FINDING THE EDGE OF THE ENVELOPE -
THE EVOLUTION OF HIGH PRODUCTIVITY MOTOR VEHICLES IN NEW ZEALAND



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Abstract

This paper presents a brief history of the evolution of heavy vehicle size and weight in New Zealand over the last 40 years. It begins with the introduction of Road User Charges where road users are charged for the full cost of operating the road transport system. The motivation for these charges was to enable fair competition between the road and rail modes.

Since the late 1980s increasing pressure has come on the regulator to improve vehicle safety and productivity with some knowledge of the predicted growing freight task. Consequently performance-based standards commenced being used to better inform size and weight regulation. Increases in allowable size and weight have been linked to additional safety technology requirements and less safe configurations have been discouraged as a deliberate strategy to optimally balance safety and productivity gains.

In 2010 an amendment to the size and weight regulations allowed for vehicles that exceeded the standard legal size and weight limits to be operated where the infrastructure could cope with them and the vehicles could be shown to be safe. The paper describes how this high productivity motor vehicle regime has been implemented and likely future directions.

Keywords: Standards and Regulations, High Productivity Vehicles, Infrastructure Access, Vehicle Safety

1. Introduction

In New Zealand, as in many other jurisdictions there has, over the years, been a steady push from the road transport sector and its stakeholders for increased productivity through larger and heavier vehicles and from the public for vehicles to be safer. In response to this there have been a number of studies and trials as well as number of legislative changes that have eventually led to significant increases in allowable size and weight limits with added safety standards and requirements.

Prior to 1961, to protect the railways, trucks were only allowed to move freight for distances up to 30 miles (50km) (Cavana et al., 1997). There were some exemptions such as livestock and also cases where the rail distance was much longer than the road distance. In 1961, the distance limit was increased to 40 miles (67km) and exemptions were increased. In 1977, the distance was increased again to 150km (94 miles) with more exemptions. By 1986 all railway freight movement protection had been removed.

In 1977 the government introduced Road User Charges (RUCs) which apply to all diesel powered vehicles and all heavy vehicles including trailers. These charges are weight and distance-based and are an alternative to the fuel excise duty that applies to petrol. RUCs are designed to recover the full cost of the road transport system from its users and thus effectively to put road transport and rail transport on an equal footing. Underpinning the RUCs is a cost allocation model (CAM) which determines the rates that apply to different vehicle configurations at different weights. RUCs represent a significant proportion of vehicle operating costs and differ considerably between different vehicle configurations. Thus they do influence the choice of vehicle configuration for different freight tasks.

This paper presents an historical review of the steps by which New Zealand has moved from the maximum length of a heavy vehicle combination of 19m and the maximum gross combination weight of 39 tonnes (New Zealand Government, 1976) that was in place 40 years ago when RUCs were introduced, through to the current high productivity motor vehicle (HPMV) regime which allows vehicles up to 23m in length with a gross combination weight of 50 tonnes to operate on most of the network. This HPMV regime further allows for combination weights up to 61 tonnes or more on approved routes.

This process was not a gradual progression of incremental change. There have been substantial government-funded research studies to investigate options for size and weight increases that resulted in no regulatory change while, on the other hand, there have been regulatory changes with substantial impacts on size and weight that have been implemented with relatively little background research.

New Zealand transport operators are under constant commercial pressure to increase productivity, while at the same time under regulatory pressure to improve safety and environmental performance. Requirements for additional environmental and safety equipment have led to increased tare weights and dimension changes which decrease payload capacity and erode productivity. Therefore any regulatory easing of mass or dimension limits which increase payload capacity are welcomed and uptake is rapid.

2. Incremental Increases in Size and Weight

The 1976 Traffic Regulations provided for a maximum length for combination vehicles of 19m and a maximum weight of 39 tonnes. The regulations also included length limits for the individual vehicles in the combination and weight limits for axles and axle groups. There was provision for heavy vehicles to tow two trailers but these configurations were not explicitly described.

