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Improving the Safety of a Log Transport Fleet

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Introduction

Forestry is a major industry in New Zealand, which is set to grow significantly. Estimates indicate that the log harvest will double by 2010. As almost all of the growth is in new forestry areas, which are not well served by rail, the road log transport industry will grow by more than the growth in the harvest. On 1997 figures, the log transport fleet consisted of approximately 650 combination vehicles and made up approximately 7-8% of the large combination heavy vehicles operating on the public road network.

The parliamentary inquiry into truck crashes (Anderson and Sinclair, 1996) initiated by the New Zealand Government identified the poor stability of logging trucks as an area of particular concern. A subsequent analysis of crash statistics (Baas and Latto, 1997) showed that logging trucks were involved in a disproportionately high number of crashes and in particular rollovers. It was conservatively estimated that more than 60 logging truck rollover crashes were occurring each year; that is about one in eleven log trucks was rolling over every year. These rather disturbing figures prompted a series of actions to address the problem, some of which have been very successful, others less so.

The Log Transport Safety Council

In response to the problem the industry established the Log Transport Safety Council (LTSC) with membership from the Forest Owners Association, the Road Transport Forum, most log transport operators and log transport manufacturers. The role of the LTSC is to work with the Land Transport Safety Authority (LTSA), who are the government's safety agency, and the industry to develop measures and strategies to improve the safety of log transport. The LTSC has developed standards for log transport equipment, recommends certifiers to the LTSA and has funded research projects and training and education initiatives. Nearly all of the measures described in this paper had some LTSC involvement.

Stability Analysis of the Fleet

In 1997 Baas and Latto, (1997) undertook a stability analysis of the logging truck fleet. The industry provided data on typical mass and dimensions for all vehicle configurations in use at the time. The Yaw-Roll software developed by the University of Michigan Transportation Research Institute (UMTRI) was used to simulate each vehicle configuration under a range of typical loads and evaluate a range of performance measures. Two of the performance measures relate directly to the vehicle's propensity for rollover. Static Roll Threshold (SRT) is the lateral acceleration at which wheel lift-off occurs. This reflects the vehicle's likelihood of rollover during steady speed cornering. Dynamic Load Transfer Ratio (DLTR) is a measure of the load transfer from one side of the vehicle to the other during a rapid lane change manoeuvre and reflects the likelihood of rollover during an evasive manoeuvre. It was found that many of the vehicle configurations used had poor performance in relation to these two measures.

From data on 450 vehicles it was found that the predominant form of log truck combination vehicle in use in New Zealand is the truck-trailer, which makes up about 90% of the fleet. The remaining 10% are tractor-semitrailer and B-double combinations. Truck-trailers can be 3 or 4 axle trucks coupled to either 3 or 4 axle trailers. All four possible combinations are used with the 3-3 combination slightly less favoured at about 18% of the total log transport fleet and the other three combinations almost equally popular at about 24% each. Trailers are built with either one or two pairs of bolsters. Those with only one pair can carry only one packet of logs and are better suited to longer log lengths, while those with two pairs of bolsters can carry one or two packets of logs depending on log length. At the time (1997) 60% of trailers were fitted with the single pair of bolsters and 40% with the double pair.

Typical log lengths vary from about 3.7m to 8.2m with export customers increasingly favouring the shorter lengths. All the vehicles were modelled with full loads of 3.7m, 4.1m, 5.8m, 7.4m and 8.2m logs. Full trailers used for log transport were operating under a 3.8m load height restriction rather than the 4.25m allowed for the general fleet. For the combinations using trailers capable of carrying only a single packet of logs, the load height limit restricted the vehicles from being loaded to the maximum allowable mass when loaded with the two shortest log lengths above. All other vehicle-log combinations were loaded to their maximum legal gross combination mass.

White and Baas, (1993) suggest the target levels for the two performance measures described above which were used in this stability analysis. They use a lower limit for SRT of 0.35g and an upper limit for DLTR of 0.6 as the benchmarks for acceptable performance. Marginal performance for SRT is defined as between 0.3g and 0.35g and for DLTR as between 0.6 and 0.8.

