REGULATORY PRINCIPLES FOR STRAIGHT TRUCKS AND TRUCK-TRAILER COMBINATIONS

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

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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. This discussion paper takes the work a step further. It is restricted only to those configurations that have some hope of meeting the performance standards. It addresses regulatory principles for straight trucks, the truck and pony trailer combination, and the truck and full trailer combination. In all cases, the vehicles are fairly tightly defined. No provision is made for configurations not conforming to the definitions. In addition, the paper also addresses some issues of busses, where there are some current suggestions for an increase in length.

2/ ASSUMPTIONS

The work which follows is based on the assumption that the principal provisions of the Memorandum of Understanding will not be changed [2]. These are summarized below.

2.1/ Tire Loading

Not more than 10 kg/mm of tire width.
Not more than 3000 kg per tire.

2.2/ Axle Units, Axle Loads and Axle Spreads

Single	9100 kg.
Tandem	17000 kg from 1.20 to 1.85 m spread.
Tridem	21000 kg from 2.40 to 3.00 m spread.
	23000 kg from 3.00 to 3.60 m spread.
	24000 kg from 3.60 to 3.70 m spread.

2.3/ Inter-axle spacings

Single to single 3.0 m.
Single to tandem 3.0 m.
Single to tridem 3.0 m.
Tandem to tandem 5.0 m.
Tandem to tridem 5.5 m.
Tridem to tridem 6.0 m.

2.4/ Equipment

One axle unit per vehicle unit.
No province need accept liftable axles, belly axles or self-steering axles.

2.5/ Dimensions

Overall length of 23 m (75 ft 6 in).
Trailer length of 14.65 m (48 ft).
Track width not less than 2.5 m.

3/ STRAIGHT TRUCK ISSUES

3.1/ Definitions

It appears necessary to define a straight truck. The Memorandum of Understanding provides a definition of a tractor [2] :

> Tractor means a motor vehicle designed to and normally used to pull a semitrailer or a semitrailer and a full trailer or a semitrailer and a semitrailer.

This definition does not explicitly exclude load from being carried by a tractor (e.g. a "drome box"), so it implicitly allows load on the tractor. The straight truck is designed to carry load. It is therefore not possible to use load-carrying ability to distinguish between tractor and straight truck. The above definition of a tractor clearly excludes a single unit straight truck, and a straight truck with a pintle hook to tow a trailer by means of a toweye. The status of a straight truck equipped with a fifth wheel for the purpose of towing a trailer that is not obviously a semitrailer is not clear. The following definition is offered for a straight truck :

> Truck means a motor vehicle that is either permanently fitted with a special-purpose device, or is designed to and normally used to carry load, that may operate as a single unit or may pull a trailer other than a semitrailer.

The tractor definition does not specify the type of coupling, though the semitrailer definition clearly requires it to be a fifth wheel. The truck definition above is also silent on the type of coupling. It therefore allows not only a pintle hitch or a fifth wheel, but also any other form of hitch.

The definition of hitch offset in the Memorandum of Understanding [2] applies only to a trailer. It needs to be amended to recognize that a truck may also be fitted with a hitch.

A definition of truck wheelbase also needs to be added. This may parallel that for tractor wheelbase, already included in the Memorandum of Understanding.

3.2/ Configuration

The preceding study showed that the basic three-axle straight truck, with a single front steering axle and a tandem drive axle, met all the performance criteria [3].

However, three other four-axle arrangements of fixed axle units need to be given some consideration. The first is the twin steer arrangement, which seems to be used almost exclusively in most provinces only for cement mixers or for special-purpose equipment, and in Quebec for dump trucks; the second is the single steer axle with a tridem drive axle unit; and the third is that of the self-steering liftable tag axle.

There are two issues with twin-steer four-axle straight trucks. The preceding study found that these trucks had a significantly lower rollover threshold than the comparable three-axle straight truck [3]. This is because the extra axle allows considerably more payload for little extra tare weight, and the additional front axle adds relatively little roll resistance, because it must have a low vertical stiffness to provide the driver with an acceptable ride quality. In real life, twin-steer trucks usually have very stiff "heavy duty" drive axle suspensions. However, increasing the stiffness of the drive suspension does little for the rollover resistance of the truck. It really needs a substantial increase in steer axle suspension roll stiffness [4]. However, the front suspensions are typically not equipped with a heavy duty torsion bar to add the level of roll stiffness necessary for a large improvement in rollover resistance. Beyond this, it appears that many twin-steer axle arrangements are actually two single axles, and in some designs one of these axles is a variable load axle. In the absence of any mechanism to ensure that twin-steer trucks meet some rollover standard, and are equipped with a proper load-sharing tandem front axle unit, the twin-steer arrangement should be discouraged.