In 1984 the industry made submissions to the government to increase that maximum gross combination weight from 39 tonnes to 44 tonnes. The government responded with a number of safety improvement prerequisites which the industry accepted (Baas and White, 1989) and in 1988 the necessary amendments to the Traffic Regulations and the Heavy Motor Vehicle Regulations were enacted. These regulations defined various combination vehicle configurations including the A-train and the B-train.

Configuration-specific vehicle length limits were introduced: 17m for a semitrailer, 19m for truck and trailer combinations and 20m for A-trains and B-trains. The various vehicle configurations were evaluated using the performance standards that were developed for the Canadian vehicle weights and dimensions study (RTAC, 1986). Based on these performance assessments, B-trains and truck and trailer combinations with 4-axle trucks were allowed gross combination weight limit of 44 tonnes, truck and trailer combinations with 3-axle trucks were limited to 42 tonnes and A-trains were held at 39 tonnes. Subsequently the allowable weight for 3-axle truck and 4-axle trailer combination was also increased to 44 tonnes and the length limit for all truck and trailer combinations was increased to 20m. The lower weight limits for A-trains and 3-axle truck and 3-axle trailer combinations were based on the poorer high speed dynamic characteristics of these vehicles. As far as we are aware, this was the first time anywhere in the world that assessment against performance standards was used to inform size and weight regulation.

These increases in maximum weight were conditional on the vehicles having implemented the safety improvements which primarily related to certification of brakes, load securing and couplings. These weight and length limits are still the current maximum standard legal limits although there are now provisions in the regulations for exceeding these limits. The safety enhancements are now mandatory for all heavy vehicles and some of these have also been extended.

3. Variations from the Standard Limits

Some variations from the configurations defined in the 1988 regulations were allowed to operate under permit. These permits were usually issued on the basis of performance assessments using the RTAC performance standards. One of the more notable examples was in the dairy industry. A major dairy company at the time put forward a case for operating A-train dairy tankers at 44 tonnes rather than the 39 tonnes allowed by the regulations. The basis of the case was that they needed to use the A-train configuration with its superior low speed turning performance to access dairy farms on narrow country roads and they believed that they could configure them to have satisfactory high speed dynamic performance.

The regulator at the time accepted these arguments and agreed that they would issue permits for 44 tonnes if the vehicles could be shown to have a Static Rollover Threshold of 0.45g or more, a Dynamic Load Transfer Ratio of 0.6 or less and a High Speed Transient Offtracking of 0.5m or less. The performance measures used were all based on those defined in the RTAC study.

A relatively small number of these vehicles were permitted but, interestingly, over time the dairy company involved switched over to using truck and trailer combinations like all the other major dairy companies. These vehicles could operate at 44 tonnes as-of-right and hence did not require permitting.

4. Heavy Vehicle Limits Study

In the early 1990s, in response to industry lobbying, the manager of the state highway network, Transit New Zealand, undertook a series of studies to investigate the options for heavy transport routes that could carry larger and heavier vehicles (Sleath, 1995, Wanty and Sleath, 1998). These studies found that the benefits of increased transport productivity would not outweigh the costs of upgrading the road network to accommodate larger vehicles.

In 1998, Transit New Zealand began a further very substantial study into the safety and economic effects of altering heavy vehicle weight limits under two scenarios. Scenario A considered having no dimensional increases but allowing higher weights across the whole network. This would require no substantial geometric upgrades to the network. Scenario B considered increases in both size and weight but these vehicles would be restricted to selected routes. The project was split in seven tasks which were contracted out separately to a number of consultants. The tasks were:

- Bridge Evaluation
- Safety Evaluation
- Industry Economics
- Pavement Evaluation
- Environmental Evaluation
- Geometric Evaluation
- Overall Economics

This study found substantial net benefits for both scenarios (Sleath and Pearson, 2000, Opus and Alan Kennaird Consulting, 2001). However, there was considerable debate about some of the projected costs and a number of follow-up analyses were undertaken to resolve these. Ultimately no size and weight increases were implemented immediately following this study.

