Session 7
Paper (c)

Higher Gross Weights and Truck/Trailer Dynamics

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INTRODUCTION

The function of a road transport operation is inherently simple — to move goods from one location to another. It is in the execution of that task that the complexities arise.

Because the transport operation normally includes travel on public highways, there are immediately constraints imposed. These constraints are for the benefit of all road users, so that mayhem and mishaps are minimised.

The constraints take such forms as driver, vehicle and transport operation licences, mass and dimension limits, minimum standards for various components, and a myriad of operating rules.

> *The very operation of trucking [is] contingent upon the public trust which has been tacitly placed in allowing a commercial enterprise to conduct its business on that which is owned, occupied and maintain publicly.*
>
> R.D. Ervin, UMTRI (in Leasure, 1986)

Mass and dimension limits are one of the constraints imposed on commercial road transport in recognition that the road network is shared with other, much smaller, road users. Transport operators need continued public approval (or lack of disapproval) to maintain or increase such regulatory limits.

MASS & DIMENSION LIMITS COMPARISON

Mass and dimension limits are imposed to

- preserve the infrastructure (roads and bridges)
- maintain an acceptable level of safety (stability and manoeuvrability)

Safety is directly related to stability, as Figure **1** indicates. As the Static Roll Threshold[1] increases, the occurrence of rollover decreases rapidly.

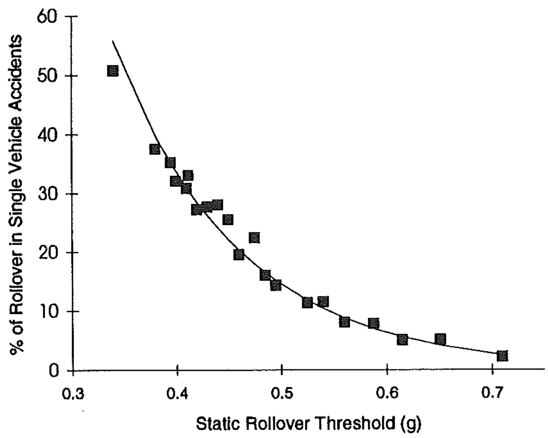

Figure 1 Direct relationship between Static Roll Threshold and vehicle safety (from Ervin, 1980)

Indicative mass and dimension limits from several countries are collated in Table **1**.

[1] Stability measures are explained in Appendix A.

Table 1 Maximum Size and Weight of As-of-Right Tractor-Semitrailer, by Country

Country	Overall Width (m)	Overall Height (m)	Overall Length (m)	Gross Combination Mass (t)
Australia	2.5	4.3[1]	19	42.5
New Zealand	2.5	4.25	17	39
Canada	2.6	4.15	23	46.5
U.K.	2.5[2]	4.2	-	38[3]
Europe	2.6	-	-	40[1]

PROSPECTS OF INCREASING MASS & DIMENSION LIMITS IN NZ

There are strong economic arguments for relaxing New Zealand's mass and dimension regime. The matter of international competitiveness is one of the most compelling.

The economic benefits are readily quantified. The cost per tonne of transporting goods on a 56 tonne GCM[4] combination is approximately nine per cent less when compared with a 44t vehicle (Smith, 1994), even considering increased costs such as fuel, tyres and Road User Charges.

The major impediments to increased mass and dimensions appear to be twofold:

1. Many New Zealand bridges were designed and constructed before "future-proofing" was considered essential. Strengthening or replacement will be required for those bridges below par before heavier vehicles can be safely admitted on the affected routes.
2. The second impediment is not technical, but political. Not only the decision-makers need to be convinced of the merits of increasing transport efficiency by relaxing the mass and dimensional limits. It is essential that the public be pursuaded that the move would provide a net benefit for the nation.

The first impediment is likely to be a matter of political will, also. If the concept is recognised as worth implementing, then strengthening bridges is merely a matter of time and money.

Even if the bid for increased GCM succeeds, it is highly unlikely to emerge without numerous pre-conditions. Politicians would find it much easier to approve mass and dimension increases if it was clear that road safety was not going to be compromised. This has been standard practice since (and including) the introduction of the 44 tonne limit. The forty-four tonne A-train policy is an extreme example, but it cannot be denied that it has resulted in significantly more stable vehicles than their 39 tonne predecessors.

STABILITY PERFORMANCE OF CURRENT LOGGING VEHICLES

A cursory initial assessment of the stability performance of typical NZ logging vehicles follows. Table **2** outlines the findings. (Results outside the target values are highlighted in bold type.) Figures **2** and **3** illustrate the results for the stability parameters in which the target values are not met in some instances.