There are also two issues with tridem drive four-axle straight trucks. The preceding study found that these trucks had a significantly greater friction demand than the comparable three-axle straight truck [3]. This is because the extra axle provides much greater resistance to turning than a tandem axle. This problem would be resolved by making one of the tridem axles self-steering or forced steering. However, the steering axle introduces other complications, as it must probably have as single tire, and must be liftable is self-steering. Such designs are already precluded by the assumptions. Forced steering technology is not widely used, and there is at this time no reason to endorse such designs without proper study. Finally, ensuring a true load-sharing tridem axle may be difficult. In the absence of any workable tridem drive axle providing proper load sharing, the tridem drive arrangement should therefore also be discouraged at this time.

The Memorandum of Understanding states that no province need allow liftable or self-steering axles [2]. The technical studies indeed provide sound reasons why such equipment should not be allowed in any province [3,5,6]. Beyond this, the technical study found major stability and control deficiencies with straight trucks having a liftable or self-steering axle as the tag axle, particularly as the spacing of the tag axle from the drive axles increased [3,7]. This is not an issue in provinces where current regulations do not allow liftable or self-steering axles, either by regulation or special permit, and such trucks presumably do not exist. This recommendation goes beyond this general limitation, and is addressed to provinces where liftable or self-steering axles are not prohibited, or are allowed by special permit. These provinces should consider positive near-term action to constrain the use of such tag axles, and not simply long-term grandfathering. This prohibition is very strong. It is intended to apply at least to the self-steering booster axle, particularly seen on cement mixers, where the inter-axle spacing would be 3.0 m or more. For such a truck, the large spacing and poor load control result in the tag axle having a very strong effect on the handling of the truck. However, there are other trucks around which have self-steering or liftable tag axles that may not be nearly as critical, such as the tractor with a liftable tag axle; the inter-city bus with its variable load tag axle; and various trucks with quite closely coupled tag axles of various designs.

3.3/ Dimensions

There appears no real reason to set any lower wheelbase limit for the straight truck that would pre-empt that value arising from the 3.0 m inter-axle spacing and the drive axle spread, set in the Memorandum of Understanding for tractors, which allegedly is derived from bridge loading considerations.

The dimensions of the straight truck would appear to be determined principally by considerations of turning.

When a straight truck turns at low speed at an intersection, its rear axle unit follows a path inside the path of the front steering axle. This is offtracking. The body of the truck on the outside of the turn overhangs both front and rear axles, so it occupies space outside the path of those axles. This is outswing. The body of the truck on the inside of the turn between the axles also occupies space outside the path of the wheels. This is chording.

Offtracking is a fundamental quantity considered in the design of intersections and other parts of the roadway system. It does not generally represent a major safety concern, as long as the truck's offtracking does not demand more space than the intersection provides. Even then, because the large vehicle is manoeuvring at low speed, and its driver is presumably vigilant for other traffic, offtracking is not known to be a major cause of fatal accidents, but it is a factor in property damage accidents, both on the highway and on private property, such as when manoeuvring in yards.

Outswing at the front of a turning truck is also not apparently of much concern, as the driver of both the truck and other vehicles are quite well aware of the trajectory of the outer front corner of the truck. Outswing at the rear has been identified as a potential issue for long semitrailers, which may have a long rear overhang of the body behind the axles [5]. This issue arises because a truck creates more space to turn right, the most demanding manoeuvre, by keeping as far left as possible in the approach to the turn. If it is presumed that the trucks wheels remain in its own lane while approaching the turn, the rear outer corner can encroach on the space in the adjacent lane to the left. Even though the outswing may be visible to the driver of the truck, it still represents a hazard to other vehicles, which might be proceeding at a much greater speed than the truck in the same direction or the opposite direction, and be surprised by a sudden outswing of the rear of the truck. Outswing was established as a performance measure, and it was decided that it should be limited to not more than 0.2 m. A limitation on semitrailer effective rear overhang was imposed to control this [2], based in part on an earlier discussion paper [8]. The control requires the effective rear overhang not exceed 35 percent of semitrailer wheelbase.

