown that logging trucks travel at the same speeds as other heavy vehicles. Therefore, the higher proportion of rollovers for logging trucks may be explained by poor vehicle stability.

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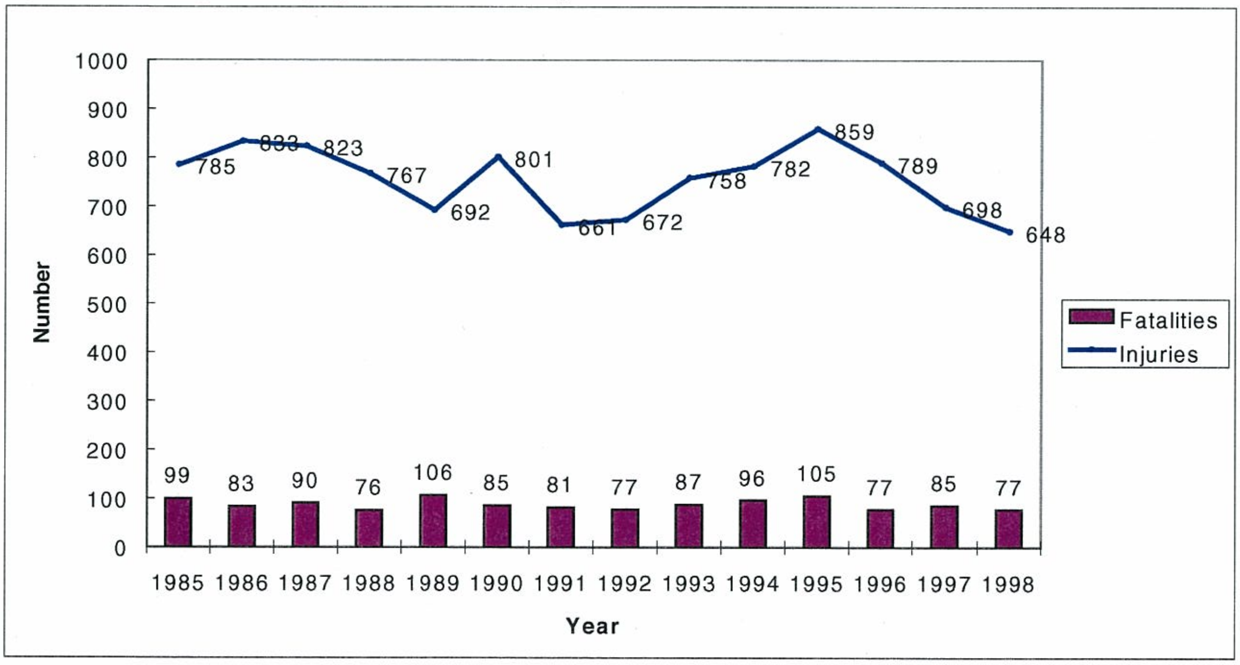

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1.4 Organisations Involved

There are several key organisations in New Zealand that research logging truck accidents. The CVIU attends most truck crashes and completes accident forms on site. These forms are then forwarded to the Land Transport Safety Authority (LTSA) who are responsible for analysing and reporting the data. The LTSA are also responsible for promoting safety on New Zealand roads by providing safe driving and practical advice for general and commercial drivers. Transport Engineering Research New Zealand Ltd. (TERNZ) is responsible for research on design and stability issues associated with logging trucks. This paper was funded by the Logging Industry Research Association (LIRA).

2 METHODS

1. The LTSA crash database was analysed to determine the causal factors and characteristics of logging truck and other heavy vehicle accidents in New Zealand. The LTSA has been storing information on motor vehicle accidents in this database since July, 1996. There were a total of 98 logging truck accidents and 593 other heavy vehicle accidents recorded in the database. Those accidents where causal factors were not listed or where rollover was listed as the cause of the accident were removed from the analysis. The causal factors in logging truck accidents were compared to those of other heavy vehicle accidents.

2. The CVIU were asked to record information on the number of heavy vehicles that were found to be non-compliant with heavy goods vehicle regulations. Three separate surveys were conducted where police checked for over-dimension, mass and loading and mechanical defect violations.

3. A review of international and New Zealand-based literature was carried out, focussing on causal factors in heavy vehicle accidents, was carried out. The main sources of information were:

- Internet
- Government Agencies
- Universities
- Industry Organisations
- LIRO Library
- Abstract searches

4. The information obtained from the literature review was analysed to determine which factors are most frequently responsible for heavy vehicle accidents. Any relationships between causal factors were also noted. For example does the presence of one factor in the presence of another factor influence the likelihood of an accident occurring? Relationships between the causal factor(s) and the consequences of the accident were also noted.

5. An investigation was made into any regulations (either government or company initiatives) pertaining to heavy vehicle operation around the world. For example set rules on maximum length of time the driver may operate the vehicle without breaks. These regulations and penalties for breach of that legislation were compared to those applying in New Zealand.

3 RESULTS

3.1 Comparison between logging truck accidents and other Heavy Vehicle Accidents

Analysis of the LTSA crash database revealed several key differences between logging truck accidents and other heavy vehicle accidents. Logging trucks are far more likely to be involved in a rollover type accident. 74% of the 65 logging truck accidents[2] were identified as rollover type accidents. Only 35% of other commercial vehicle accidents resulted in a rollover.

The incidence of rollovers in New Zealand is substantially higher than for heavy vehicles in other countries. In Canada only 10% of heavy vehicle crashes result in a rollover (CRASH, 1999).

60.6% of logging truck accidents occur on corners, 13.1% are head on collisions and 12.1% occur when the vehicle has lost control or gone off the road on a straight road. 5% of accidents are rear endings.

