REGULATORY PRINCIPLES FOR STRAIGHT TRUCKS AND TRUCK-TRAILER COMBINATIONS

Additional Remarks

A Further Discussion Paper
for the
Interjurisdictional Committee on Vehicle
Weights and Dimensions

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7 May 1991

TABLE OF CONTENTS

1/ INTRODUCTION

The CCMTA/RTAC Vehicle Weights and Dimensions Study addressed the stability and control characteristics of the principal heavy truck configurations in use for interprovincial trucking in Canada, and developed regulatory principles to control the internal dimensions that are important to stability and control for tractors, semitrailers and converter dollies, and for the important combinations of these vehicle units [1]. The subsequent Memorandum of Understanding on Vehicle Weights and Dimensions is an agreement among the provinces on truck weight and dimension regulations for tractor-semitrailer and A-, B- and C-train double trailer configurations [2].

All provinces have trucks of other configurations than were addressed during the technical portion of the Weights and Dimensions Study. These are principally straight trucks and truck-trailer combinations. Once the Memorandum of Understanding was in place, provinces were asked, and started asking, how the regulatory principles and the terms of the Memorandum applied to these other trucks. Since these trucks are of quite different configuration than those covered by the technical studies done in support of the Memorandum, no easy answer was possible. The majority of these trucks are for local use, only within one province. In addition, many of these trucks that reach the weight or dimension limits are configured narrowly according to the regulations of their province. The configuration of these trucks is therefore much more diverse than the tractor-semitrailer and doubles covered by the Memorandum of Understanding, because they do not have the "lowest common denominator" effect that arises when trucks must be designed to cross boundaries between jurisdictions. A further technical study was therefore conducted, to provide some basis for extending the regulatory principles to straight trucks and truck-trailer combinations. This used the same methodology as was used for the Weights and Dimensions Study, and assessed the various configurations against the same performance standards [3].

The preceding study [3] covered a very wide range of configurations, most of which had at least one severe performance deficiency. An earlier discussion paper proposed regulatory principles for those configurations that had some hope of meeting the performance standards, straight trucks, the truck and pony trailer combination, and the truck and full trailer combination [4]. This discussion paper takes the work a step further. It builds directly on the earlier discussion paper, without summary of any of the discussion or conclusions of that paper [4].

2/ STRAIGHT TRUCK ISSUES

The previous discussion established that there was no real need to limit truck wheelbase. The largest general purpose truck wheelbases available are in the range 6.6-7.1 m (260-280 in). Any greater wheelbase would require a product from truck manufacturers that is not immediately available, and for which there does not appear significant demand. The longest box commonly produced under body manufacturing industry standards is about 8.5 m (28 ft) long, and fits well within the overall length of 12.5 m. It was therefore proposed and accepted that maintaining the overall length at 12.5 m would not require any control on wheelbase.

The principal issue in dimensioning the straight truck seems now to be control of rear overhang. Generally speaking, rear overhang of van boxes configured to industry recommended practice does not exceed the range 3.1 to 3.6 m (10-12 ft), which keeps the outswing is always within or close to 0.2 m [4], the performance standard. It may be a different matter for pieces of equipment that are single unit vehicles, such as mobile cranes, cement pumpers, cherry pickers, and others that have permanently mounted equipment that happens to have a long rear overhang. Overhanging loads also fall into the same category. However, there are three mitigating circumstances that need to be considered in discussion of rear overhang in this case.

First, rear overhang is an issue for long semitrailers because, for the first time, the possibility of a long rear overhang is being regulated by the combination of semitrailer length with a wheelbase limit, so a counter-measure is appropriate. The proposed dimensions for straight trucks are no different than current practice. Therefore it must be questioned whether, in the absence of a clear hazard, there is need for a counter-measure when no change is being made, and the vast majority of trucks already essentially meet the performance standard.

Second, the outswing at the outer rear corner of a semitrailer making a tight turn at an intersection is not visible to the truck driver during the turn, so the driver may not be aware of the path being traversed by that corner of the vehicle, and any hazards it may be causing. However, the driver of a straight truck can see all corners of the vehicle, and may be able to adjust progress through the turn to take account not only of fixed obstructions, but also of other traffic.

Finally, the straight truck can turn well inside the space demanded by a tractor-semitrailer, so there is a lesser likelihood that rear outswing will intrude into an adjacent lane. It was this lane intrusion that was used as the basis for the effective rear overhang limit of the semitrailer. It is realized that straight trucks may travel proportionately more on urban roads that do not have the generous geometrics of highway intersections. However, the trucks that are likely to have a large rear overhang are principally those with the fixed equipment, and such trucks are generally allocated to the same driver for an extended period, so the driver tends to become familiar with the characteristics of the vehicle and to make allowances when circumstances so demand.