Poor performance is when SRT is less than 0.3g and when DLTR is greater than 0.8. The distribution of performance of the truck-trailer combinations analysed was as shown in Table 1. Note that the percentages are based on the number of simulation runs so that all log lengths are equally represented. On the road there is a higher proportion of the shorter logs so the on-road distribution will be worse.

Table 1. Distribution of performance measures by trailer type.

Performance Measure	Vehicle Configuration	Acceptable	Marginal	Poor
SRT	Truck-trailers - 1 bolster pair	64%	36%	0%
	Truck-trailers - 2 bolster pairs	100%	0%	0%
DLTR	Truck-trailers - 1 bolster pair	8.3%	86%	5.6%
	Truck-trailers - 2 bolster pairs	43%	57%	0%

Performances Measures and Crash Risk

A further study (Mueller et al., 1999, de Pont et al., 2000) investigated the relationship between performance and crash risk in New Zealand. This work estimated the distribution of performance measures in the general heavy fleet and for a set of vehicles that had been involved in rollover and loss of control crashes. By comparing these two distributions, the relative crash risk for a level of performance was determined. Figure 1 shows the relative crash risk against SRT while Figure 2 shows the risk related to DLTR. Figure 1 is very similar to a figure produced by Ervin,

(1983) for the same type of relationship using US data. The DLTR relationship is interesting in that it appears to be bi-modal. The reason for this is that the distribution of DLTR in the fleet is bi-modal with roll coupled vehicles (tractor- semitrailers and B doubles) having a lower DLTR than similarly loaded combination vehicles that are not roll coupled (truck trailers). Within each of these two categories, however, DLTR is correlated to SRT. Thus a relationship between SRT and crash risk such as that shown in Figure 1 will automatically result in Figure 2 having the form it does. It is difficult to determine whether DLTR has an effect on crash rate that is independent of the effect of SRT. However, because they are correlated improving one improves the other and we would expect to see a corresponding crash rate reduction.

Safety Improvement Initiatives

Load Height Reductions

Following the results of the stability analysis, which identified both the high rollover rate and the poor stability of a significant number of logging truck/ load combinations, the LTSA and the industry represented by the LTSC and the Road Transport Forum (RTF), an organisation representing all road transport operators, developed a strategy to reduce the crash rate. The first step in this plan was to introduce a load height restriction on log trailers. Three axle trailers were restricted to 3.5m overall height and four axle trailers to 3.8m. These height restrictions really only affected the load capacity of trailers with a single pair of bolsters and then only when loaded with the shorter log lengths. Stability analyses were undertaken for the affected trailers with the reduced heights. These height restrictions did eliminate the worst cases in terms of stability but were not severe enough to bring the SRT of all vehicles above the 0.35g target. Anecdotal evidence from operators suggests that the height restrictions had very little impact on efficiency because they adapted by using the problem vehicles for transporting longer logs whenever possible.

Driver Education

The second part of the joint LTSA industry strategy was driver education. A short course was prepared for drivers to make them aware of the inherent instability of logging trucks loaded with shorter logs. The course presented some of the results of the stability analysis, identifying the vehicle combinations with the worst stability. It emphasised the importance of complying with the new height restrictions and the need to reduce speed on corners. Attendance at a course was compulsory for all log truck drivers. However, there was no test to check to what extent drivers had understood and assimilated the material presented to them. A follow up course aimed at operators is currently being presented at venues around the country.

A formal qualification, the National Certificate in Commercial Road Transport has been established for all commercial vehicle drivers. Log truck drivers are being encouraged to attain this qualification.

The "points" system for vehicle design

The LTSC realised that the above two measures only partially addressed the problem while continuing to operate the existing fleet but that a long-term strategy was needed to bring the safety performance of the logging fleet into line with the best-performing vehicles in the fleet. Thus they funded a project to develop a pen and paper based points system to estimate the stability of a log truck-trailer combination. The development and use of the points system is described in more detail in another paper (de Pont et al., 2001) presented at this meeting.

