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Development of a Performance Based Mass and Dimension Limits Rule

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Abstract

This paper describes the development of a proposed new Rule to limit the weights and dimensions of heavy vehicles in New Zealand. The development of the Rule draws on new knowledge on the performance of heavy vehicles and experience that has been gained in New Zealand over the past 15 years with the use of the vehicle performance based approach. The Rule is currently in a draft stage and any comments would be most welcome. It is not yet Government policy.

Research undertaken for the Rule setting process established the relationships between vehicle performance measures, crash rates and social cost. This information has been used to provide the underlying requirements in the Rule including the prescriptive requirements that will apply to the majority of heavy vehicles on the road. The continued use of prescriptive requirement is in recognition of the cost and complexity of compliance and enforcement for a purely performance based approach.

To illustrate the approach being used in New Zealand the steps being taken to address log truck safety are described. The safety of log trucks has been of considerable concern with an estimated 1 in every 11 log trucks rolling over every year. A number of approaches have been investigated including: reductions in their allowable load height (for which the effect on social cost and productivity were calculated), improved trailer design (and whether these should be controlled through prescription or performance), the development of a proposed operator safety rating scheme and the management of vehicle speed.

1.0 INTRODUCTION

The last major changes in weights and dimension limits in New Zealand occurred in 1989. These changes included an increase in maximum combination mass to 44 tonne and an increase in overall length to 20m. These limits were similar to those in Australia at that time, however the Australian limits have been increased since then. There has been some rationalisation of the limits, for example truck-trailer combinations, initially restricted to 42 tonne, are now permitted to operate at 44 tonne and 20m. There have however been no major changes. Changes that have been made have had to be justified on their effect on safety and benefits versus costs.

Currently two major reviews on weights and dimensions are being undertaken in New Zealand. One of these is aimed at determining whether it is feasible to increase the current maximum allowable weights and dimensions. It is considering the effect an increase would have on safety, pavement and bridge life, and productivity and what changes would be required to the geometry of the existing network to accommodate larger vehicles. An outline of this review is being presented at this conference by (Sleath and Pearson, 2000).

The other initiative is the development of the Land Transport Rule on Vehicle Dimensions and Mass. This paper describes the development of this Rule, which is awaiting Government approval for consultation with registered interest groups. The Rule is aimed at ensuring existing and new vehicles fit safely on the present road network

2.0 LAND TRANSPORT RULES

In 1993 the New Zealand Land Transport Safety Authority (LTSA) began converting much of the existing land transport legislation into Rules. These Rules bring together requirements from many legislative sources including the regulations, Gazette notices, orders and policy directives. They also provide the opportunity to undertake a zero-based review of the current requirements. They do not however replace Acts of Parliament. They are at a second-tier level with the authority to make rules contained in the Acts.

The Rules must promote safety at a reasonable cost, must be technically accurate, legally correct and must be written in plain language to ensure they are easily understood. Formal procedures for the development of Rules have been established. These procedures include a number of consultation stages that begin with consultation with registered interest groups, followed by public consultation, review by technical specialists and finally presentation to Parliament.

3.0 PRESCRIPTIVE VERSUS PERFORMANCE BASED REQUIREMENTS

Mass and dimension regulations have traditionally been prescriptive – vehicles are prohibited from operating on public roads unless they are within certain mass and dimension limits. These limits reflect the general state of the road network and the state of vehicle technology when the limits are set. The increase from 39 tonne to 44 tonne gross combination mass in 1989 was facilitated, at least in part, by the introduction of B-trains and general improvements in the roading network. Initially only B-trains were permitted to operate at 44 tonne.

Actual or perceived changes in vehicle technology and the state of the roading network soon lead to pressure to amend the limits. Generally these requests are driven by potential commercial advantage and on their own appear to be reasonable. They tend to be considered on an ad-hoc, case-by-case basis resulting in incremental creep if no rational basis for setting the prescriptive limits is available.