5. The Vehicle Dimensions and Mass Rule

The traffic regulations were consolidated into the Vehicle Dimensions and Mass (VDAM) Rule in 2002. Although the Rule did not provide any increase to the maximum size and weight limits for heavy vehicle combinations, it did, however, introduce a rollover stability requirement for all large heavy vehicles (de Pont et al. 2004). It also introduced a number of dimensional constraints that were designed to improve the safety performance of different combinations. The various policies that allowed permits were incorporated into the new Rule to provide as of right operation for the safer configurations.

Also in 2002, the regulator allowed log trucks to operate at 22m overall length under permit. The additional length was in the form of load overhang at the rear of the vehicle and the vehicles themselves remained within the 20m length. The purpose of this concession was to enable an additional packet of logs to be accommodated which reduces the height of the load and substantially improves the rollover stability. This is illustrated in Figure 1. The two trailers shown are carrying the same payload weight. Clearly the trailer in the right hand side image has substantially better rollover stability than the one in the left hand side image although the one on the left does still achieve the minimum level of rollover stability required by the VDAM Rule. Log trucks in New Zealand operate in difficult terrain on roads of variable quality and have in the past had a high rollover rate. The concession allowing them additional length to improve their rollover stability was granted on the basis that the safety gains were significantly greater than any safety risk associated with the additional length.

Figure 1. Reduced load height from 2-packet trailer load.

6. High Productivity Motor Vehicles

In 2010, the government introduced an amendment to the VDAM Rule which enabled the operation of High Productivity Motor Vehicles (HPMVs). The HPMV provisions included small increases in the axle load limits and a revised bridge formula which allowed higher weights but imposed no upper limits on gross weight or vehicle length. Essentially it enabled the regulator to allow any weight and length combination under permit provided that the vehicle could operate safely and that the infrastructure could accommodate the vehicle.

Obviously this provided the regulator with significant challenges. The first step that they took was to recognize that, if the gross weight was not changed, longer vehicles would be able to access the entire network providing that the vehicles could meet the geometric requirements. Thus, they specified some turning performance requirements based on the performance characteristics of the worst performing standard legal vehicle on the basis that if the longer vehicles could achieve these performance standards they would fit on the network. The second step that they took was to recognize that assessing each individual vehicle design would be time-consuming and costly and would hamper the uptake of these more productive vehicles and so they promoted the concept of pro-forma designs. These designs are dimensional envelopes for the most common vehicle configuration types in New Zealand. These pro-forma designs were evaluated using a performance-based standards approach to establish that they would be acceptable and their limits were then prescriptively defined for ease of implementation and enforcement.

The first pro-forma designs were based on a 22m overall length limit. This choice of length limit was rather arbitrary but the previous experience with the 22m log trucks provided a degree of confidence that vehicles of this length would not cause any serious safety problems. After a few months, the industry asked for this length limit to be increased to 22.3m to enable the vehicles to accommodate an additional row of pallets. Subsequently this length limit was then increased further to 23m. Although the overall length limit was increased there was no change to the low speed turning performance standards that the pro-forma designs were required to meet. As the overall length increased the amount of flexibility for the individual wheelbases and coupling positions decreased.

It is possible to have an overall length greater than 23m and still achieve the require low speed turning performance and several trial vehicles with lengths between 24m and 25m have be approved. However, although these longer vehicles have performed very well, there are traffic engineering concerns associated with the length of these vehicles. These issues include stacking distances at intersections particularly where an intersection is adjacent to a rail crossing, intersection clearance times, length of turning bays, sight distances etc. Currently 23m remains the upper limit for HPMVs.

In order to achieve the low speed turning performance requirements, the vehicles' dimensions have to be constrained. Thus a single pro-forma design cannot meet all user requirements. Consequently a number of pro-forma designs were needed for each vehicle configuration. Figure 2 shows three of the pro-forma designs available for truck and trailer combinations.