For all other commercial vehicles, 36.7% occur while cornering, 21.4% occur when the vehicle loses control on a straight road, 8.7% are head on collisions and 8.2% are rear ends.

3.1.1 Primary Causes

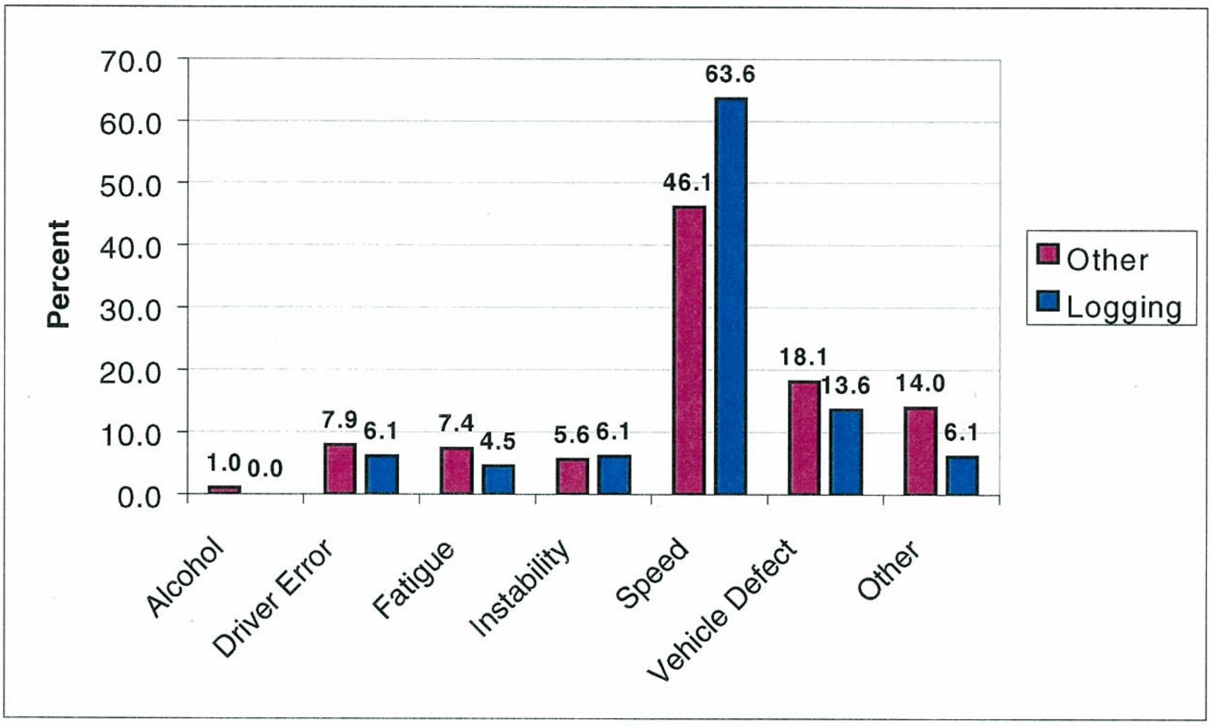
The primary cause of the accident is defined as the factor listed as Cause A in the accident report.

The most frequently cited primary causes for logging truck accidents were speed (64%) and vehicle defect (14%).

The same two factors were identified for other heavy vehicle accidents. Speed was the primary cause in 46% of other heavy vehicle accidents and vehicle defect for 18%.

[2] Excludes logging truck accidents with no causes listed.

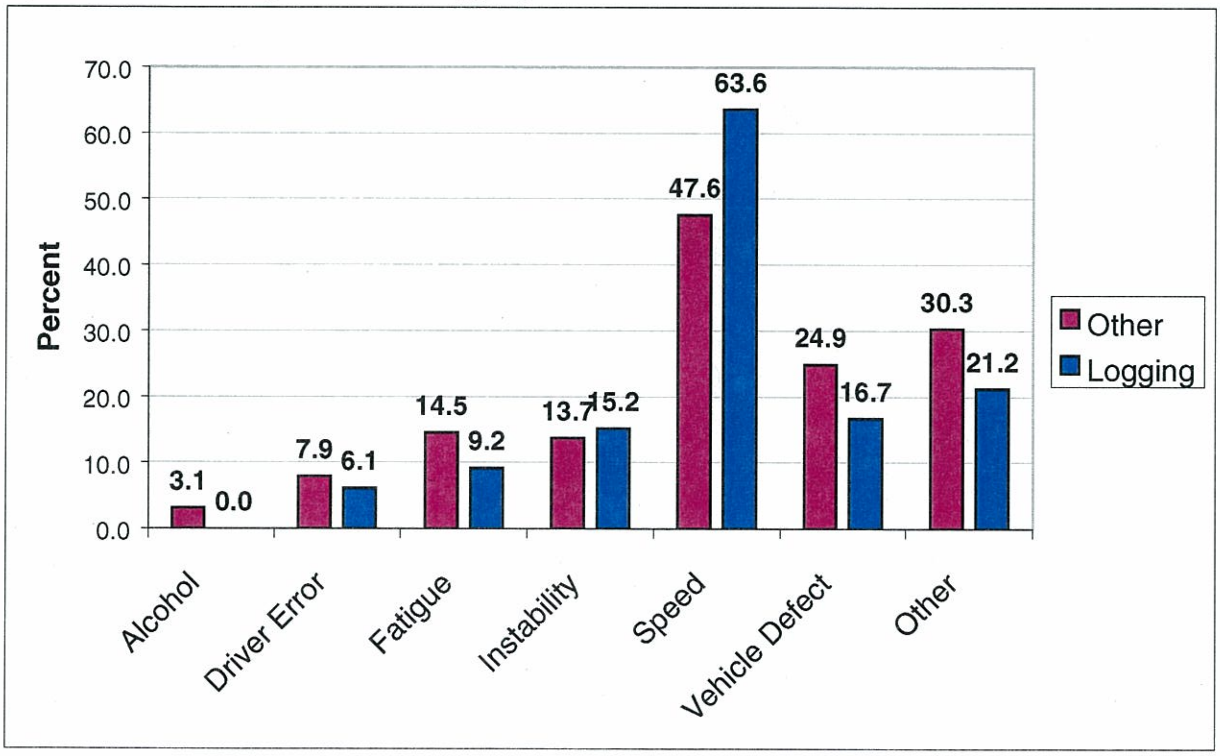
Figure 2: Primary Causes in Logging Truck and Other Commercial Vehicle Accidents