This has lead to the use of performance measures as a means of assessing proposed changes to the prescriptive limits in New Zealand. A major driving force behind the adoption of this approach has been the requirement that the benefits of any changes need to outweigh any social costs.

Since the early 1990's performance assessment has been used extensively as a means of assessing the effect of changes in mass and dimensions. This has included, for example, the increase in truck-trailer combination mass from 42 tonne to 44 tonne with an associated increase in overall length from 19m to 20m, and the introduction and control of self-steering axles on semi-trailers. It has also led to restrictions being placed on the overall height of full trailers carrying logs due to concerns about their safety.

These changes have generally resulted in modifications to the prescriptive requirements. One of the exceptions to this approach has been the permitting of A-train configurations to operate at 44 tonne GCM. The dairy industry sought an increase from the then 39 tonne limit. For these combinations certification of each combination to performance targets was required. Due to the inherently poor stability of A-trains particular attention had to be paid to factors such as payload height, suspension and tyre properties. Being milk tankers payload height could be controlled through design. The resulting vehicles have proved to be considerably safer and more productive than their 39 tonne GCM predecessors.

This experience has highlighted some of the benefits of the performance measures approach but also its practical limitations. The cost of design, certification and compliance has meant that there has been very few 44 tonne A-trains approved, with operators opting for truck-trailer combinations instead. There are also significant complications associated with obtaining accurate component data and compliance verification.

Both the prescriptive and performance measures approaches have their place. While the prescriptive approach is relatively easy and cost effect to administer, unsafe vehicles can slip through, it can stifle progress resulting in the loss of potential productivity improvements as vehicle technology and the roading infrastructure improve, or ad-hoc incremental creep and a consequential gradual reduction in safety can occur. The performance measures approach has the potential to better manage the safety outcome but is more difficult and expensive to administer and enforce.

4.0 PROPOSED APPROACH

The objective of the proposed Rule is to manage the risk to road safety resulting from the size and mass of vehicles while ensuring the efficient operation of the heavy vehicle fleet within the constraints imposed by the road network.

A set of performance requirements form the high-level basis of the proposed Rule. A motor vehicle will have to comply with requirements for stability, manoeuvrability, fit on the road, and interaction with other traffic. The performance targets that are proposed are:

- A static rollover threshold of 0.35g for vehicles manufactured before 12 months after the Rule comes into force and 0.4g for new vehicles after that date.
- Low-speed off-tracking that does not exceed 4.2m.
- A dynamic load transfer ratio that does not exceed 0.6.
- A rearward amplification that does not exceed 2.
- A high-speed transient off-tracking that does not exceed 0.8m.
- A yaw damping ratio that does not exceed 0.15.
- A swept path of less than 25m in a 360-degree turn.
- Outswing of the front corners of a trailer of not more than 0.35m beyond the path of the front of the towing vehicle when driven through a 180 degree turn of 12.5m radius.
- Tailswing of each vehicle in a combination, measured from the centre of the rear axis to the centre of the rear of the vehicle, that does not exceed 0.5m through a 180 degree turn of 12.5m radius.
- Inter-vehicle spacing for a truck and full trailer of at least 0.4m through a 270 degree turn of 12.5m radius. Log trucks towing a full trailer must have an inter-vehicle spacing of at least 0.3m.

A set of general requirements are proposed. These include, for example, overall width and length, rear overhang, ground clearance, turn-table position, inter-vehicle spacing in the straight ahead position, and trailer mass ratio. Vehicles that meet these requirements generally meet the performance requirements.

Permits will continue to be available for the transport of over-dimension or overweight loads although the eligibility criteria may the changed in order to reduce the number of vehicles that require a permit.

Deviations to the general requirements will need to be justified on the basis of the performance requirements and cost-benefit analysis.

5.0 HIGH RISK VEHICLES

There are some existing vehicle combinations that would fail to meet the proposed performance requirements but would meet the proposed general requirements. An example of this is logging trucks.