HPMVs with satisfactory performance were then able to operate on the entire network at 44 tonnes which made them very attractive for volume-constrained loads. The additional three metres of length represents an increase in payload volume of around 20%. These were also able to operate at higher weights (typically 57-58 tonnes) on approved routes where the infrastructure could accommodate them.

The RUC system outlined in the introduction means that the heavier vehicles pay more RUCs to reflect the additional infrastructure wear that they generate and both the industry and state highway road manager are comfortable with this because the state highway road manager is fully funded for road maintenance from RUCs. However, for local roads about half of the infrastructure maintenance costs are paid by local rate payers rather than through the RUC system. Thus many local road controlling authorities were not prepared to allow higher weight operations on their roads. This lack of access to local roads constrained the uptake of the higher weight vehicles.

To overcome this, the New Zealand Transport Agency, who are both the regulator and the manager of the State Highway network proposed a compromise solution called 50MAX vehicles. These are 23m HPMVs which have nine or more axles which is one more than the typical standard weight vehicle and operate at 50 tonnes. Based on the 4th power pavement wear model it can be shown that these vehicles generate the same or less pavement wear per tonne of freight moved. As well a minimum first-to-last axle spacing of 20 m was set to manage bridge life to similar limits. This concept has now been widely accepted by local road controlling authorities and the 50MAX network covers nearly the entire country.

