HIGH PRODUCTIVITY MOTOR VEHICLES – NEW ZEALAND'S APPROACH

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Abstract

As in many jurisdictions there has, in New Zealand, been a strong lobby by road transport stakeholders for increases in the size and weight limits on heavy trucks to provide increased efficiency and productivity. In 2010 the government introduced an amendment to the Vehicle Dimensions and Mass (VDAM) Rule which provided for larger and heavier vehicles to be used on roads that could accommodate them. These vehicles, which are called High Productivity Motor Vehicles (HPMVs), operate under permit. To reduce compliance costs and facilitate the uptake of these vehicles, the New Zealand Transport Agency promoted the development of a series of "pro-forma" designs. These designs are combination vehicles that are longer than the standard vehicles but have a restricted envelope of dimensions that ensures that they can meet the performance criteria. Pro-forma vehicles have general access at standard weights and can operate at higher weights on approved routes. Currently about 1000 HPMVs have been approved.

Keywords: Heavy Vehicles, Productivity, Size and Weight, Performance Standards, Freight Efficiency.

1. Introduction

As in many jurisdictions, in New Zealand there has for many years been a strong lobby by road transport stakeholders for increases in the size and weight limits on heavy trucks to provide increased efficiency and productivity. A number of investigations have been undertaken culminating in the Heavy Vehicle Limits study (Allan Kennaird Consulting Ltd and Opus 2001) which commenced in 1999. This study investigated two scenarios:

1. Scenario A which considered running vehicles at higher weights within the existing dimension limits across the whole network.
2. Scenario B which considered allowing increased dimensions and weights on a specific network of major transport routes.

The study consisted on six related research elements which were contracted separately. These were investigations into the impacts on:

- bridges
- safety
- pavements
- geometrics (road widening to accommodate the larger vehicles)
- environment
- industry economics (productivity)

Subsequently an additional study combining the results of the six elements into an overall economic assessment was undertaken. Although these studies showed an overall net benefit, there were some significant costs particularly for bridges and geometrics as well as considerable debate on some of the assumptions on which the analyses were based. Some additional studies were undertaken to try to resolve the debate but in the end the government at the time did not proceed with implementing the higher weight limits.

However, the industry lobbying continued and in 2010 the government introduced an amendment to the Vehicle Dimensions and Mass (VDAM) Rule which provided for larger and heavier vehicles to be used on roads that could accommodate them. These vehicles, which are called High Productivity Motor Vehicles (HPMVs), operate under permit. The Rule amendment included a revised "bridge formula" for HPMVs, some small increases in axle group weight limits for HPMVs and identified the dimensional limits that could be violated. It did not explicitly specify any upper limit on size or weight for the vehicles although clearly the New Zealand Transport Agency (NZTA), which is both the road controlling authority for state highways and the regulatory authority for vehicles, did have views on the maximum sizes and weights that could realistically be achieved in practice.

2. Implementation

Under the existing VDAM Rule, large combination heavy vehicles in New Zealand are limited to a maximum of 20m overall length and 44 tonnes GCM. Semi-trailer configurations were previously limited to 18m overall length but the 2010 amendment increased this to 19m for most cases. The most popular configuration used in New Zealand is the truck and full trailer, which makes up a little over half of the combination vehicle fleet by distance travelled. Tractor semi-trailers are the next most common configuration with about 35% and B-trains make up about 14%. There are also small numbers of truck and simple trailer combinations used for specific freight tasks. For most truck-trailers and all B-trains the sum of the weight limits for the axle groups is greater than 44 tonnes and so the weight that these vehicles can operate at is constrained by the GCM limit of 44 tonnes not by the axle group weights. For

most semitrailer configurations the sum of the axle group weight limits is less than 44 tonnes and so the maximum combination for these vehicles is less than 44 tonnes (the exception is a 4-axle tractor towing a quad-axle semitrailer where the axle group limits sum to 45.8 tonnes).

In New Zealand heavy vehicles are charged for their road use according to a schedule of charges for weight and distance. These road user charges (RUCs) are based on fully recovering the costs of operating the road transport system from the users. The pavement wear component of these costs is allocated to users on the basis of the fourth power rule and thus vehicles with more axles pay significantly lower RUCs than vehicles with fewer axles at the same weight. Thus when operators optimize their vehicle configurations in term of total operating costs they are implicitly including pavement wear costs. The end result of this is that most combination vehicles in New Zealand have more axles than they need to carry the weight but if we assume that the pavement wear model is correct then they are optimised in terms of total system costs.