3.1.2 Contributing Factors

A contributing factor is any factor listed as a cause in the accident report. The same trend as for primary causes is evident when all contributing factors are examined. Speed and vehicle defect contribute to the most accidents for both logging trucks and other heavy vehicles. However, the effects of fatigue and instability become more evident. Logging truck accidents have slightly lower rates of fatigue-related crashes but slightly higher rates of instability-related crashes.

Figure 3: Contributing Factors to Logging Truck and Other Commercial Vehicle Accidents



Appendices 1 and 2 contain the number and percentage of accidents for each causal factor for logging trucks and other heavy vehicles.

3.2 CVIU Survey

At the Rotokawa weighbridge the CVIU inspected nearly 100% of passing logging trucks. Over a six-week period they found seven that were over-height. This was a very small percentage given that hundreds of logging trucks are stopped each day.

On two separate highway checks, out of the 300 logging trucks stopped during random checking, 15 (5%) were found to have an insecure load.

At a separate highway location, 79 heavy vehicles were stopped. Of these, 28% had mechanical problems. Out of the 79, 21 were logging trucks, of which 9 (43%) were taken off the road due to mechanical defect.

When the LTSA conducted a similar survey, they found that while 79% of logging trucks complied with height rules, 14% of loads were not correctly crowned and 5% were not using belly chains when required (LTSA, 1999).

3.3 Characteristics of Logging Truck Accidents

Most logging truck accidents occur during daylight hours with 44% occurring between 0600 and 1200, 33% from 1200 to 1800, 18% between 0000 and 0600 and 6% between 1800 and 0000.

The majority (85%) of accidents occur in 100km zones, 10% occur in 50km zones and 5% in either 70 or 80 km zones.

Truck trailers are involved in 84% of logging truck accidents, semi-trailers and B-trains are involved in 5% and A-trains in 1%.

One quarter of all logging truck accidents occur in the Bay of Plenty, 7% of accidents occur in Northland and 4% each in Te Awamutu and Gisborne.

Table 2 – Percent of Log Truck Crashes by Region

DISTRICT	PERCENT OF CRASHES
Tauranga	13%
Rotorua	12%
Northland	7%
Te Awamutu	4%
Gisborne	4%
Canterbury	2%
Manawatu	3%
Wellington	3%
North Shore-Waitakere	2%
Otago	2%
Southland	2%
Wanganui	1%
Papakura	1%
Wanganui	1%
Tasman	1%
Auckland City	1%
Palmerston North	1%

3.4 Vehicle Operation Restrictions & Penalties

The restrictions on drivers of heavy vehicles are listed in Appendix 3. The restrictions on mass and dimension are listed in Appendix 4.

The penalties for insecure and overloading heavy vehicles in New Zealand and Australia are similar. However, there is a significant difference in penalties for breach of dimension and mass regulations. In New Zealand an instant fine of $NZ370 for each offence is issued. In Australia, a corporate owner may be fined up to $AU10,000 for an over dimension offence or $AU15,000 for an over mass offence (http://www.nrtc.gov.au).

Table 3: Penalties for Violation of Mass and Loading Regulations in Australia and New Zealand

Offence	Max Penalty NZ (Individual)	Max Penalty NZ (Corporate)	Max Penalty AUS. (Individual)	Max Penalty AUS. (Corporate)
Insecure load	$NZ2,000	$NZ10,000	$AU2,000	$AU10,000
Overloading	-	$NZ10,000	$AU3,000	$AU15,000
Over dimension	-	$NZ370[3]	$AU2,000	$AU10,000
Over mass	-	$NZ370	$AU3,000	$AU15,000

4 OVERSEAS RESEARCH

4.1 Speed

A study performed by the Oregon Department of Transportation showed that of the 1776 truck crashes in Oregon in 1998, 25.6% were caused by excessive speed (Oregon Department of Transportation, 1999).

In Australia, a significant factor for one in three fatalities where the rigid truck driver was at fault was speed. Of the single vehicle crashes involving articulated vehicles, the driver was speeding in one quarter of fatalities (FORS, 1997).

4.2 Vehicle Deficiency

The United States' National Transportation Safety Board (NTSB) performed a study on 186 fatal to the driver accidents that occurred during the period dating from 1 October 1987 to September 30, 1988. They found that 62% of the trucks management deficiency of either the driver or company (NTSB, 1990).

In Canada between 1995 and 1998, the average percentage of heavy vehicles with safety defects was 30%. Brake problems featured in 30% of them (CRASH, 1999).

In a 1997 surprise blitz in Ontario, Canada, 71 out of 124 heavy vehicles stopped were taken off the road due to mechanical defects. This blitz was a result of the large number of truck-wheel separations. There were 32 cases resulting in 4 fatalities in the Greater Toronto area alone (Richmond, 1998).

4.3 Driver Factors

4.3.1 Driver Error

[3] There is a $370 instant fine for over-dimension and over-mass violations and the vehicle is "parked up" until it meets regulation standards.