It is therefore suggested that there is no real need for a rear overhang limit. If a limit is necessary, then the 5 m limit currently used by Quebec would be a suitable limit. It is sufficiently large that it would not be expected to be restrictive in very many cases, but it does serve to constrain the grossly excessive rear overhang.

Category 5 : Straight Truck Configuration Summary

Parameter	Limit
DIMENSIONS	
Truck :	
Wheelbase	No limit
Tandem Axle Spread	Minimum 1.2 m, maximum 1.85 m
Rear Overhang	No limit
Inter-axle Spacing :	
Single - single	Minimum 3 m
Single - tandem	Minimum 3 m
Overall length	Maximum 12.5 m
Overall Width	Maximum 2.6 m
Overall Height	Maximum 4.15 m
WEIGHTS	
Axle Weights :	
Steering Axle	Maximum 5500 kg
Single Axle	Maximum 9100 kg
Tandem Axle	Maximum 17000 kg
Gross Vehicle Weight	Maximum 22500 kg

3/ TRUCK AND PONY TRAILER COMBINATION ISSUES

3.1/ Dynamic Performance

The typical pony trailer appears to be designed and used to carry relatively high density freight. This results in a moderate centre of gravity height, which means that rollover performance is generally not critical for the typical current uses of this combination. The stability and control analysis found that load transfer ratio in a high-speed evasive manoeuvre, and friction demand in a tight right-hand turn, are the primary performance measures of concern [3].

These performance measures are strongly affected by the following three parameters :

1/ hitch offset;
2/ pony trailer wheelbase; and
3/ number of trailer axles, tandem or tridem.

The previous discussion paper provided a recommendation of a minimum 7.5 m wheelbase for the pony trailer to meet the performance standards [4]. Subsequent review increased this to 8.5 m. This would result in the trailer drawbar being much longer than for most current pony trailers. The inter-axle spacing limit would not be restrictive.

Further computer simulations of the truck-pony trailer have been conducted, and the results are presented in Tables 1, 2 and 3 below.

Table 1 presents the results for a gravel dump pony trailer as a function of hitch offset and trailer wheelbase. This is basically the same trailer used in the earlier simulation [3], which uses a pintle hitch. These results are intended to confirm the previous recommendation, which was made from extrapolation of data that did not cover the required range of parameters. As can be seen, even at the recommended wheelbase of 8.5 m, the vehicle does not quite achieve the desired maximum load transfer ratio of 0.6 [1].

Table 2 is new. It represents the same trailer, but uses a fifth wheel rather than a pintle hitch. It is not common for a pony trailer to use a fifth wheel, and it is not known whether it would be operationally compatible with the kind of rough ground seen in typical construction industry uses of such vehicles. It shows that such a combination can meet the target load transfer ratio even at a wheelbase of 5.5 m. Table 3 presents a variation of fifth wheel roll stiffness, which may be considered as a combination of the stiffness of the fifth wheel support structure, the fifth wheel itself, and the drawbar. This shows there is little effect due to variation in the combination of these stiffness.

These results suggest (at least) four regulatory options for the tandem axle pony trailer :

1/ Maintain the 8.5 m minimum pony trailer wheelbase;
2 Reduce the 8.5 m minimum pony trailer wheelbase, but limit the load it can carry;
3/ Compromise on meeting the performance standard; or
4/ Require use of a fifth wheel hitch to pull the pony trailer, limit the load if a fifth wheel hitch is not used, and reduce minimum wheelbase to 5.5 m.

Other options could also be developed.

Table 1/ Performance Measures of Truck with Tandem Axle Pony Trailer Pintle Hitch

Hitch Offset (m)	Wheelbase (m)	Load Transfer Ratio
1.50	5.50	0.770
1.80	5.50	0.793
2.10	5.50	0.821
1.50	5.50	0.770
1.50	6.50	0.744
1.50	7.50	0.700
1.50	8.50	0.661

Table 2/ Performance Measures of Truck with Tandem Axle Pony Trailer Fifth Wheel Hitch

Hitch Offset (m)	Wheelbase (m)	Load Transfer Ratio
1.50	5.50	0.546
1.80	5.50	0.558
2.10	5.50	0.568

Table 3/ Performance Measures of Truck with Tandem Axle Pony Trailer Fifth Wheel Hitch, Roll Stiffness Variation Hitch offset 1.50 m, Wheelbase 5.50 m

Fifth Wheel Roll Stiffness (in-lb/deg)	Load Transfer Ratio
1000000	0.546
300000	0.548
100000	0.554
50000	0.556

3.2/ Dimensions

The previous study suggested a maximum pony trailer length of 14.65 m, and a maximum box length of 18.5 m for the combination [4]. The issue of rear outswing of the pony trailer has now been examined, and has been found to be sensitive to a combination of trailer wheelbase and trailer box length, as shown in Table 4.