In terms of the new HPMV provisions this RUC system has two significant benefits. The first is that a road pricing mechanism is already in place so that the cost of additional pavement wear caused by these heavier vehicles will be recovered from them automatically through them paying RUCs for higher weights. The second is that most existing combination vehicles already have the capacity to operate at higher weights so implementation could potentially occur rapidly.

3. Criteria for Approval

For the NZTA, who are the regulatory agency that is charged with issuing the permits for HPMVs to operate, the initial problem was setting the criteria for deciding whether or not a route could accommodate a vehicle. To facilitate a more rapid uptake of HPMVs the NZTA decided to specify geometric requirements for general access. Vehicles that could meet these geometric requirements would be able to operate at current legal weights over the entire network and would be able to operate at higher weights on approved routes.

In general, because of the bridge formula requirements, HPMVs need to be longer to be heavier. This increase in length will affect low speed turning performance. Thus NZTA specified a low speed turning performance requirement. The manoeuvre specified was a 120° turn with a 12.5m wall-to-wall outer radius and the requirement was that the inside wheels of the vehicle should not cross a 4.9m radius inner circle. The criterion was based on the performance of a 19m quad-axle semi-trailer which is the worst case legal standard dimension vehicle. The reason for using a 120° turn instead of the more usual 90° turn was to include the effect of roundabouts.

For vehicles that could achieve this low speed turning performance requirement a suite of performance measures was also evaluated to ensure that the vehicles' performance was satisfactory overall. These measures included: Static Rollover Threshold, Rearward Amplication, Load Transfer Ratio, High Speed Transient Off-Tracking, Front Swing, Tail Swing, Steer Friction Utilisation, High Speed Steady Off-tracking and Yaw Damping Ratio. In most cases these measures were evaluated in accordance with the definitions in the Australian PBS system (National Transport Commission, 2008). Some of these measures are not part of the Australian PBS system but they were considered when the PBS was developed. In general there is a trade-off between low speed turning performance and high speed dynamic performance (Fancher and Winkler, 2007) and thus it was expected that the increases

in length which would degrade low speed turning performance would generally improve high speed dynamic performance.

4. Pro Forma Designs

To reduce compliance costs, the NZTA in conjunction with the Truck and Trailer Manufacturers Federation (TTMF) promoted the development of a series of "pro-forma" designs. These designs are combination vehicles that are longer than the standard vehicles but have a restricted envelope of dimensions that ensures that they can meet the required performance criteria.

The process of developing these designs went as follows:

The TTMF canvassed their members to provide candidate designs for these vehicles. Twelve designs were forwarded for analysis. These consisted of three truck and trailer combinations, eight B-trains and one truck and simple trailer (car transporter). Five different vehicle designers produced these designs.

Although the low speed turning performance requirements had been communicated to the designers at the time of requesting them to propose vehicle designs, only some of them took this into account. It seems that the others did not have any in-house capability for evaluating low speed turning performance. This is not surprising because for standard legally dimensioned vehicles there is no need to undertake any assessment. Several of the designers appeared to have gained the impression that the maximum length and weight that would be acceptable under the amendment to the VDAM Rule were about 25m and 62t and based their designs on utilising these limits to the full. The designers who did undertake some low speed turning analysis realised that this length, in particular, is not achievable if the low speed turning criterion is to be satisfied and thus proposed more modest length and weight options.

Because of similarities between some of the B-train designs, the eight B-trains were consolidated to four leaving a subset of eight vehicle configurations for analysis. Each of these vehicles was modelled using the TERNZ version of the Yaw-Roll simulation program developed at UMTRI (Gillespie 1982).

Only two of the designs achieved the required low speed turning performance but three of the others were sufficiently close that we knew we could get them to pass with minor changes to key dimensions. Three of the designs were too far away from achieving the required level of performance to have any chance of meeting the standard without major dimensional changes.