An Oregon Department of Transportation study showed that of the 1776 heavy vehicle crashes in 1998, 2% involved driving off the road while "grabbing a coffee" or adjusting the radio (Oregon Department of Transportation, 1999).

4.3.2 Driver Health

In the NTSB 1987-88 study, the driver's medical condition either caused or contributed to 10% of the crashes and 90% of these were cardiac incidents (NTSB, 1990).

4.4 Drugs/Alcohol

The NTSB's 1987-88 study, showed that after fatigue, drug or alcohol impairment were the most frequently cited accident probable cause (29%). Of the 57 drivers that were fatigued, 19 (33%) were also alcohol or drug impaired (NTSB, 1990).

The NTSB (1990) found that 33% of fatally injured drivers tested positive for alcohol and other drugs of abuse. The most prevalent drugs were marijuana and alcohol with 13% of drivers testing positive for each. Cocaine use was also significant with 9% of drivers testing positive.

The board also noted that fatigue and fatigue drug interactions were involved in more fatalities than alcohol and other drugs of abuse alone (NTSB, 1990).

This study also revealed relationships between the violation of federal hours of service regulations and drug usage and between a positive drug test and the driver's prior alcohol and drug prior offences. Likewise a relationship was found between drug use and shipment deadlines, truckload (42% positive) and less than truckload (14% positive) (NTSB, 1990). These statistics do not reflect all heavy vehicle crashes, as accidents were selected for study where it was believed that fatigue was a factor. However, this information does show a relationship between drug use and fatigue.

Alcohol also features as a causal factor in rigid truck crashes in Australia. The main contributing factor in single vehicle fatalities, involving rigid trucks, where the truck driver was at fault was alcohol. In total, 50% of this type of fatality can be directly attributed to alcohol (FORS, 1997).

4.5 Fatigue

There is high variability in the reported incidence of fatigue-related crashes both between and within countries. The role of fatigue in heavy vehicle crashes is difficult to quantify due to the lack of obvious measures of fatigue.

An Australian study found that in one quarter of fatalities involving an articulated truck where the truck driver was at fault, the driver was fatigued. The truck driver was at fault in less than 1 in 6 multiple collisions (FORS, 1997).

Analysis of officially reported accident data in the UK produced estimates of the involvement of fatigue in heavy goods vehicle accidents ranging from 0.5 to 3.7% depending on the county (Maycock, 1995).

Knipling and Wang cite Deering's 1994 review of 1,000 Michigan Police Accident Reports, which found 1% attributed to "dozing," 17% more attributed to "daydreaming"/distraction, and another 18% to "looked but didn't see." They cited Treat, Tumbas, McDonald et al. (1979) as finding that 56% of crashes involved "recognition errors" as a certain or probable factor, and note that the role of fatigue in such recognition failures and other mental errors resulting in crashes is currently unknown (TDC, 1996).

Howarth, Heffernan & Horne found that between 1984 and 1986 19.9% of Victorian fatal truck crashes were fatigue related (Hartley & Mabbot, 1998). In Tyson's (1992) South Australian study 13% of fatal truck crashes were attributed to fatigue (Hartley & Mabbot, 1998).

Ryan and Spittle (1995) found that fatigue was a factor in 16.5% of fatal road train crashes and 8.8% of semi-trailer crashes (Hartley & Mabbott, 1998).

A 1965 press release from the office of the Oklahoma Turnpike Authority stated that 22% of the 2,128 motor-vehicle accidents occurring between 1953 and 1964 were a result of the driver being asleep at the wheel. These accounted for 48% of traffic fatalities (Hartley & Mabbot, 1998).

4.6 Other

Occupant protection was the most common non-causal factor reported (68/185 or 36.8%) (NTSB, 1990).

4.6.1 Multiple Vehicle Collisions

In Australia, multiple vehicle crashes are the most common form of crash in which an articulated truck driver is involved. The majority of rigid truck crashes also have multiple vehicles involved. Car drivers were primarily responsible for 5 out of 6 crashes involving an articulated truck and 2 out of 3 crashes involving a rigid truck (FORS, 1997).

The same trend is apparent in New Zealand though to a lesser extent. Where multiple vehicles are involved in heavy vehicle crashes, 53% of the time the other vehicle is at fault. The truck drivers are found to be at fault in 31% of cases.

4.6.2 Seatbelts

In 1995, in 94% of the fatalities involving articulated trucks in Australia, the truck driver was not wearing a seatbelt. For rigid truck drivers 42% of fatal accidents involved the truck driver not wearing a seatbelt. The study concluded that seat belt usage for both articulated and rigid trucks is much lower than usage in the general population where only 25% of fatalities involved the driver not wearing a seatbelt (FORS, 1997).

In New Zealand, a 1995 LTSA survey found that one in eight adults fail to wear their safety belts. This figure put New Zealand near the bottom of the list of comparable countries for safety belt use. Given the trend in Australia, it is possible that seat belt use among heavy vehicle drivers is lower than seven in eight.

5 ANALYSIS & DISCUSSION

5.1 Comparison of Logging Trucks and Other Heavy Vehicles

One of the positive findings to come out of the analysis of the LTSA crash database was the low incidence of alcohol and drugs in heavy vehicle crashes. Alcohol was a factor in none of the logging truck accidents and just three of the other heavy vehicle accidents. For all motor vehicles, between 1996 and 1998, alcohol contributed to 28% of fatal accidents (http://www.ltsa.govt.nz/research/index.html).

However, research has shown that logging trucks have proportionally more accidents than other heavy vehicles based both on number of kilometres travelled and the proportion of the fleet.