Logging trucks are predominantly truck-trailer combinations. They generally have relatively high centre-of- gravity loads because of the need to be able to load and unload with grapple loaders, and short wheelbase trailers to enable them to be piggy-backed when empty. Laden log trucks typically have a static rollover threshold of 0.3g, compared to the target value for existing vehicles of 0.35g.

Research undertaken in 1997 (Baas and Latto, 1997) conservatively estimated that over 60 logging trucks rolled over each year, or more than one per week. With 650 logging trucks in the fleet this equates to one in every 11 logging trucks rolling over each year. This is approximately four times the average for all truck combinations.

In New Zealand the cost the public is prepared to pay (referred to as the social cost) to prevent 1 fatal crash involving a truck is NZ$2.64million. This includes average property damage costs. Using the stability versus crash rate relationship reported by (de Pont, Mueller et al., 2000) at this conference, combined with the social cost values and crash history data, the social cost of a laden log truck is estimated to be approximately $222 per 1,000 km. A typical log truck will spend approximately ½ of its journey laden and ½ unladen. An unladen log truck piggy-backing its trailer has an SRT of approximately 0.53g and a social cost of approximately $39 per $1,000km which, when combined with the laden travel, results in an average social cost of approximately **$130 per 1,000 km** for existing log trucks.

The social cost of a combination vehicle with an SRT of 0.35g is estimated to be approximately $154 per 1,000 km. When combined with unladen travel, the social cost equates to $96 per 1,000 km. The net benefit from an improvement of SRT from 0.3g to 0.35g is then **$34 per 1,000 km**.

An option that is being considered is to reduce the allowable payload height on existing trucks until a SRT of 0.35g is obtained. A reduction in maximum load height by approximately 200mm would be required. Currently 3 axle and 4 axle log trailers are restricted to 3.5m and 3.8m respectively. B-trains, currently with a limit of 4.2m, would need to be restricted to 3.3m maximum load height, depending on log length being carried. Even though such a reduction would result in a 2 percent loss of productivity, the benefits outweigh the costs and consequently can be justified on safety grounds. Rather than suffer a reduction in productivity the logging industry has agreed to develop a number of alternative measures including radical changes to the design of log trucks and trailers, aimed at significantly reducing bolster (load deck) height and longer wheelbases. A safety rating scheme is also being trialed.

6.0 SCREENING SYSTEM

The experience with logging trucks has highlighted the need for a system that ensures all vehicles have adequate performance. Reliance on the general prescriptive requirements is not adequate on its own.

One possible option is to require all heavy vehicles to be certified to show that they have adequate performance. As mentioned above, the experience with certifying the performance of milk tanker A-trains suggest that this approach is expensive, unnecessarily complicated and open to abuse. A number of other heavy vehicle systems such as brakes, drawbars and load anchorage points, already require certification in New Zealand. Certifying for overall performance would be more complex than it is for these other systems because of the variations in payload type, dimensions and weight that would need to be taken into account. With the milk tankers the load was largely known and contained. This is not the case for general freight.

Another possibility is screening using a variation on the methods proposed by Winkler, Fancher et al. (1992). The first level of screening would involve the calculation of T/2H where T is the track width and H is the CG height. Any type of suspension could be used if a minimum T/2H value was achieved. Vehicle types that failed this first level of screening would be subject to a second level that would allow a lower T/2H value but would require minimum levels of suspension and tyre stiffness. Vehicles that failed this second level of screening would have to either meet performance tests or comply with the baseline vehicle points system being developed for log trucks. This approach is described below.