Using the specific designs proposed by the trailer manufacturers three pro-forma designs were developed. These were a 22m truck and full trailer, a 22m B-train and a 23m truck and simple trailer. The truck and simple trailer was primarily configured for car transporters and its weight is restricted to 36 tonnes. However, it is also permitted front and rear overhangs of up to 1m with a combined total less than 1.3m provided the width of the overhangs is less than 2m and so its total length is 24.3m.

These designs were implemented and a number of vehicles were built to these designs and approved. However, it soon became apparent to some trailer builders that a relatively small increase in overall length for the B-train would produce a significant productivity benefit (an additional row of pallets). Thus alternative pro-forma designs for the B-train and truck and

full-trailer were developed with an overall length of 22.3m. These designs were still required to meet the original specified performance criterion. In the case of the truck-trailer design, the dimensional envelope for the new 22.3m vehicle included the existing 22m pro-forma design and so the existing pro-forma design was replaced with the new 22.3m design. In the case of the B-train, the new 22.3m design was more restrictive on some dimensions than the existing 22m design and so both options had to be retained.

Some of the pro-forma designs are illustrated in Figure 1-4 below. The complete set can be viewed on the NZTA web-site http://www.nzta.govt.nz/vehicle/your/hpmv/proforma.html.

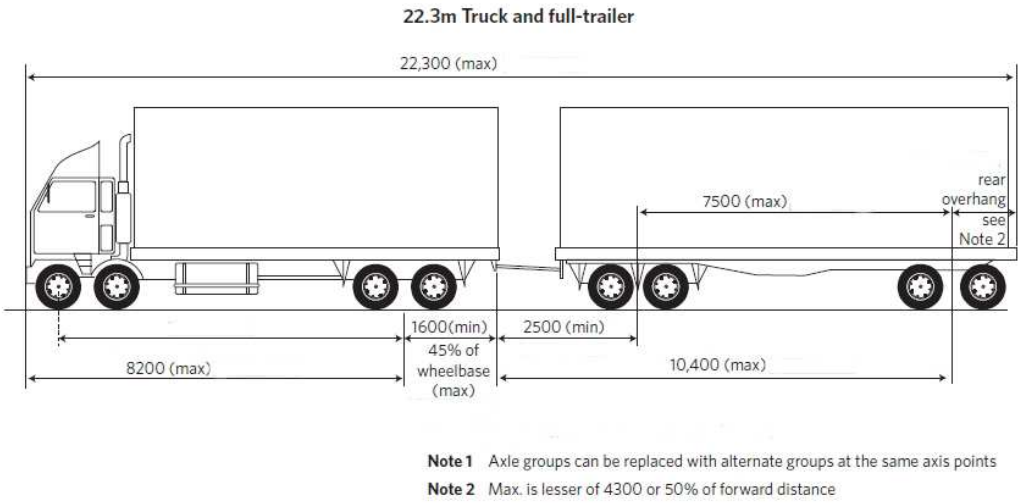

Figure 1. Pro-forma design for a 22.3m truck and full trailer.