Offtracking uses considerable space on the inside of a turn. This is a safety issue if the truck driver does not signal, and moves initially to the outside of the turn, leaving space for an unwary driver of a small car, motorcyclist, or cyclist to pass on the inside of the truck. The operator of this vehicle then quickly gets trapped between the truck and the curb. However, if the truck driver makes proper use of turn signals, and a proper approach to the turn, then the other vehicle is not presented an opportunity to try and pass on the inside.

This work therefore looks at the offtracking and rear outswing of a generic straight truck with a nominal 1 m front axle setback, a variable wheelbase, and a variable rear overhang. For typical trucks, the BBC dimension (bumper to back of cab) varies between about 2.3 and 3.1 m (90 and 120 in). Since a load bed cannot reasonably be greater than double the CA distance (back of cab to centre of drive axles), there is a real dimensional constraint that limits rear overhang to no more than wheelbase less at least 0.5 m, if the payload is balanced over the drive axles. Typical overhangs are generally much less than this. Of course, the load may overhang beyond the end of a "reasonable" length loadbed.

Ontario uses a minimum curb radius of 10 m in urban areas, or 15 m in rural areas. These may be reduced to 5 and 10=m respectively for minor or local roads. Major urban areas try to use the larger rural radius where possible. These standards apply where trucks are less than 10% of traffic. Where trucks are a greater percentage, a two segment curb having an initial radius of 14-18 m and a second radius of 80-90 m is used. This geometry was derived from a WB15 tractor-semitrailer design vehicle, which represents approximately a tractor-semitrailer with a 5.5 m (216 in) wheelbase tractor and an 11.3 m (37 ft) long semitrailer. SU represents a single unit truck, B-12 represents an inter-city bus, and WB17.5 represents a 13.7 m (45 ft) semitrailer with the same tractor as WB15. Other provinces have generally similar dimensions. Older standards tend towards the lower end of these ranges.

Two radii were used to generate the current design standard using the WB15 vehicle. These were 14 m or 18 m radius at the left front wheel in a right-hand turn. A radius of 11 m is close to the minimum turning radius of many trucks, although this is subject to considerable variation in steering geometry. For the purpose of this analysis, radii of 11, 14 and 18 m were used. Any vehicle that fits inside the envelope of the WB15 design truck should be compatible with a design standard used on at least all construction and reconstruction since that standard was adopted, quite sometime ago.

Table 1 summarizes the offtracking of straight trucks in 90 degree right-hand turns of radii 11, 14 and 18 m, where the radius is measured at the left front wheel. Note that steering geometry may prevent the shorter wheelbase trucks actually achieving some of these turns.

Table 2 summarizes the offtracking of design vehicles in the same turns. A 6.2 m wheelbase tractor is used for the 48 and 53 ft semitrailers. The 14.65 m (48 ft) semitrailer has a 0.91 m (36 in) kingpin setback and a 12.5 m (41 ft) wheelbase. Comparisons are made with the same trailer but with wheelbase reduced to give a 35% rear overhang, and a 16.2 m (53 ft) semitrailer with a 35% rear overhang. If the highway system is largely designed to a WB15 standard, although recent design and construction may be to a WB17.5 standard, it is obvious that the current largest tractor-semitrailers consume more space to turn than the roadway design provides.

Table 1/ Offtracking

Wheelbase	Turn radius		
(m)	11 m	14 m	18 m
4	0.891	0.699	0.537
5	1.327	1.069	0.820
6	1.814	1.501	1.158
7	2.335	1.985	1.541
8	2.883	2.509	1.965
9	3.450	3.068	2.420
10	4.032	3.654	2.901
12	5.229	4.887	3.929
14	6.456	6.178	5.019

Table 2/ Offtracking of Design Vehicles

	Turn radius		
Vehicle	11 m	14 m	18 m
SU	1.860	1.541	1.191
B-12	2.499	2.140	1.666
WB15 semi	4.667	4.258	3.379
48 ft semi 35% R.O.	5.462	5.081	4.064
WB17.5 semi	5.921	5.571	4.404
53 ft semi 35% R.O.	6.005	5.653	4.546
48 ft semi 12.5 m WB	6.705	6.399	5.177

Comparison of Tables 1 and 2 shows that a straight truck may have a wheelbase as long as about 14 m if it is allowed the same envelope as the largest tractor-semitrailer for turning. That wheelbase would be restricted to 11 m if the WB15 design vehicle onvolopo ir applied.
envelope is applied

Table 3 presents an interpolation of the rear overhang ratio (rear overhang divided by wheelbase) to an outswing of 0.2 m, the criterion used in setting the dimensions for semitrailers [1]. A wide range of rear overhang ratio is observed, and the data do not readily reveal a criterion that could conveniently be used to control outswing.