Logging truck accidents are more likely to be caused by speed and are more likely to occur on corners than other heavy vehicle accidents. Logging truck accidents are also far more likely to involve a rollover. The high incidence of rollover accidents is a concern. Truck driver injury and death rates in rollover accidents are higher than for any other type of accident. In Canada, rollovers account for about 10% of big truck crashes, including 60% of big truck crashes fatal to the truck driver (CRASH, 1999). There is also a high risk of hazard to other motorists.
There are two key factors in determining whether vehicles will roll over:

1. Speed
2. Vehicle Stability

Studies on the speeds travelled by logging truck drivers compared with other heavy vehicle drivers show that logging truck drivers travel no faster than other commercial vehicle drivers[4]. However, an LTSA survey found that all heavy vehicle operators were travelling up to 20 km/hr above their speed limit on straights and 10 km/hr above advisory postings on corners (LTSA, 1999).

The reason for the higher incidence of rollovers for logging trucks, given that they are travelling at the same speeds as other heavy vehicles, may well be explained by vehicle design. Logging trucks are designed so that the trailer can be piggybacked when not carrying a load. This design includes having a short trailer with a short wheelbase. This design can result in poor handling[5].

Static Rollover Threshold (SRT) is the lateral acceleration, in units of gravity (g), at which vehicles will rollover while negotiating a steady curve. Previous New Zealand research confirms that vehicles require an SRT of at least 0.35g (0.4g for A-trains exceeding 39 tonne) in order to be able to negotiate curves at posted advisory speed limits (LTSA, 1999). Baas & Latto (1997) found that 33 of 105 logging trucks sampled had a SRT below the required 0.35g. A high proportion of these were B-trains carrying shorts and Bailey bridge configurations which had 58% and 0% respectively above 0.35g. These configurations have higher bolster heights and are frequently loaded to 4.2 meters, which increases the centre of gravity. The advantage of having multi bolsters was evident though. The percentage of load combinations above 0.35g was 100% for trucks with multi-bolster trailers and 91.7% for B-train multi-bolsters.

A recent TERNZ/LTSA study has found that 85% of all heavy vehicles surveyed in a random sample met or exceeded the internationally accepted SRT target value of 0.35g. However, the study found that 40% of vehicles involved in the rollover and loss of control crashes had an SRT of below 0.35g. It was concluded that a small percentage of low performing vehicles are contributing disproportionately to the overall number of crashes.

The evidence is there to suggest that vehicles with a SRT lower than 0.35g have a higher chance of being involved in rollover type accidents. Given the high incidence of rollover type

[4] Pers. Comm. Don Hutchison - LTSA
[5] Pers. Comm. Don Hutchison - LTSA

accidents for logging trucks, increasing the SRT of those logging trucks with marginal or poor SRT is imperative.

Based on the results of the CVIU survey, the proportion of logging trucks that had to be taken off the road due to vehicle defect was substantially higher than for other heavy vehicles. Given that the logging industry already has a poor safety reputation, it is of concern that such a high proportion of vehicles are being operated in an "unroadworthy" state.

Despite the low percentage of trucks found to be overheight at the Rotokawa weighbridge, the fact that seven were may be an important indicator of the attitude of logging truck drivers. Senior Sergent Dave Harris (CVIU) commented that he was surprised they found ***any*** over-height trucks, given that the drivers knew there was a high chance of being pulled over. He believes this to be symptomatic of poor driver attitudes both towards safety and potential penalties.

5.2 Logging Truck Driver Profile

Of the 98 logging truck driver accidents in the LTSA database only one was female. The average age of drivers was 36.8 years. The driver's ages ranged from 18 to 64.

The Transport Research Laboratory in the UK found that accident frequencies were strongly dependent on the age of the driver. Drivers in the 17-29 year old age group average 0.44 accidents in a 3-year period compared with 0.15 accidents for drivers aged 55 and over (Maycock, 1995).

5.2.1 Speed and Driver Age

Because speed was such an important factor in logging truck accidents, a statistical test was performed to determine whether there was a relationship between the age of the driver and the proportion of accidents that were caused by speed. A chi-squared test was used for this analysis.

The proportion of accidents where speed was a causal factor for drivers under 40 was 0.56. The proportion where speed was a factor for drivers over 40 was 0.42.

Ho: there is no relationship between driver age and speed being a causal factor in the accident.
Ha: there is a relationship between driver age and speed being a causal factor in the accident.

The number of crashes where speed was a factor is displayed below.

SPEED	DRIVER UNDER 40	DRIVER OVER 40	TOTAL
Yes	23	10	33
No	18	14	32

The expected values are displayed in the table below:

SPEED	DRIVER UNDER 40	DRIVER OVER 40	TOTAL
Yes	20.5	12	32.5
No	20.5	12	32.5

The squared differences between observed and expected values are displayed below.

SPEED	DRIVER UNDER 40	DRIVER OVER 40
Yes	0.305	0.33
No	0.305	0.33

The calculated Chi-squared value is 1.277. The critical chi-squared value for 1 degree of freedom at the 5% level is 3.84. The calculated value is less than the critical value. The test shows that there is not a relationship between speed and age in logging truck crashes.

Because speed is not the only factor that may cause an accident, this analysis does not show that there is no difference in accident rates for younger and older drivers. However, it does show that speeding is just as prevalent in causing accidents for older drivers as it is for the younger drivers.

5.3 Restrictions and Penalties

Research has shown that the number of continuous driving hours is less important in determining whether a driver will be affected by fatigue than the number of cumulative trips. The key restrictions on driver hours are those attaining to time on duty and continuous rest time over a number of trips. While New Zealand doesn't have the minimum rest allocation for a 7 day period, drivers are required to have 24 hours continuous rest after (whichever comes first) 70 hours on duty or 66 hours drive time. This is lower than the continuous rest periods required in the US and UK.