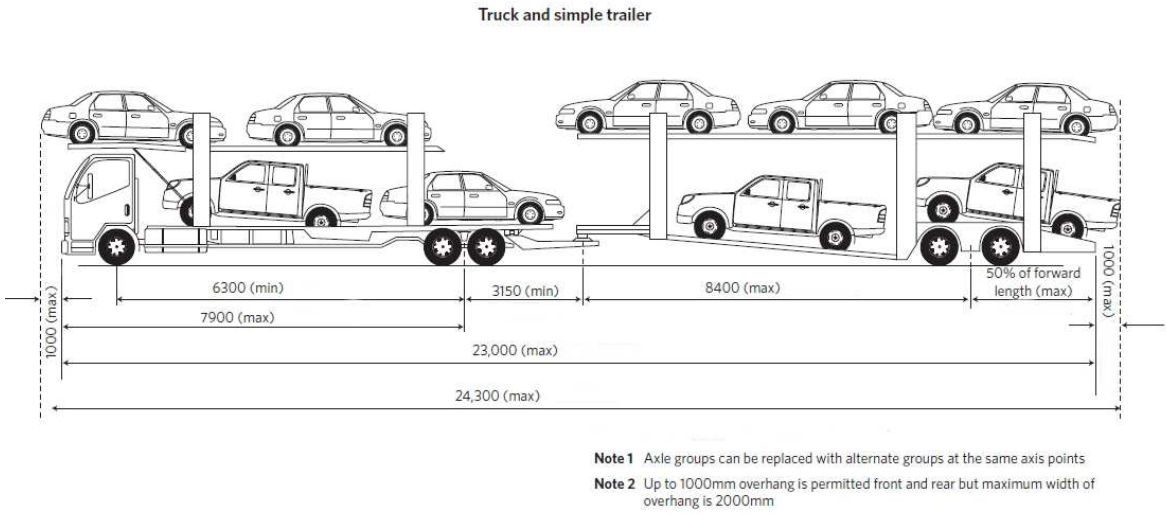

Figure 2. Pro-forma design for a 22.3m truck and simple trailer.

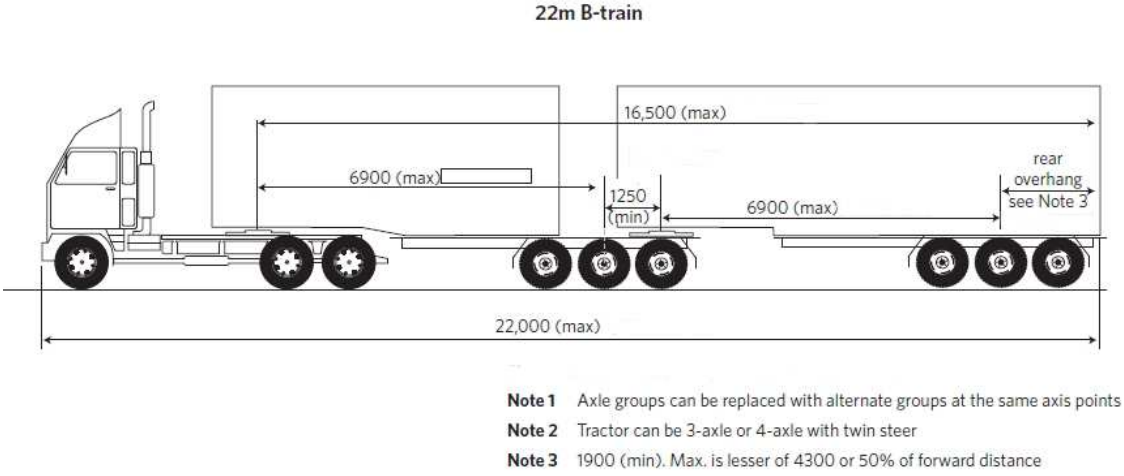

Figure 3. Pro-forma design for a 22m B-train.

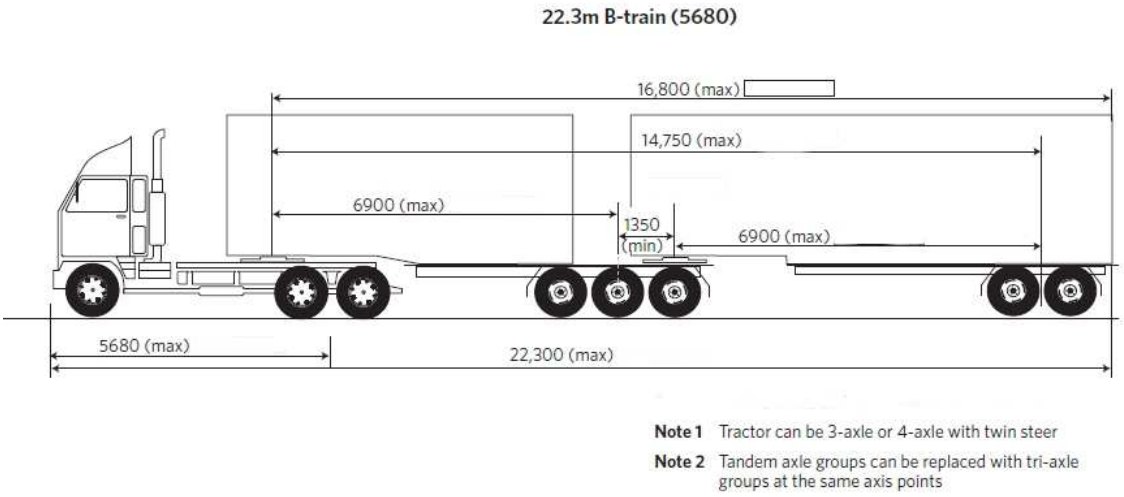

Figure 4. Pro-forma design for a 22.3m B-train.