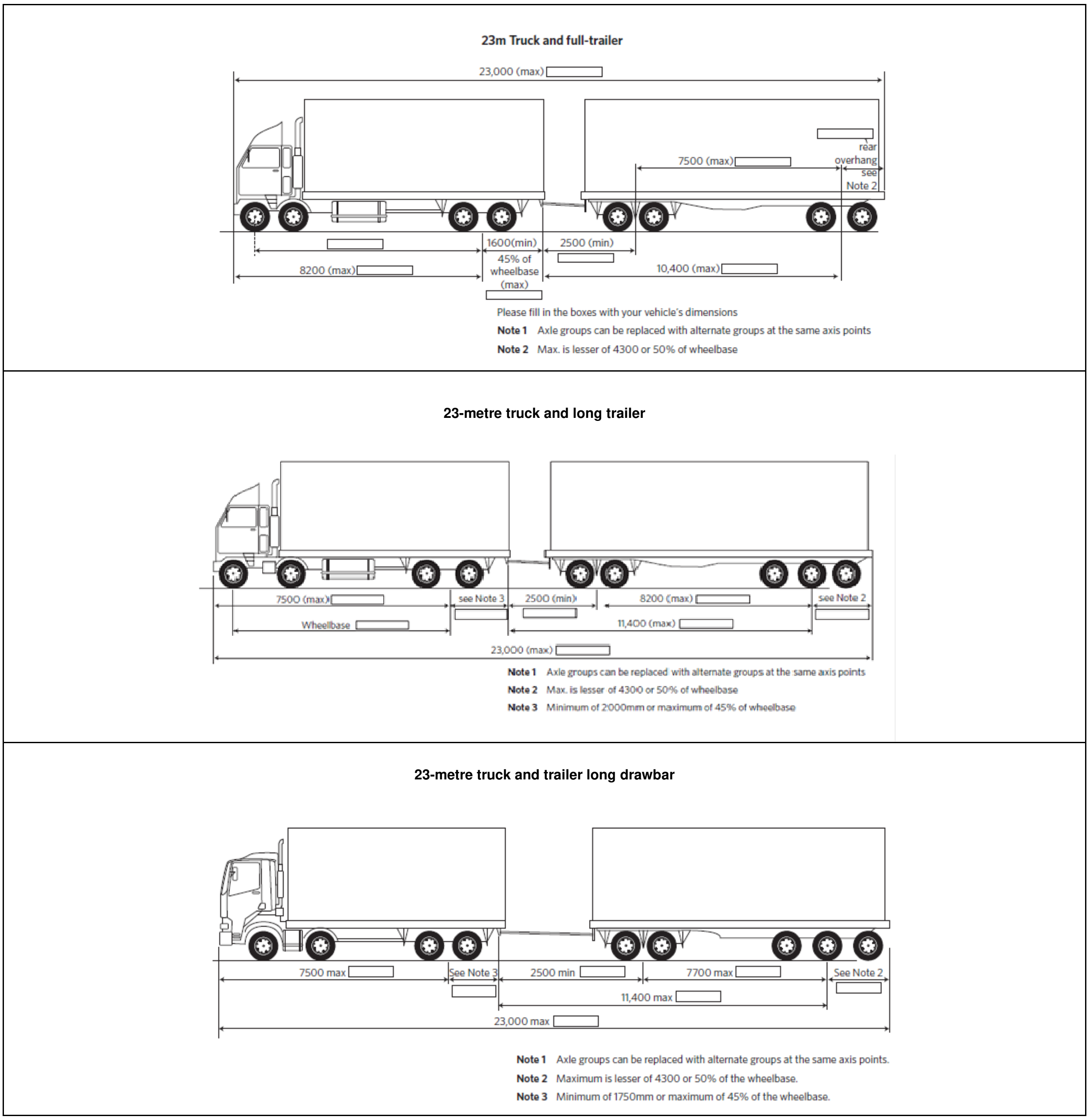

Figure 2. Three different 23m truck and trailer pro-forma HPMV designs.

Although the 50MAX configurations are not optimal from a total system cost perspective, they are a reasonable compromise which has enabled wide acceptance. The uptake of the HPMV by industry has been very strong. By 2016 over 30% of all heavy vehicle travel distance was undertaken by HPMVs (Silvester, 2016) and approximately half of the long combination vehicle fleet are HPMVs.

As with the earlier size and weight increases, the regulator took the opportunity to enhance vehicle safety by imposing some additional requirements for permitted vehicles. Standard legal vehicles are required to have a static rollover threshold (SRT) of 0.35g or more. HPMVs are required to meet this SRT value and also to be fitted with rollover stability control system or alternatively to have an SRT of 0.40g or more.

7. Moving Forward

The performance based standards that have used for assessing whether or not an HPMV design is satisfactory are a hybrid of the Australian PBS system, the RTAC measures and a New Zealand-specific low speed turning requirement. The low speed turning performance pass/fail criteria are based on the characteristics of the worst case standard legal vehicle which is a 19m quad-axle semi-trailer combination.

In-service video recordings on the 24-25m trial vehicles found that on some critical highway curves these vehicles occupied the full lane width. Thus if two of these vehicles were to meet each other on one of these curves there would be little is any clearance between them. The critical curves are low speed curves, typically with advisory speeds of 15 or 25 km/h, which occur in difficult terrain. The difficult terrain means that it would be very expensive to widen these curves.

The lack of clearance on these curves does not represent a failure of the performance-based standards approach because the reference vehicle (19m quad semi-trailer) would similarly occupy the full lane width. However, if most of the fleet moved to having this level of performance it would increase the safety risk significantly.

In 2016 the VDAM Rule was reviewed and updated. As part of this process there was a review of the performance-based standards being used in New Zealand with a view to developing a more formal PBS system for New Zealand (de Pont et al, 2016) which would reflect New Zealand operating conditions. Unfortunately, time and resource constraints prevented the PBS system review from being completed in time for the new PBS system to be integrated into the updated VDAM Rule. However, work is now continuing on establishing a PBS system that reflects the road transport operating environment in New Zealand. In conjunction with this there is on-going work to establish the processes for approving HPMVs in the future and the results may feed into a further amendment to the VDAM Rule.

In particular there are a number of issues with the current system that both the regulator and the industry would like to resolve.