The mass and dimension restrictions in New Zealand are middle of the range compared with other countries. Australia and Canada allow much heavier, longer vehicles to operate while the UK and US have tighter restrictions than New Zealand. However despite Australia and Canada allowing longer and heavier vehicles, the Australian height restriction is similar to that in New Zealand (4.3 compared with 4.25) and Canada's is lower at 4.15 meters. Given that many New Zealand roads contain frequent sharp bends and corners, it may be that the height restriction is too lenient for this country's roads. The LTSA has already recognised this fact and is campaigning to further reduce the height of heavy vehicles.

The penalties for not adhering to mass and dimension regulations are substantially lower in New Zealand than in Australia. Overloading penalties in New Zealand are also slightly lower than in Australia. While over-dimension or overloading did not feature strongly in the crash database, survey results have portrayed the poor attitude by some drivers and companies to the restrictions. The LTSA survey found 14% of loads were not correctly crowned and 5% were not using belly chains when required. The CVIU found 5% of trucks to have an insecure load (a high proportion given that the drivers knew there was a high chance of being stopped). Given that Australia is experiencing a greater decline in the rate of heavy vehicle accidents than New Zealand, it may be that increasing the fines for not adhering to regulations is one solution to poor attitudes, that should be examined.

5.4 Fatigue

5.4.1 Fatigue – The Hidden Factor

While the incidence of reporting of fatigue in New Zealand is relatively low – it contributed to 9.1% of logging truck accidents – it is possible that many other accidents resulted because of subtle effects of fatigue on the driver that were not noticed by police at the accident scene. In particular it is believed that speed, looking but not seeing and inattention factors are caused in many cases, by fatigue.

For example, in three of the cases where speed was determined as the probable cause of the accident, fatigue was noted as a secondary cause. Given the low incidence of identifying fatigue, this statistic may be important in that half the cases where fatigue was identified related to the driver speeding. It is likely, based on overseas research showing that fatigue is a significant cause of road accidents, that speed, in some instances, may be caused by fatigue and the resulting lack in concentration.

Haworth, Hefferman and Horne (1989) estimated that fatigue was a contributing factor to 19.9% of fatal accidents involving trucks when vehicle movements, tiredness reports and driving hours were included in the analysis. Coroners' reports only implicated fatigue in 9.1% when other factors were excluded (Hartley and Mabbot, 1998).

While there is significant debate as to the extent of fatigue's role in heavy vehicle crashes, two key findings are consistent throughout the research.

Accidents where fatigue is a causal factor are more likely to involve loss of life or serious injury.

Fatigue-related crashes are more likely to result in severe injury or death (Hartley & Mabbott, 1998).

Knipling and Wang (1994) examined the incidence of crashes related to driver drowsiness/fatigue. They stated that National Highway Traffic Safety Administration (NHTSA) General Estimates System (GES) statistics for 1989-93 showed about 1% of police-reported crashes (including both cars and trucks) cited driver drowsiness/fatigue but that the 1989-93 Fatal Accident Reporting System (FARS) show that 3.6% of fatal crashes were cited as involving drowsiness/fatigue (TDC, 1996).

Vehicle operators are unable to adequately determine when they are suffering from fatigue.

In 1993, Transport Canada performed an extensive study on driver fatigue and alertness. Drivers from the US and Canada were assessed for levels of fatigue using video surveillance, physiological tests and by undertaking various performance tests. The study found that drivers' self-ratings (of fatigue) differed sharply from the other criterion variables. Unlike other criteria, drivers self-rating correlated significantly with trip segments ranked primarily by hours of driving and accumulation of number of trips. A strong relationship between "elapsed time from trip start" and self-ratings exists. These changes of self-ratings with time-on-task may reflect increasing fatigue, where fatigue is defined as a subjective experience distinguishable from physiological impairment (TDC, 1993).

Other international research supports this finding. Skipper and Wierwille (1986) reported that 31% of drivers who had experienced drowsiness were initially unaware of the onset of their drowsiness (TDC, 1996). Dingus, Hardy and Wierwille (1987) concluded that two of the leading causes of automobile accidents are driver impairment due to alcohol and drowsiness. A relatively large percentage of these accidents is believed to occur because drivers are unaware of the degree to which they are impaired (TDC, 1996).

It is widely believed that police reports underestimate the role of fatigue in commercial vehicle accidents. Reasons for the under-reporting of fatigue may include difficulty for police officers in determining the physiological state of the driver and the drivers inability to identify their own level of fatigue. Fatigue is difficult to identify because its effects on vehicle operators are often subtle.

Knipling and Wang (1994) suggested that the 3.6% of accidents that were identified as caused by fatigue by FARS may be an underestimate for a number of reasons including:

- lack of a specific checkoff box for fatigue on some state police report forms,
- lack of firm evidence on which to base a police finding of fatigue,
- lack of awareness on the part of the driver of his/her own fatigue,
- and the significant number of crashes involving "drift out of lane" which are not cited as drowsiness-related (TDC, 1996).

For these reasons, while the incidence of reporting of fatigue as a causal factor in logging truck accidents is relatively low in New Zealand, it should not be ruled out as a significant factor in heavy vehicle accidents.

5.4.2 Effects of Fatigue

The consequences of driver fatigue are believed to include:

- Increased lapses of attention
- Increased information processing and decision making time
- Increased reaction time to critical events
- More variable and less effective control responses
- Decreased motivation to sustain performance
- Decreased psychophysiological arousal (e.g., brain waves, heart action)
- Increased subjective feelings of drowsiness or fatigue
- Decreased vigilance (e.g., watchfulness)
- Decreased alertness (e.g., readiness) (TDC, 1996).