Although the points system has only recently been released for general use by operators and vehicle builders, the development process involved considerable consultation with stakeholders in the industry. These discussions highlighted the key factors that contribute to vehicle stability, which created an industry awareness of the issues that had not existed.

One of the largest operators commissioned Yaw-Roll simulation analyses on a large number of vehicles in his fleet to assess their stability performance. When he found that he could not get existing manufacturers to design and build new vehicles to what he considered a satisfactory level of stability performance, he established a new trailer manufacturing operation as a joint venture with an aluminium fabricator. Based on his ideas they have developed a new vehicle design with superior stability characteristics. This company is now probably the fourth largest manufacturer of log trailers in New Zealand. All the other major log trailer manufacturers have responded and all the current generation of new log trailers being built have better stability characteristics than the typical vehicles that were analysed in the 1997 stability analysis.

Anecdotal evidence on the safety of these new vehicles is very encouraging. The operator, who developed these new vehicles, has reported on two incidents involving these trailers that resulted in minor crashes where, in his opinion, the older style of trailer would have rolled with potentially disastrous consequences. In one of these incidents the other vehicle was a laden bus. Driver feedback on their handling and driveability is also very positive.

Speed Control

This is a critical issue and one of the most contentious. The open road speed limit in New Zealand for passenger cars is 100 km/h. For rigid trucks, buses and articulated vehicles including

B doubles it is 90 km/h. For all vehicles towing trailers that are not roll-coupled it is 80 km/h. However, heavy vehicles are not required to be fitted with speed limiters and those that are fitted with them often have them set to 100 or 110 km/h. Speed limit enforcement is undertaken by the police using microwave and laser detectors, which are either connected to cameras or manually operated. The camera-operated systems, which are the most widely used, are automatically triggered and the trigger level is set to 110 km/h. As the cameras cannot distinguish between light and heavy vehicles these systems apply no enforcement to trucks below 110 km/h. Manually operated radar can, of course, distinguish trucks from light vehicles but from front-on operators have difficulty distinguishing truck-trailers from B-doubles. Again a tolerance of 10 km/h is typically used so for these devices the enforcement level on heavy vehicles is 100 km/h.

Most of New Zealand is hilly or mountainous. This is particularly the case in forestry areas, as flat land is not usually used for forestry. Roads are generally two-lane and can be winding. The recommended speed for curves is based on vehicles being subjected to a lateral acceleration of 0.22g when driving through the curve at that speed. Where the recommended speed is below the speed limit for the road an advisory speed sign is normally posted. The speed on the advisory sign is rounded to the nearest 5 km/h but the method used for determining the recommended speed is probably less accurate than this. In a passenger car it is possible to exceed the advisory speed by 20% quite comfortably while for a truck with an SRT of 0.3g exceeding the advisory speed by 20% will cause rollover.

The LTSA conducts six-monthly speed surveys of heavy vehicles and has found that the mean free-running speed of truck trailers is typically around 92-93 km/h with between 60 and 70% exceeding 90 km/h and 10-15% exceeding 100 km/h. The latest figures for early 2001 show a reduction in speeds but there was no overall downward trend apparent in the figures for the preceding periods. It is too soon to say if these measurements were just a statistical glitch or the beginnings of a reduction in mean speeds.

An analysis of the data on rollover and 'loss of control in a curve' crashes of logging trucks for the period from July 1996 to December 1999 was undertaken. Assuming the vehicles had an SRT of 0.32g, it was found that in 55% of cases the rollover speed for the curve was greater than 85 km/h and in 45% of cases it was greater than 90 km/h. These percentages were relatively insensitive to the SRT value assumed. The number of crashes where the site could be identified and the road geometry data was available was small (20 crashes) so there is relatively high uncertainty on the results. Nevertheless it appears that if log trucks were fitted with speed limiters to restrict them to 85 km/h a significant proportion of the rollover and loss of control could be prevented. However, there is strong opposition in the industry to compulsory speed limiters.