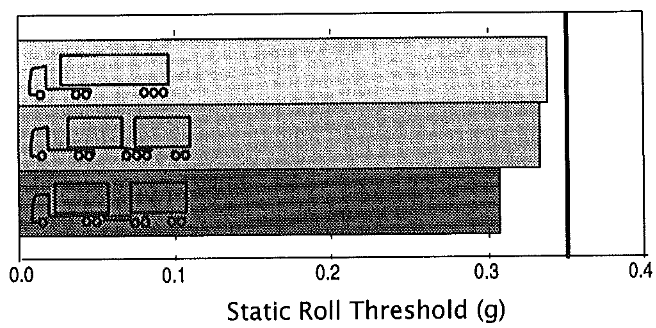

Figure 2 Static Roll Threshold results for typical on-highway logging trucks (target: 0.35 g minimum)

1 some 4.6m in Queensland

2 2.6 m for refrigerated vehicles with sidewalls at least 45 mm thick.

3 44 tonne on intermodal transport.

4 Gross Combination Mass

Table 2 Typical Stability and Manoeuvrability Levels for NZ Logging Vehicles

Vehicle	Static Roll Threshold (g)	Dynamic Load Transfer Ratio	High-Speed Transient Offtracking (m)	Yaw Damping Ratio	Low-Speed Offtracking (m)
6-axle Tractor Semitrailer (39t)	**0.34**	**0.63**	0.39	> 0.30	3.67
8-axle B-train (44t)	**0.33**	0.53	0.41	> 0.30	4.42
3-axle Truck 4-axle Trailer (42t)	**0.31**	**0.67**	0.35	0.28	3.17
Target Values	≥0.35	≤0.60	≤0.60	≥0.05	≤4.5

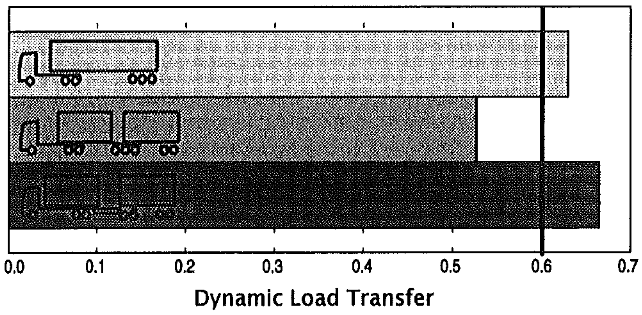

Figure 3 Dynamic Load Transfer Ratio results for typical on-highway logging trucks (target: 0.6 maximum)

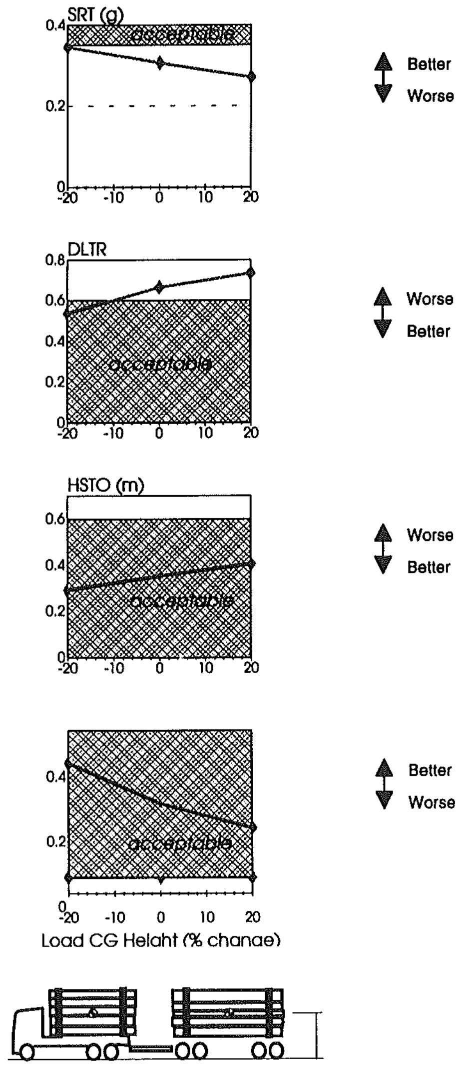

Figure 4 Effect of Load Height on stability results

MEANS OF IMPROVING STABILITY

Logging trucks have one advantage over milk collection vehicles when it comes to improving their stability: their starting stability levels are worse, and thus it is easier to make gains!

Immediate Improvements

Load Height

Substantial gains in stability are possible if the load centre of gravity is lowered. For example, designing trailers to accommodate five bunks of short logs, where previously only four bunks were available, will lower the height of the load CG[1] above the bolsters by 20%.

1 Centre of Gravity

Figure 4 highlights the strong influence of CG height on all stability measures. In every measure, stability improves markedly as CG height is reduced.