In May 1992, the Australian Federal Office of Road safety surveyed 960 truck drivers. 49% of the drivers perceived that fatigue caused them to be slow to react, 37% said it resulted in poor steering and 11% in poor braking. 27% stated that fatigue made them less aware of other traffic (LTSA, 1998).

5.4.3 Causes of Fatigue

Transport Canada's Commercial Motor Vehicle Driver Fatigue and Alertness study found that the most significant factor in determining fatigue is time of day.

Video surveillance of drivers showed that in 4.9% of the hours driven, the driver was drowsy. 82% of these hours occurred between 1900 and 0659. Two thirds of the drivers were drowsy in at least one observation but 14% of the drivers accounted for 54% of the drowsy observations TDC, 1996).

Similarly, night driving (0000-0600) was associated with the worst performance on each of the four important criterion variables (drowsiness, lane tracking, code substitution and sleep length) whereas hours of driving and the number of consecutive trips had little or no relationship to those criterion variables (TDC, 1996).

There was some evidence of cumulative fatigue across days of driving. For example, performance on the Simple Response Vigilance test declined during the last days of all four conditions. There was no evidence to suggest that length of trip resulted in increased levels of fatigue. The fact that length of trip is not a good indicator of fatigue is supported by other research. Fell (1995) found from a NSW study of fatigue related crashes that 59% of incidents occurred within 2 hours of the trip starting. Analysis of the LTSA crash database showed that the range of continuous hours on duty for the accidents where fatigue was a contributing factor was 5.75 hours to 58.25 hours. This information suggests that length of time on duty is not a good indicator of how likely the driver is to be suffering from fatigue.

The NTSB (1995) examined single-vehicle truck accidents that were likely to have been fatigue related to determine the role of specific factors such as work-rest cycles. Selection was limited to drivers that survived and where the previous 96 hours could be reconstructed. Of the 107 accidents selected, 58% were considered to have fatigue as a probable cause. 65% occurred between 2200 and 0800 and of these 74% were fatigue related. Nineteen of the 107 drivers said they fell asleep at the wheel (TDC, 1996).

Of the logging truck accidents analysed from the LTSA crash database, eighteen occurred between 2200 and 0800. Fatigue contributed to 11% of these accidents and inattention (a potential symptom of fatigue) contributed to an additional 6%. This is higher than the percentage for all logging truck accidents but significantly lower than overseas research suggests. However, the incidence of speeding was higher than expected (72%). It is believed in certain cases the truck driver speeds because of the effects of fatigue. Based on overseas research, it is likely that fatigue contributed to a higher proportion of these accidents than was suggested by the police reports.

5.5 Ways to Combat Fatigue

Maycock (1995) found that the most common measures taken to combat driver sleepiness in the UK were:

Table 4: Driver response to combat fatigue

Driver Response	Percent
Open window – fresh air	68%
Stop – take a walk	57%
Radio	30%
Talk to passenger	25%
Coffee	14%
Other	15%

The NTSB 1990 study found that napping was a frequent driver initiated response to drowsiness and fatigue. They noted that the alertness-enhancing effects of napping have been demonstrated in other operator performance settings (eg aviation) and should be the subject of future research (TDC, 1996).

6 RECOMMENDATIONS

There are two ways of tackling the problem of high accident rates in the log transport industry. One is to improve the safety and stability of the trucks themselves, the other is to improve the attitudes of truck drivers and companies towards safety.

TERNZ has studied ways to improve logging truck stability and is best equipped to continue research in this area. However, coupled with this, studies on the economic effects of changing vehicle design and/or mass and dimension restrictions are required.

The main problem with improving truck design is the scale of investment in the present fleet. A long-term means of improving log truck stability may need to come in the form of legislative changes that enforce certain design requirements for all vehicles made after a certain date. Also, a campaign to enforce the 0.35g SRT; based on the TERNZ/LTSA evidence that vehicles with less than this threshold account for a disproportionately high number of rollover and loss of control accidents, should also be examined.

It is also recommended that safety initiatives for logging truck companies be trialed. For example in Canada each province is given a safety score based on the number of accidents they have and their compliance with National Safety Code Standards. A similar report could be performed on a company by company basis so that those companies with poor safety records are known to the industry. Variables the company could be rated on include:

- number of fatalities, injuries and accidents
- level of driver training
- compliance with heavy vehicle restrictions
- number of log book offences

Drivers should also be educated as to what factors cause accidents. In particular, they should be made aware of the effects of fatigue, when they are most at risk and that they themselves are incapable of accurately assessing their own levels of fatigue.

In order to prove that fatigue is a factor in more accidents than police reports suggest it is necessary to perform an indepth study on fatigue. Video surveillance of drivers appears to be the clearest means of assessing fatigue, with other researchers finding that physiological tests rarely identify fatigue (TDC, 1996).

Research into alarm mechanisms for identifying fatigue based on driver performance or psychophysiological arousal would help drivers identify when they are too fatigued to drive. Fitness for duty testing may also be an area that should be researched. A comprehensive identifier of fatigue is needed if the problem is to be readily addressed. A pass or fail test will have a much better success rate that a subjective measure of fatigue.

Drivers also need to be informed of the best way of reducing the effects of fatigue. Research in this area would help identify what the driver should do when they feel fatigued.

CVIU officers should be educated in picking up on signs of fatigue. For example, more intensive observation of the driver, discussion of their past 24, 48 hours and the nature of the accident, education on what the main causes/symptoms of fatigue are. Education on the nature of accidents is also useful. For example, research has shown that in crashes determined to be due to fatigue, the truck invariably either ran off the road with no avoidance manoeuvre, or was involved in a head on collision on the wrong side of the road when not overtaking another vehicle (Mabbot & Hartley, 1998).