Truck-trailers can be subdivided into four configurations reflecting the number of axles they have. Specifically these are: 3-axle truck 3-axle trailer, 3-axle truck 4-axle trailer, 4-axle truck 3-axle trailer, and 4-axle truck 4-axle trailer. For each of these configurations a reference vehicle will be designed, which meets all of the target values for performance and so will be rated as having zero safety points. This vehicle design process is being undertaken in consultation with the logging industry to ensure the final designs are viable from an operational point of view. The most critical vehicle parameters (including, for example, load height and wheelbase) are being identified together with the reference values for the different configuration. Changes from these reference values will generate positive points if they have a positive effect on stability and hence reduced crash risk and negative points if they have a negative effect. For a good vehicle, the sum of all the changes from the reference values should give positive total points. If a vehicle ends up with negative total points the operator would need to look hard to see where improvements could be made. The points scale will clearly identify those factors which have the greatest impact on stability and this should help in this decision making process.

As an example of how this would work, consider the steady speed cornering performance of a three-axle trailer. For rollover, the main determining factor is the CG height of the rig. However, an operator cannot easily determine this. For a typical rig with specified tare, log density, payload mass (the values used will be given), this Cg height is directly related to the sum of the bolster bed height from the ground and the maximum load height from the ground which are measures that the operator can easily determine. Figure 1 shows the relative safety effect using a points scale related to crash risk for this parameter.

The zero points level is based on a performance target for static roll threshold (SRT) of 0.4g. The tare weight used was 4.2 tonnes with a typical suspension configuration. This graph illustrates the difficulty in getting a three-axle trailer to meet the desired stability target. Other factors will be able to be adjusted to improve the rating but these will give fewer points. For example, changing to the best available suspension (highest roll stiffness) might gain one point (this calculation has not yet been done so this is purely a speculative value at this stage) which is equivalent to an increase of 0.08m in the bolster bed height + payload height parameter.

Similar graphs will be developed for other vehicle types and other crash risk parameters. In specifying a vehicle the operator would aim to achieve an overall points tally which was zero or positive indicating that the vehicle was as good or better than the recommended standard.

7.0 DISCUSSION

Even with a clean sheet of paper and no state or territorial boundaries to worry about, the setting of weights and dimensions is a complex task. Any Rule or regulation must be easily understood, must be able to be administered and enforced, and must result in a high level of compliance while ensuring road safety is not compromised.

We do not profess to have all the answers and would welcome any comments or suggestions on the proposed Rule.

8.0 DISCLAIMER

The views expressed in this paper are entirely personal and should not be relied upon as representing those of LTSA or Government policy. The Government has not to date considered the issue of changing the requirements for heavy vehicle mass and dimension limits.

9.0 REFERENCES

Baas, P. H. and D. J. Latto (1997). Logging truck stability analysis. Auckland, TERNZ: 59.

dePont, J. J., T. H. Mueller, et al. (2000). Performance Measures and Crash Rates. 6th International Symposium on Heavy Vehicle Weights and Dimensions.

Sleath, L. and R. A. Pearson (2000). Heavy Vehicle Limits in New Zealand - A New Approach. 6th International Symposium on Heavy Vehicle Weights and Dimensions, Saskatoon, Canada.

Winkler, C. B., P. S. Fancher, et al. (1992). Heavy Vehicle Size and Weight - Test Procedures for Minimum Safety Performance, UMTRI: 118.

10.0 ILLUSTRATION

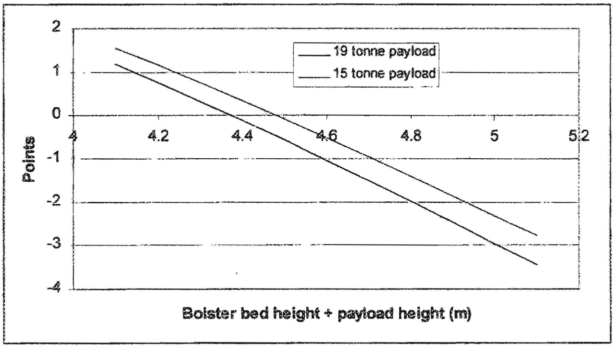

Figure 1: Safety Points versus the sum of bolster bed height and payload height.