Table 4 presents the same data as Table 3, but uses the rear overhang directly. It is seen that if the rear overhang is controlled (say) in the range 3.1 to 3.6 m (10-12 ft) the outswing is always within or close to 0.2 m, except for the shortest wheelbase trucks on the tightest turn. For these trucks, a rear overhang in this range is not even practical. Even if it were, such a truck can turn well inside other common vehicles, and outswing should not be a problem. The extent to which a rear overhang limit of 3.6 m would impose on existing trucks has not been investigated.

A straight truck with 14 m wheelbase and 3.6 m rear overhang could be as long as about 19 m (62 ft 4 in). With an 11 m wheelbase, it would be 16 m (52 ft 6 in) long. A 3.1 to 3.6 m rear overhang dimension would only start restricting the overall length of trucks when that length reaches about 10 m (33 ft), and the truck is relatively light duty.

Table 3/ Rear Overhang Ratio for 0.2 m Outswing
(Rear overhang/wheelbase)

Wheelbase	Turn radius		
(m)	11 m	14 m	18 m
4	0.719	0.800	0.891
5	0.604	0.664	0.746
6	0.518	0.573	0.649
7	0.456	0.506	0.575
8	0.409	0.456	0.514
9	0.372	0.417	0.468
10	0.342	0.385	0.429
12	0.296	0.336	0.372
14	0.262	0.297	0.331

Table 4/ Rear Overhang for 0.2 m Outswing

Wheelbase	Turn radius		
(m)	11 m	14 m	18 m
4	2.877	3.199	3.565
5	3.019	3.321	3.728
6	3.108	3.438	3.895
7	3.195	3.545	4.025
8	3.273	3.650	4.112
9	3.348	3.754	4.210
10	3.418	3.854	4.294
12	3.555	4.034	4.464
14	3.664	4.152	4.629

This suggests that there is no reason why the overall length of straight trucks or other single unit vehicles should not be increased to 15-18 m, provided the rear overhang is limited to about 3 m. These constraints recognize offtracking and rear outswing performance criteria. This would provide a box length of 12-15 m, considerable longer than the maximum of about 10 m now possible within the common overall length limit of 12.5 m, and perhaps competitive with some large semitrailers.

There appear at least three options for straight truck overall length :

1/ 12.5 m, the current limit;

2/ About 15.5 m; or

3/ About 18.5 m.

The dimensional limits for these three options are summarized in Table 5. Notice that even within a 12.5 m overall length, a wheelbase of 11 m, the largest compatible with the older geometric standards is achievable. If this option is selected, there would appear to be no real reason to constrain the maximum wheelbase. Note that the largest general purpose truck wheelbases available are in the range 7.1-8.1 m (280-320 in). Any greater allowable length would require a product from truck manufacturers that is not immediately available, and for which the demand is presumably not great. This overall length provides a box length up to 9.7 m (32 ft), which is a little more than is possible on each trailer with two equal length trailers in a B-train with 20 m box length. A greater overall length would need a wheelbase limit. This should be in the range 11 to 14 m, depending on the approach taken regarding accessibility for these trucks. The concept of box length is not really applicable to straight trucks.

At this time there appear to be few straight trucks that approach the (almost) uniform single unit vehicle overall length limit of 12.5 m (41 ft). This is presumably because the majority of heavy straight trucks are in the construction or agricultural sectors, and their dimensions are limited either by accessibility requirements, because greater size will accrue no more gross weight, or by other operational considerations. Lighter trucks in pickup and delivery operations are usually limited in size by accessibility requirements. Those trucks that approach the current length limit are often special-purpose vehicles, with permanently mounted equipment such as a crane or a lift. There does not appear evident demand for trucks of even the current maximum allowed dimension, let alone greater dimension. This does not mean that the effect of greater allowable length might not create some demand.