Hitch Overhang

The longitudinal distance from the ringfeeder coupling forward to the rear axis is the Hitch Overhang. A large Hitch Overhang acts to amplify the motion of the truck rear causing larger sideways displacements of the drawbar eye. Since lateral movement of the drawbar eye steers the trailer, increased trailer yawing[1] results. This tends to diminish the dynamic stability.

The effect is significantly smaller than changing the load height, however (Figure 5).

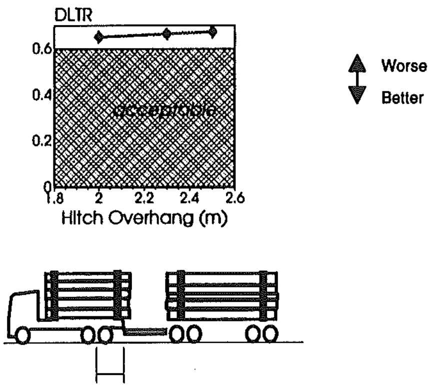

Figure 5 Minor effect of Hitch Overhang on Dynamic Load Transfer Ratio results

Component Selection

In previous stability investigations it was found that careful attention to the properties of tyres and suspensions can make a large difference to the stability performance of vehicles. Not all results can be anticipated from common sense, though (White, 1994).

Future Improvements

Further means of improving vehicle stability are possible, though not yet. This is either because of a need for a change in policy in New Zealand, or because the technology is still under development.

2.6m Width Limit

Some countries have changed their maximum allowable width to 2.6 metres. There are advantages in storing standard sizes of pallets and sheet material inside 2.6 m wide containers.

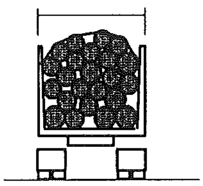

Figure 6 Benefit of Increased Width

If vehicles are designed with chassis spacing and axles for 2.6 m width, all stability results improve by at least 10%, Figure 7.

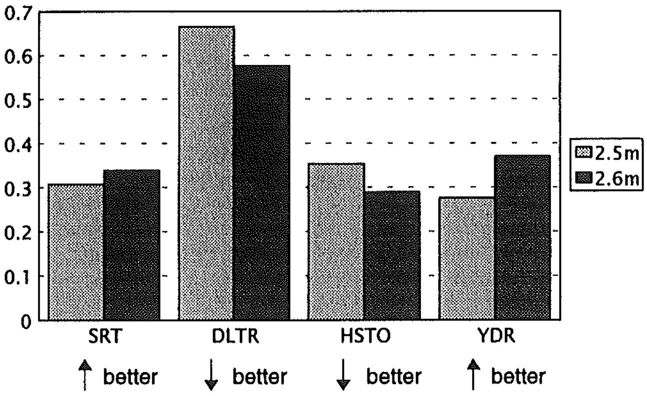

Figure 7 Stability improvements possible by increasing allowable vehicle width

Figure 7 only examines the advantage of wide suspension and tyre track widths. Many loads (including logs) will also take advantage of the added width to lower the payload CG height, increasing the stability benefits further.

However, while the stability benefits are obvious, the response from regulatory authorities in New Zealand to the concept of a 2.6 m overall width has always been very negative. Clearly there is also the disbenefit of the extra road space required, and in constrained situations such as narrow bridges there is potentially an increased safety hazard.

1 Yaw is rotation about a vertical centreline. Yawing is changing direction.

Longer Overall Length

By permitting longer vehicles, the deck area can be increased. As with the 2.6 m width situation, this can result in lower payload CG height.

Rollover Warning Devices

While not contributing directly to the vehicle stability performance, rollover warning devices could improve the safety of heavy vehicles. Similar in operation to an aircraft stall warning device, a rollover warning device would activate when a rollover is imminent, providing the driver with time to take corrective action.

Research in this field is in progress in Australia (George, 1992).

Active Suspension/ "Tilting Truck"

Active suspension, made famous by the Lotus car company, particularly with its use on Grand Prix cars, opens added possibilities for stability enhancement.

Active suspension replaces the spring and shock absorber with a hydraulic cylinder. (Semi-active suspensions keep these "passive" components and augment them, reducing the power demanded by the hydraulic pump.) The hydraulic cylinder length is controlled by a computer system, based on inputs giving the road profile, force in the cylinder, vehicle forward speed and tailored according to a selected operating mode. The suspension characteristics of the vehicle can be readily converted from "ambulance-quality ride" to "formula one racing car".

How does this relate to trucks? By developing a "tilting truck". In the early 1980s, the British developed an advanced passenger train for high-speed operation on existing tracks[1]. The method they adopted for increasing the safe cornering speed in "less than optimum radius" corners was to tilt the carriages towards the inside of the corner, as a motorcycle does. The same principle could be applied to heavy trucks and trailers, Figure **8**.