A measure requiring log truck drivers to negotiate corners at 10% below the posted advisory speed was proposed. As part of speed limit enforcement the police would report any drivers exceeding the advisory speed thus allowing a 10% tolerance. There were no legal sanctions but the industry agreed that three "strikes" by any operator within a 12 month period would result in their truck immediately being withdrawn from duty for 24 hours.

Initially the measure was introduced on a trial basis where the reporting was done but no sanctions were imposed. The number of violations was substantial and it was clear that a significant number of vehicles would be stood down. The operators felt that the advisory speeds for many bends were incorrect. It was accepted that it would be unfair to penalise operators based on incorrect information and so the scheme was modified. The recommendation that log truck drivers negotiate curves at 10% below the advisory speed remains. However, in order to receive a "strike" the driver had to be exceeding the advisory speed and be issued with a traffic infringement notice for dangerous driving. In practice this requires speeds significantly above the advisory level. In addition the policy was extended in November 2000 to include over-height loads, general speeding offences and excess weight as generating a "strike". The "strikes" are marked against the driver rather than the operator and the penalty was changed so that the offending driver was stood down from duty for five days rather than the truck for one day.

The Safety Rating Scheme

The safety of heavy vehicle operations in New Zealand is, at present, controlled by regulation and enforcement. The LTSA sets standards for vehicles, limits for dimensions and mass, controls driver licensing, driving hours and operator licensing. Since the deregulation of the industry in the mid-1980s there are minimal barriers to entry into the industry. The prospective operator is required to be a "fit and proper" person, which essentially means that s/he has no serious criminal convictions and is not an undischarged bankrupt. There are no checks on their financial viability or their ability to run a safe transport business.

Compliance with vehicle standards is tested through compulsory six-monthly inspections at specialised certified testing facilities and a limited amount of random roadside inspection, which is usually undertaken by a special unit of the police. Compliance with driver licensing and driving hours regulations is also enforced by the police through random roadside inspections. Occasional audits of operators for compliance with road taxes and driver hours regulations are undertaken, usually in response to some evidence of wrongdoing.

This overall approach has some serious limitations. Many operators appear to use the periodic inspections as part of their vehicle maintenance procedures. 30-40% of heavy vehicles presented for inspection fail their first check (Anderson and Sinclair, 1996). Because of the high mileages travelled by heavy commercial vehicles, the chances of a vehicle developing a defect between inspections is very high and thus this approach leads to a significant number of vehicles on the road with defects. The LTSA conducted a heavy vehicle brake survey in 1998 using a Truckalyser portable brake testing device. This study found that more than half of vehicles had defects and that for more than a quarter of the vehicles the defects were so serious that that vehicle had to be withdrawn from service. Compliance with the driving hours regulations is also poor. A study on driver fatigue (Charlton and Baas, 2000) found that 30% of the subjects tested had violated the driving hours limits in the previous 48 hours.

To address these issues the LTSA is proposing the introduction of a safety rating scheme similar to that used in the United States. Under this scheme the emphasis will change from a regulation and enforcement philosophy to one where the operators are required to take responsibility for the safe operation of their fleet. They will be expected to have systems in place to ensure that they have safe vehicles and safe drivers and will be rated on their performance. Operators with a poor record in respect of crashes, failures at roadside inspections or periodic inspections and traffic violations will be targeted for intervention. Their management practices will be audited and they will be helped with advice on improvements. Operators receiving an unsatisfactory rating will be given a period to improve and if they fail to do so will be removed from the industry. Operators with a superior rating may receive some concessions.

This approach has been strongly supported by the log transport industry and they are trialling it for the LTSA. Two operators have acted as guinea pigs for the first audits, which have been undertaken.

Dimensions and Mass Rule

The LTSA is currently developing a new dimensions and mass rule (LTSA, 2001) for all heavy vehicles. This includes a stability requirement for all heavy vehicles. The mechanism for how this will be implemented is presented in another paper (de Pont et al., 2001) at this conference. This stability requirement specifies an SRT level that all heavy vehicles must meet and will effectively remove all of the worst cases from the road. Log trucks with poor inherent stability will have load height restrictions that ensure their SRT is greater than 0.35g. This rule is currently under public consultation and will probably become law in July 2002.