Following the implementation of these pro-forma designs some issues came to light that required addressing. One of the most significant was that the forward length limit of the tractor is the 22.3m B-train was a little less than forward distance on one of the more commonly used tractors. Increasing the maximum forward length limit to accommodate this tractor resulted in a small reduction in the allowable trailer dimensions. The end result is that there are now two pro-forma 22.3m B-train designs with only very minor differences between them.

Because the truck and full trailer is inherently more manoeuvrable than the B-train it was possible to develop a significantly longer pro-forma truck and full trailer design that could achieve the required turning performance. This vehicle, which is 24m long, has not, at this stage, been approved for general access use. There are a number of reasons for this. One is the clearance distance required at intersections and rail crossings. In many places in New

Zealand the main rail line runs parallel to the main highway. At these locations some side roads entering the main highway cross a railway line immediately before the intersection. There is some concern that at some of these locations vehicles longer than 22.3m might not clear the rail crossing when they are stopped at the intersection and thus there is a reluctance to allow length greater than this for general access. A second reason is that with this configuration, the trailer is longer than the standard maximum allowable length for a trailer and thus if the vehicle broke down the trailer could not legally be moved by a standard truck. The third reason is that this vehicle would be substantially more productive than the B-train alternative. The B-train, however, has better dynamic stability than a truck and full trailer and there is a reluctance to introduce a policy which discourages the selection of a vehicle with better performance.

Although the outcome of the process of developing the pro-forma designs has been reasonably successful in that usable designs with satisfactory performance have resulted there are some aspects of the process that could potentially be improved. The main industry stakeholder representative in the process was TTMF who represent primarily trailer builders with some equipment suppliers. Although the organisation is open to the truck manufacturers and dealers they are not actively involved in it. From within TTMF only a small number of trailer builders submitted designs. Thus the vehicle designs from which the pro-forma designs were derived were not fully representative of what the industry wanted. One of main weaknesses was that the range of truck and tractor dimensions that were indicated did not span the full range of dimensions of vehicles currently supplied to the New Zealand. This was, in spite of several review cycles where draft pro-forma layouts were presented to the industry for comment.

5. Non Pro-Forma Designs

The pro forma designs provide a framework for designing vehicles that will achieve the required level of performance. Designs that meet the pro-forma specifications are issued permits at standard legal weights without requiring further analysis. Permits to operate at higher weight are given on a route-specific basis and require the route to be assessed to ensure that the infrastructure can cope with the weight.

Operators are not restricted to the pro-forma designs. However, vehicles that lie outside the dimensional envelopes of the pro-forma designs are required to go through a performance assessment. For general access they are required to meet the same low speed turning criterion as was used in developing the pro-forma designs. If the vehicle is only to be used on specific routes then it is possible to get a permit even if the vehicle does not achieve the low speed turning performance requirement providing the route can accommodate it.

Most of the vehicles that have gone through this one-off assessment process have been for general access with configurations that fall slightly outside of the dimensional envelope of the pro-forma designs. Often this situation arises where an existing vehicle is being modified to gain some increased length and capacity. In some cases it occurs where a particular model and make of truck or tractor does not meet the pro-forma dimensions.

However, there are a number of innovative vehicles that are outside the pro-forma designs which have been built to utilise the productivity opportunities that the HPMV regulations provide. A striking example is shown in Figure 5. This is a 24.5m B-train which has a route-specific permit to operate at 62 tonnes. The VDAM Rule does not provide quad axle groups

or castor steer axles in B-trains, so this vehicle has an exemption allowing first trailer to have a quad axle set in which the rearmost axle is castor steered. With this axle arrangement the vehicle can just meet the general access low speed turning requirement. Most notably this vehicle is 50% more productive than the truck and trailer units it replaced and thus there is a 33% reduction in the number of truck trips required to move the same quantity of freight.

Figure 5. 24.5m 62t B-train HPMV.