- All HPMVs are currently operating under permit. As noted above, approximately half of the long combination vehicle fleet are now HPMVs. The regulator's view is that it is undesirable for half the fleet to be operating under permit as this creates a substantial administrative workload for what are essentially mainstream vehicles.
- Currently standard legal vehicles are registered as individual vehicle units, i.e. trucks and trailers are registered separately. Provided the overall length and combination weight limits are met, any truck can be connected to any trailer. HPMVs, on the other hand, are permitted as a combination. Thus the permit applies to a specific combination of truck and trailer(s). For some operators this is problematic as they mix and match combinations to meet operational requirements and thus they need multiple permits to cover all possible combinations. The regulator is looking at options for bulk permitting to facilitate a range of trailers behind the prime mover.
- As noted above some trailer manufacturers have used the one-off design process to effectively create a pro-forma HPMV design to which they have exclusive access. The regulator would like to see more standardization across the mainstream HPMV fleet with the one-off design process limited to special purpose vehicles for

specific applications on dedicated routes. Permits for one-off designs are administratively much more burdensome.
- There are still opportunities to simplify the permit process and develop a clear distinct separation between the current regulatory limits and a process to real world test innovation within an acceptable risk envelope.

The regulator is currently working with an Industry Advisory Group to develop a New Zealand PBS system and the processes for using it to manage the HPMV regime. It is envisaged that this will be formalized and included on the regulators website.

8. Conclusions and discussion

Over the last 40 years since the introduction of the RUC system the New Zealand road transport system has been substantially deregulated and has become the dominant mode for domestic freight movement. At the start of this period the largest trucks on the road were 19m long and 39 tonnes gross combination weight.

Because New Zealand has a single tier of government controlling transport size and weight regulation, it is able to move relatively quickly in adopting change. Thus New Zealand was the first jurisdiction in the world to implement using performance standards to inform size and weight regulation. As a result of this, the size and weight limits were increased to 20m and 44 tonnes respectively but these increases were not available to some vehicle configurations with poor high speed dynamic performance. Additional safety technology requirements were imposed on the heavier vehicles.

An assessment against performance standards was also used to permit some specific vehicles to operate at the higher weights.

Throughout the 1990s an extensive programme of research was undertaken to investigate various options for increasing the size and weight of trucks in order to improve the efficiency of the road transport system. Although the findings of this research indicated substantial net benefits could be achieved no changes to size and weight limits were made as a direct result of these findings.

In 2010 with no additional research work, the government amended the VDAM Rule to allow HPMVs that are longer and heavier to operate on roads that could accommodate them. The amendment set no upper bound on either length or weight. The regulator was then required to implement this Rule change. Apart from the infrastructure capacity limitations, the key determining issue identified by the regulator was that the vehicles must be able to operate safely. Performance standards were used to quantify this safety performance.

Infrastructure geometry and traffic engineering considerations have resulted in a de facto length limit of 23m for general access HPMVs. A small number of longer vehicles are operating on a trial basis on specific routes. A gross combination weight limit of 50 tonnes can be utilized on most of the network with higher weights possible on specific routes. The HPMV bridge formula requirements mean that the maximum weight achievable for a 23m vehicle is theoretically 61 tonnes although in practice it is difficult to keep the axle group weights within legal limits at this combination weight and 59-60 tonnes is the practical limit.

The use of pro-forma design templates has simplified the permitting process for HPMVs and has kept the cost to operators very low. This has facilitated a high level of uptake of these more productive vehicles within a relatively short time with significant economic benefits. A 50MAX HPMV has about 20% greater payload capacity, both by weight and by volume, than a comparable standard legal maximum vehicle. On approved routes where higher gross combination weights are possible, the payload weight capacity can be increased by 70% or more.

On each occasion where size and weight increases have been implemented, the regulator has introduced additional safety requirements for the larger and/or heavier vehicles as a condition for accessing these increases. These safety requirements were typically technology-based and would have been introduced over time anyway but the size and weight concessions provided a mechanism for accelerating their adoption by the industry. This is a win-win solution. The transport industry has gained more productive vehicles while the regulator and the motoring public has benefited from having fewer safer trucks on the network.

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