Vehicle rollover, in a very simplified explanation, happens when the resultant force on the CG (from addition of the cornering force and weight) passes outboard of the tyres.

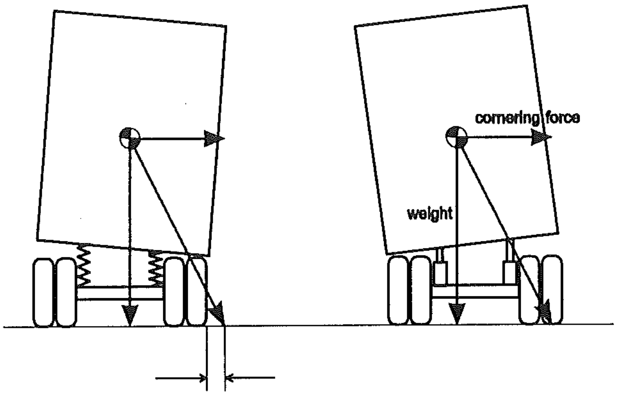

Figure 8 Stability improvements possible by tilting body inboard

The weight doesn't change. The cornering force is a function of the speed, radius of corner, camber and mass. The tyre track width is controlled by overall width limits. CG height, as has been shown previously, has a strong influence on rollover stability. The other main variable is the lateral position of the CG.

With conventional trucks, the CG moves outboard in a corner. If roll stiffness is raised, the sideways shift of the CG is reduced, and stability is enhanced.

If a "negative roll" is applied to the chassis (using a active suspension system), it would be possible to construct a truck that would never roll over![2]

Intelligent Axles

An axle can be designed to incorporate transducers to sense such parameters as tyre vertical and lateral forces, braking torque and wheel speed. The addition of an embedded controller chip, software and actuators would result in an "intelligent axle".

For example, the braking torque could be tailored to suit the instantaneous wheel loads (adapting to the forward transfer of forces and inter-axle load transfer under braking). Antilock capability could

1 The French and Japanese, on the other hand, run their TGV and Bullet trains, respectively, on purpose-designed tracks with very gentle corners.

2 Instead, the tyre sliding limit would be reached before rollover, as with most other road vehicles.

be built in to the axle hardware, rather than being an add-on system.

The same vertical wheel force transducers could calculate lateral weight transfer in a corner, and thus provide the raw signal for a rollover warning device. They could also be used as inputs to an active or semi-active suspension, and to the "tilting truck" mode.

"Dead Space" — the Final Frontier

Lowering CG height will require ingenuity on the part of trailer designers. Buying novel trailers will require from operators a willingness to break from the conservative "we know what works" mold.

One area where no effort to date appears to have been expended in lowering CG height, is in utilising the "dead space" below chassis height between axles. Admittedly, log trucks have particular loading and durability requirements, which may preclude any practical use of the "dead space". But it is worth noting that the potential exists.

Public Perception is Critical

Roads are a Shared Public Resource

As expressed in the Introduction, the views of other road users are significant. The public cannot be dismissed as unimportant. It is only with the tacit approval of the public that trucks are permitted on the highways at all. (Witness the anti-truck bylaws enacted by some local councils in response to public perceptions of heavy trucks.)

Public Feel Trucks are Threatening and Unsafe

The public image of trucks is critical in two senses.

1. At present, the public is more anti than pro heavy trucks. Trucks are blamed for road damage, crashes (even if the truck driver is not at fault) and congestion/speeding (either they travel too slowly, holding up cars, or they travel too fast and appear impatient and unsafe).
2. The public perception is critical in that only with the support of the public will the trucking industry succeed in efforts to increase dimensional and gross combination mass limits in New Zealand.

It is heartening to see the industry attempts at improving this area through attention to appearance and responsibility.

Large Ignorance Factor

The public are largely unaware of the contribution of heavy trucks to their lifestyle, or how much life would be disrupted if all trucks were to suddenly cease operating. Not only would the direct supply of essential (and non-essential) consumer goods be halted, but the longer-term economic impact of halting almost all exports would be almost inestimable.

Strategies to inform the public may be a necessary prerequisite to any campaign for heavier trucks. A market research survey conducted in Switzerland (M.I.S. Trend,1993) found that opposition to heavier vehicles reduced significantly when respondents were better informed about the ramifications of proposed mass limit increases.

Conclusions

Present logging truck stability is at the low end of the spectrum. Increased mass limits will require better stability.

Stability improvements are possible, both with presently available methods and technology, and through enhancements to trucks in the future.

Public perception will be a key issue.

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