6. Uptake

The amendment to the VDAM Rule came into force on 1st May 2010. By May 2012, 984 HPMV permits had been issued. The vast majority of these were pro-forma designs. To put these numbers into context, there are just over 20,000 combination vehicles in the New Zealand fleet so the number of HPMV permits is approaching 5% of the fleet.

A little over half of the HPMV permits have been approved to operate at higher weights but many of these vehicles are still operating at 44 tonnes rather than at those higher weights. For many of the vehicles that do not have higher weight permits this is because the type of load they carry is volume constrained. The extra 2.3m of vehicle length represents a substantial productivity gain and they do not require an increase in weight. However, in other cases the operators would like to go to higher weights but are not currently doing so. There are a number of reasons for this and these are gradually being addressed:

- Difficulties in getting route approvals because of infrastructure deficiencies. Existing bridges were not designed with these loadings in mind. However, in most cases there is no increase in the maximum axle group loadings and so the issue mainly applies to longer span bridges. Many of the local road controlling authorities do not have good information on the structural capacity of their bridge inventory and thus tend to take a conservative approach.
- Funding of local road maintenance. Through RUCs the operators of HPMVs pay for any additional infrastructure wear that they cause. The maintenance of the State Highway network is fully funded from RUCs but the local road network is 50% funded from RUCs and 50% from local body taxes. Some local road controlling authorities therefore are reluctant to issue route approvals for higher weight vehicles.

- Road User Charges. Operators pay RUCs based on distance and the maximum weight that the vehicle operates at. These RUCs are based on a fourth power pavement wear model and thus increase substantially as weight increases. If the operator can only utilise the higher weights for part of the vehicle travel distance because of route constraints, then the additional RUCs he has to pay for all of his travel distance may make operating at higher weights uneconomic.
- Enforcement issues. If the operator is found to be violation of the conditions of his HPMV permit the vehicle is deemed to be a standard legal vehicle and the relevant penalties apply. Thus, for example, if the 62t vehicle shown in Figure 5 was found to be in breach of some aspect of its permit, it would be considered to be 18 tonnes overloaded which incurs very high penalties. Initially the permits had quite narrow bounds on the axle group weights and thus a relatively minor deviation from the desired load distribution could result in the vehicle being in breach of its permit. This issue has largely been addressed.

There is concern within the NZTA and the industry that the higher weight provisions in the HPMV regulations are not being utilised to the extent that they could be and that as result some potential productivity gains are not being achieved. There are various initiatives underway to unlock this potential. These involve upgrading key bridges, resolving some of the administrative issues and developing some new higher weight pro-forma designs that will have a neutral pavement wear impact which will be more acceptable to the local road controlling authorities.

7. Conclusions

The New Zealand government has introduced changes to the vehicle regulations to allow increases in size and weight where the infrastructure can accommodate it to enhance productivity. The regulatory regime is permit-based and is reasonably flexible. Essentially the requirement to fit within the capacity of the infrastructure means that this is performance based approach.

To facilitate a more rapid uptake of these HPMVs the NZTA promoted the development of pro-forma designs. These are vehicles that are larger than the standard legal vehicles but with restrictions on their dimensions so that they can achieve the same level of performance as the worst-case standard vehicles.

There has been a strong uptake of the opportunities for increased dimensions but the uptake of increased weight has been slower. There are several reasons for this. The main one is the capacity of the infrastructure to handle the higher weights and hence limitations on the available routes. There are also some administrative issues. These are currently being addressed.

8. References

Allan Kennaird Consulting Ltd, and Opus. (2001). "Transit New Zealand heavy vehicle limits project. Report 7, Overview, Part 1: Main report and Part 2: Appendices." *7*, Transit New Zealand, Wellington.

Fancher, P. and Winkler, C. (2007), "Directional performance issues in evaluation and design of articulated heavy vehicles", Vehicle System Dynamics, 45(7-8), 607-647.

Gillespie, T. D. (1982). "Constant velocity yaw/roll program - User's manual." *UMTRI - 82 - 39*, University of Michigan Transportation Research Institute, Ann Arbor.

National Transport Commission (2008), "Performance Based Standards Scheme. The standards and vehicle assessment rules", National Transport Commission, Melbourne.