Table 4/ Rear Outswing for Pony Trailer, (m)

Box Length (m)	Wheelbase (m) 5.5	6.5	7.5	8.5
6.0	0.098	0.089	0.082	0.075
8.0	0.221	0.204	0.190	0.177
10.0	0.411	0.386	0.363	0.343
12.0	0.679	0.641	0.608	0.582
14.65	1.142	1.097	1.052	1.012

These results, based on a trailer box centred above the trailer axle unit, suggest that consideration of outswing should limit the pony trailer box length to around 8 m (26 ft), almost independent of its wheelbase.

The previous discussion paper suggested a definition of pony trailer length from the front of the drawbar to the rear of the trailer [4] :

> **Length (pony trailer)** means the longitudinal dimension from the front of the drawbar of the pony trailer to its rear.

Since the pony trailer's box is placed more or less squarely over the axle unit, this definition produces an unnecessary interaction between drawbar length, wheelbase and pony trailer length. A definition modeled after that for the semitrailer and full trailer is now suggested as more appropriate :

> **Length (pony trailer)** means the longitudinal dimension from the front of the cargo carrying section of the pony trailer to its rear, exclusive of any extension in length caused by its drawbar or auxiliary equipment or machinery at the front that is not designed for the transportation of goods.

The box length limit previously suggested of 18.5 m will generally not be very restrictive of most truck-pony trailer combinations, which seem mostly to be used in the construction and agricultural produce sectors.

With limits for truck length, hitch offset, pony trailer wheelbase, pony trailer box length, and box length, an overall length of even 23 m is probably not feasible. Nevertheless, an overall length limit of 23 m is suggested, even for jurisdictions where there is an overall length limit of 25 m, for consistency with the truck-full trailer (below), and to ensure that options for innovation are limited.

Category 6 : Straight Truck and Pony Trailer Combination

Parameter	Limit
DIMENSIONS	
Overall Length	Maximum 23 m
Overall Width	Maximum 2.6 m
Overall Height	Maximum 4.15 m
Box Length	Maximum 18.5 m
Truck :	
Length	Maximum 12.5 m
Wheelbase	No limit
Tandem Axle Spread	Minimum 1.2 m, maximum 1.85 m
Rear Overhang	No limit
Hitch Offset	Minimum practical Less than 1.8 m with fifth wheel Less than 1.5 m with other hitch
Pony Trailer :	
Box Length	Maximum 8.0 m
Wheelbase	Minimum 5.5 m with fifth wheel Minimum 8.5 m with other hitch
Tandem Axle Spread	Minimum 1.2 m, maximum 1.85 m
Tridem Axle Spread	Minimum 2.4 m, maximum 2.5 m
Track Width	Minimum 2.5 m, maximum 2.6 m
Inter-axle Spacing :	
Single - single	Minimum 3.0 m
Single - tandem	Minimum 3.0 m
Tandem - tandem	Minimum 5.0 m
Tandem - tridem	Minimum 5.5 m
WEIGHTS	
Axle Weights :	
Steering Axle	Maximum 5500 kg
Single Axle	Maximum 9100 kg
Tandem Axle	Maximum 17000 kg
Tridem Axle	Maximum 21000 kg
Gross Combination Weight	Maximum 39500 kg with 5 axles Maximum 43500 kg with 6 axles

4/ TRUCK AND FULL TRAILER COMBINATION ISSUES

4.1/ Dynamic Performance

There are three full trailer axle arrangements being considered :

1/ single-single;
2/ single-tandem; and
3/ tandem-tandem.

The typical full trailer towed by a straight truck appears to be designed and used to carry relatively high density freight. This results in a moderate centre of gravity height, which means that rollover performance is also generally not critical for the typical current uses of this combination. The stability and control analysis has found that load transfer ratio in a high-speed evasive manoeuvre is the primary performance measure of concern [3].

This performance measure is strongly affected by the following four parameters :

1/ hitch type;
2/ hitch offset;
3/ full trailer drawbar length; and
4/ full trailer wheelbase.

The first issue is easily dealt with. The C-dolly, or any other non-articulating dolly, should not be used in the truck-full trailer combination, as it can seriously degrade its handling and lateral/directional stability of the vehicle [3,4].

The previous study [3] resulted in a set of recommended minimum wheelbases for 2-, 3- and 4-axle full trailers [4]. The importance of minimum hitch offset was recognized, and it was concluded that drawbar length was either not a sufficiently powerful parameter, or it would be adequately controlled by the minimum inter-axle spacing. The values for minimum wheelbase were also obtained by extrapolating from a series of simulation results from parametric studies that did not fully cover the domain of interest. Tables 5, 6 and 7 present the results for the load transfer ratio of 2-, 3- and 4-axle full trailers, for a range of wheelbases.