Effectiveness of the Measures

When the findings of the stability analysis were released showing both the high crash rate and the inherent poor stability of many of the log trucks, the load height and driver education measures were introduced within three months. In the first three months following the implementation of these measures there was an apparent major reduction in rollover rate with only two or three rollover crashes reported to the police. There is no legal requirement to report non-injury crashes so there may have been some other unreported crashes. Furthermore, this period was at the end of 1997 and beginning of 1998, which coincided with the Asian economic downturn. As the transport of logs to ports for export to Asia is a major component of the log transport business there was also a significant reduction is traffic volumes. Nevertheless, this was a substantial reduction on the previous crash rate. However, after these initial gains, the rollover crash rate gradually crept back up again so that nine months later the rollover crash rate did not appear to be significantly lower than it had been prior to the measures. Although there is no firm evidence to support this contention, it appears that after the initial impact of the education programme drivers may have been more conscious of their cornering speeds but that over time they reverted back to their previous practices. Surveys by LTSA have shown that compliance with the load height restrictions is good but no long-term changes in speed behaviour have been observed.

The work on the "points" system started in mid 1999 and has taken some time to complete. However, as outlined above the project involved considerable industry consultation. The result of this consultation together with the results of other stability analyses has had a significant impact on the performance characteristics of the latest generation of log trailers. With the increase in the harvest and the recovery of the Asian market there has been substantial growth in the industry in the last two years. This has seen a boom in trailer manufacturing and it is estimated that there are now nearly 1,000 log transport combination vehicles operating (up from 650 in 1997). As many of these additional vehicles are the new higher stability vehicles the average performance of the fleet has changed dramatically.

The measure of voluntary restricting the cornering speed to 10 km/h below the advisory speed was implemented in the fourth quarter of 1999. It seems to have had minimal impact. The LTSA have conducted speed surveys at two curves on a major log truck route in 1999 (before the measure), 2000 and 2001 and found very little difference in speeds between the three years and certainly no reduction. At one of the sites the advisory speed was 65 km/h and so the log truck limit was 58 km/h. Only 9% of vehicles had a speed of 58 km/h or less and 74% exceeded the 65 km/h advisory speed. The mean speed through the corner was 70 km/h. The other curve had an advisory speed of 75 km/h and hence a log truck limit of 67 km/h. In this case no vehicles were at or below 67 km/h and 71% exceeded the 75 km/h value with the mean speed being 79 km/h. Another LTSA speed survey looking at free-running speeds on straight sections conducted in August 2000 found that log trucks were travelling at an average speed of 90.6 km/h with 94% of them exceeding 80 km/h, which is the speed limit for this type of vehicle.

The safety rating scheme and the new dimensions and mass rule have not yet been implemented. The discussions and consultation associated with them has resulted in improved operator awareness of the issues and may well have had some impact although it is not possible to quantify this.

Overall the rollover crash rate has improved substantially over the four years that these measures have been introduced. An analysis undertaken by TERNZ for the LTSA in September 2000 compared the rollover crash rate for logging trucks for the year ending June 2000 with that for the year ending June 1997. It was found that although the number of logging truck combinations had increased by 44% the number of rollover crashes had declined by 48%. If the increase in the number of vehicles is taken into account the rate of rollover crashes reduced by 64%. Over the same period the rate of rollover crashes for all combination heavy vehicles also declined by 45%. Thus the improvement in rollover crash rate for logging trucks was significantly greater than that of the general fleet. Nevertheless the rollover crash rate for logging trucks was still significantly higher than the fleet average. There is a reasonably high degree of uncertainty in these figures because they include assumptions about the level of under-reporting of rollover crashes. However, the same assumptions are made for both the logging trucks and the general fleet so the relative magnitudes of the two figures should be reasonably accurate.