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APPENDICES

APPENDIX 1 – Causal Factors in Logging Truck Accidents

Table 1 – Total Number of Accidents by Causal Factor

	Cause A	Cause B	Cause C	Total
Alcohol	0	0	0	**0**
Driver error	4	N/a	N/a	**4**
Fatigue	3	3	0	**6**
Instability	4	3	3	**10**
Speed	42	0	0	**42**
Vehicle	9	2	0	**11**
Other	4	8	2	**14**
Total	**66**	**16**	**5**	**87**

Table 2 – Percentage of Accidents by Causal Factor

Cause	Cause A	Cause B	Cause C	Total
Alcohol	0.0%	0.0%	0.0%	0.0%
Driver error	6.1%	N/a	N/a	6.1%
Fatigue	4.5%	4.5%	0.0%	9.1%
Instability	6.1%	4.5%	4.5%	15.2%
Speed	63.6%	0.0%	0.0%	63.6%
Vehicle	13.6%	3.0%	0.0%	16.7%
Other	6.1%	12.1%	3.0%	21.2%

APPENDIX 2 – Causal Factors in Other Heavy Vehicle Accidents

Table 3 – Number of Accidents by Causal Factor for Other Heavy Vehicles

Cause	Cause A	Cause B	Cause C	Cause D	Total
Alcohol	4	8	-	-	**12**
Driver error	31	N/a	N/a	N/a	**31**
Fatigue	29	23	5	-	**57**
Instability	22	21	9	2	**56**
Speed	181	6	-	-	**187**
Tool	11	3	1	1	**16**
Vehicle defect	71	25	2	-	**98**
Weather	17	N/a	N/a	N/a	**17**
Other	27	50	12	1	**90**
Total	**393**	**136**	**29**	**4**	**562**

Table 4 – Percent of Accidents by Causal Factor for Other Heavy Vehicles

Cause	Cause A	Cause B	Cause C	Cause D	Total
Alcohol	1.0	2.0	0.0	0.0	**3.1**
Driver error	7.9	0.0	0.0	0.0	**7.9**
Fatigue	7.4	5.9	1.3	0.0	**14.5**
Instability	5.6	5.3	2.3	0.5	**13.7**
Speed	46.1	1.5	0.0	0.0	**47.6**
Tool	2.8	0.8	0.3	0.3	**4.1**
Vehicle defect	18.1	6.4	0.5	0.0	**24.9**
Weather	4.3	0.0	0.0	0.0	**4.3**
Other	6.9	12.7	3.1	0.3	**22.9**

APPENDIX 3 – Heavy Vehicle Operator Restrictions

HOURS	NZ	AUS	USA	CAN	EC GS	UK GS	EC PS	UK PS
A. Max single cont. drive period	5.5	5	N/a	N/a	4.5	N/a	4.5	5.5
B. Min rest time after A.	0.5	0.5; or 2 x 0.25	N/a	N/a	0.75, or 3 x 0.25	N/a	0.75, or 3 x 0.25	0.5
C. Max drive time 24 hrs	11	12	10	13	9 (10 twice a week)	10	9 (10 twice a week)	10
D. Max On duty time, 24 hrs	14	14	15	15	N/a	11	N/a	N/a
E. Min rest period, 24 hrs	9 cont. hrs	10; 6 cont.	8 cont.	8 cont.	11 cont. (reduce to 9, 3 times per week)	13	11 cont. (reduce to 9, 3 times per week)	10 cont.
F. Min rest period, 7 days	#	84; 24 cont.	48	N/a	45, can be 36 or 24		45, can be 36 or 24	##
G. Max. drive time total, total 7 days	#	72	60; or 70 in 8 days	60	56		56 (max 90 in a fortnight)	70
H. Max on duty time, total 7 days	#	84	N/a	N/a	N/a		N/a	N/a

APPENDIX 4 – Mass and Dimension Restrictions

Table 5 - GVW for various truck configurations by country.

Truck Configuration	NZ	Australia	USA	Canada	UK	Sweden	Finland	EC	Chile	Mexico
A train - 7axles	39	-	36.3	53.5	40	-	-	40	-	-
A train - 8 axles	39	-	36.3	53.5	40	-	-	40	-	-
B train - 7 axles	44	65	36.3	56.5	40	-	-	40	-	-
B train - 8 axles	44	65	36.3	62.5	40	60	56	40	-	62
Logging Jinker (6 axle)	42.2	-	36.3	-	-	-	-	40	-	-
Logging Jinker (5 axle)	37.4	-	36.3	-	-	-	-	40	-	-
Truck and Full Trailer (5 axle)	37.4	45.5	36.3	-	40	40	44	40	47	-
Truck and Full Trailer (6 axle)	42	45.5	36.3	42.6	40	40	53	40	-	-
Truck and Full Trailer (7 axle)	44	45.5	36.3	53.5	40	-	-	40	-	-
Truck and Full Trailer (8 axle)	44	-	36.3	-	40	-	-	40	-	-
Tractor/Semi trailer(5 axle)	-	45.5	36.3	39.5	40	40	44	40	-	-
Tractor/Semi Trailer(6 axle)	39	45.5	36.3	46.5	40	40	53	40	-	-

Table 6 – Vehicle Dimension Restrictions

Dimension	NZ	Australia	USA	Canada	Mexico	EC	Sweden	Finland
Max Length Semi	17	19		23		16.5		
Max. Length (m)	20	25			31.3	18.75	25.25	25.25
Max. Width (m)	2.5	2.5	2.6					
Max Height (m)	4.25	4.3		4.15				