The recommended minimum wheelbases for 2-, 3- and 4-axle trailers were 6.5, 8 and 8 m respectively. It is seen from Tables 5, 6 and 7 that the load transfer ratio does not quite diminish to the target performance standard of 0.6, even at the recommended wheelbases.

These results suggest (at least) three regulatory options for the full trailer :

1/ Maintain the proposed minimum full trailer wheelbases;
2 Reduce the proposed minimum full trailer wheelbases, but limit the load it can carry; or
3/ Compromise on meeting the performance standard.

Other options might also be developed.

Table 5/ Performance Measures of Truck with 2-axle Full Trailer

Wheelbase (m)	Load Transfer Ratio
4.50	0.722
5.50	0.664
6.50	0.625

Table 6/ Performance Measures of Truck with 3-axle Full Trailer

Wheelbase (m)	Load Transfer Ratio
5.00	0.786
6.00	0.709
7.00	0.659
8.00	0.613

Table 7/ Performance Measures of Truck with 4-axle Full Trailer

Wheelbase (m)	Load Transfer Ratio
5.00	0.799
6.00	0.738
7.00	0.683
8.00	0.638

4.2/ Dimensions

The previous study suggested a maximum full trailer box length of 14.65 m, and a maximum box length of 18.5 m for the combination [4]. The main consideration in restricting the box length was to try and ensure that the truck-trailer did not become an attractive combination for low-density freight, by providing volume comparable to that of the B-train. Indeed, it would be quite practical, even within an overall length of 23 m, to offer the truck-full trailer a box length in excess of 20 m. With the box length restriction of 18.5 m, and even a minimal truck, it is unlikely that the trailer box length of 14.65 m will be approached. It is therefore unnecessary to allow a full trailer box length of 16.2 m, even in those provinces where this is the semitrailer length.

The issue of rear outswing of the full trailer does not appear to be important, but offtracking is. The offtracking of a 12.5 m wheelbase 14.65 m long full trailer pulled by the maximum length truck possible in the balance of the 23 m overall length, and the maximum practical length straight truck with the maximum length trailer possible in the balance of the 23 m overall length, are both slightly less then the offtracking of a maximum wheelbase tractor-semitrailer. It is therefore suggested that a maximum wheelbase limit of 12.5 m be established for a full trailer of this length. If a lesser full trailer length should be established, a maximum wheelbase limit would not be needed.

With limits for truck length, hitch offset, full trailer box length, box length and inter-axle spacing, an overall length of 23 m is probably not feasible for 2- and 3-axle full trailers. However, it will be approached for 4-axle full trailers. Nevertheless, an overall length limit of 23 m is suggested, so that this vehicle does not become popular.

Category 7 : Straight Truck and Full Trailer Combination

Parameter	Limit
DIMENSIONS	
Overall Length	Maximum 23 m
Overall Width	Maximum 2.6 m
Overall Height	Maximum 4.15 m
Box Length	Maximum 18.5 m
Truck :	
Length	Maximum 12.5 m
Wheelbase	No limit
Tandem Axle Spread	Minimum 1.2 m, maximum 1.85 m
Rear Overhang	No limit
Hitch Offset	Minimum practical Less than 1.8 m with fifth wheel Less than 1.5 m with other hitch
Full Trailer :	
Length	Maximum 14.65 m
Wheelbase	Minimum 6.5 m with two axles Minimum 8.0 m with three axles Minimum 8.0 m with four axles
Tandem Axle Spread	Maximum 12.5 m Minimum 1.2 m, maximum 1.85 m
Track Width	Minimum 2.5 m, Maximum 2.6 m
Inter-axle Spacing :	
Single - single	Minimum 3.0 m
Single - tandem	Minimum 3.0 m
Tandem - tandem	Minimum 5.0 m
WEIGHTS	
Axle Weights :	
Steering Axle	Maximum 5500 kg
Single Axle	Maximum 9100 kg
Tandem Axle	Maximum 17000 kg
Gross Combination Weight	Maximum 40700 kg with 5 axles Maximum 48600 kg with 6 axles Maximum 56500 kg with 7 axles

REFERENCES

[1] "Recommended Regulatory Principles for Interprovincial Heavy Vehicle Weights and Dimensions", CCMTA/RTAC Vehicle Weights and Dimensions Study Implementation Committee Report, September 1987.

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[3] Lam C.P. and Billing J.R., "Stability and Control Characteristics of Straight Trucks and Truck-trailer Combinations", Draft report to Interjurisdictional Committee on Vehicle Weights and Dimensions, Ontario Ministry of Transportation, October 1989.

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