Conclusions

An analysis of log truck stability in 1997 identified their poor stability performance and their high incidence of rollover crashes. A number of measures have been introduced since then to reduce the number of these crashes.

Of these, the vehicle-related measures, including the load height restriction, the development of a points system for assessing stability and changes to the dimensions and mass regulations for all vehicles have been successful. Many new logging vehicles have considerably better stability performance than their predecessors do. The success of the human-related measures has been mixed. The driver education programme appears to have been effective in the short-term but its benefits did not last, the attempts to reduce speeds in curves seem to have had no impact at all, while the measures to improve the safety management of the operators have generated an encouraging response but it is too soon to determine their effectiveness.

Overall as a package the measures have resulted in a reduction in the rollover crash rate of the log truck fleet. On going developments should see further improvements over the next few years. The one obvious area where potential gains seem likely and yet where there is little progress is in reducing speeds particularly on curves.

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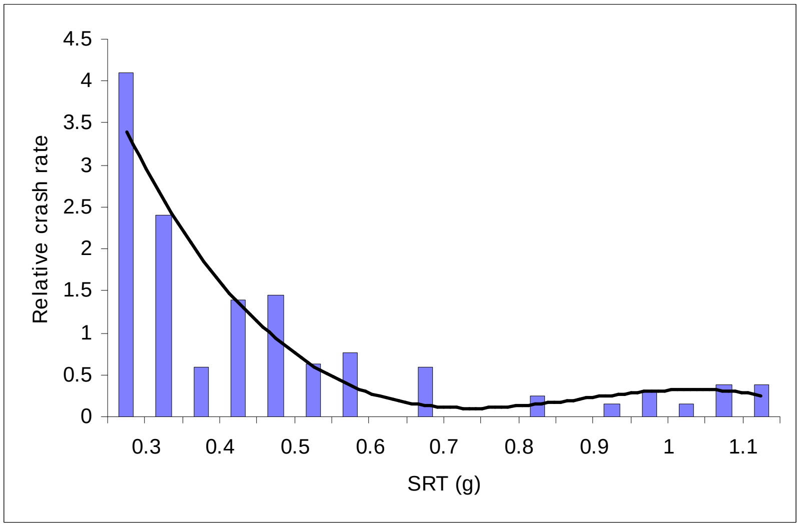

Figure 1. Relative crash rate against SRT for all vehicles in New Zealand.

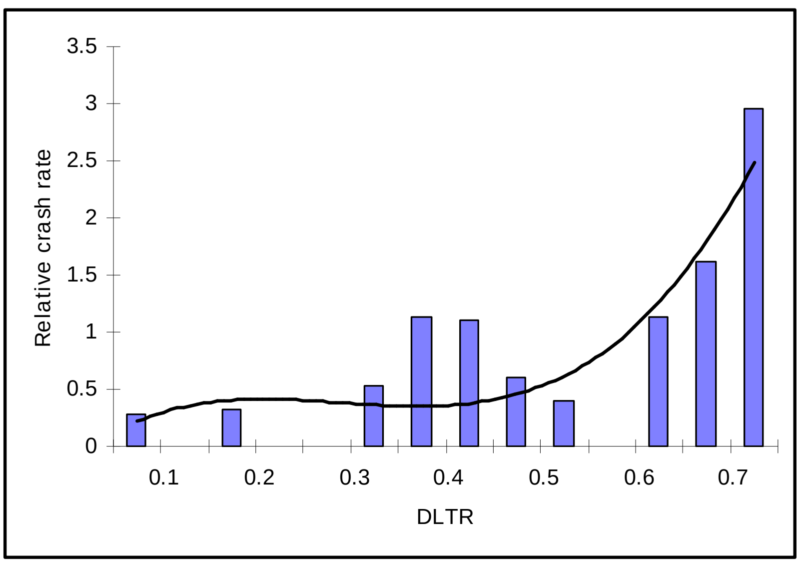

Figure 2. Relative crash rate against DLTR for all vehicles in New Zealand