It is concluded that 12.5 m is a reasonable overall length limit for the straight truck, and that no limits on wheelbase are necessary. Rear overhang should be limited to no more than 3.6 m. It is a matter for debate whether this should, or should not, include load.

Table 5/ Straight Truck Dimension Options

	Length (m)		
	12.5	15.5	18.5
Maximum single axle wheelbase	11.0	14.0	17.0
Maximum tandem axle wheelbase	10.2	13.2	16.2
Wheelbase with maximum overhang	8.1	11.1	14.1
Maximum box length	9.7	12.7	15.7

The relationship between front axle load, tire width and tire load is given in Table 6, in round numbers. Note that the 5500 kg tractor front axle load is slightly more damaging than the nominal dual tire-single axle with a load of 9100 kg, and the dual tire tandem and tridem [9]. The pavement impacts of front axles have not been studied in great depth, and the research has not been reviewed. If any higher load is selected, it might be wise to ensure that it is conservative with respect to pavement damage.

Finally, it is necessary to consider typical front suspension ratings, which include (but are not limited to) 5443, 6350, 6622, 7257, 8164 and 9071 kg (12000, 14000, 14600, 16000, 18000 and 20000 lb). It would be wise to choose a combination of tire width, tire loading and common suspension rating that conforms to widely available equipment, if possible.

Table 6/ Front Axle Loads

Tire Width		Tire Load (kg/mm)		
(mm)	(in)	8	9	10
250	10	4000	4500	5000
275	11	4400	4950	5500
300	12	4800	5000	6000
350	14	5600	6300	7000
400	16	6400	7200	8000
450	18	7200	8100	9000

3.5/ Loadability

Loadability is a term used to describe the ease with which a truck can be loaded to its gross weight while simultaneously meeting axle weight limits. Solid or packaged commodities can often be arranged to provide proper axle load distribution. Tankers are usually designed for proper axle load distribution. Loadability is primarily an issue for loose bulk commodities, such as excavated material, aggregates, grains, etc. These commodities are relatively dense, and may need a different box size and placement than that compatible with the bed length available from the truck having minimum length for maximum allowable gross weight. It is not uncommon for such trucks simply to be built with the wrong box size and location for the planned payload. Once built, there is no way they can ever expect to conform to allowable axle weights when loaded to their allowable gross weight.

This issue would be addressed by a requirement that the maximum allowable gross weight for a bulk commodity is the lesser of the values derived from sum of axle loads; allowable gross weight (where different than sum of axle loads); and that value from a water level load in the load box, as assessed by an appropriately qualified person, such as a professional engineer.

4/ TRUCK AND PONY TRAILER COMBINATION ISSUES

4.1/ Definitions

The pony trailer, pony pup, truck pup, or stiff-pole pup trailer probably has other local names too. It is a trailer having one axle unit, a relatively short body mounted more or less centrally over the axle unit, and its drawbar is a rigid forward extension of the trailer frame. It is most often towed by a pintle hitch or a ball hitch, though some do use a low-mounted stinger fifth wheel. In Ontario at least, there are other hybrid trailers with more than one axle unit that are described as pony trailers but are different than the trailer described above. None of these has obvious merit, and they are not considered further.

One common design of open-frame car carrier might be considered as a straight truck with a stinger fifth wheel pulling a trailer. That trailer may be described as a semitrailer, because it has a kingpin and the load is essentially distributed over the entire length of the trailer. Arguably, though, it could equally be considered as a pony trailer, because it is hauled by a straight truck. The status of this combination, tractor-semitrailer or truck and pony trailer, or whatever, may also need to be clarified. It is believed that the special-purpose car carrier is defined as a separate class of vehicle in some way in the U.S. However, this issue is confused now that closed vans are used as car carriers.

The utility trailer, usually a low-bed design, is used primarily in the construction industry, for moving small and medium size pieces of equipment. It may have two or three heavy duty axles, often with small tires. The key design feature is that such trailers have their axle unit about the centre of the load bed, and are designed to transfer minimal load to the towing truck. A trailer of this design may also be considered a pony trailer. There are also many similar light duty trailers, with closely spaced tandem, tridem or even quad axle units using light duty axles and often with single small tires. These may be used to transport large (but light) pieces of equipment, such as modular buildings. There is a clear decision necessary to determine how inclusive any custom definition of pony trailer should be.

The recreational house trailer, boat trailer and utility trailer may all also be considered as a pony trailer, despite their light weight and the light duty vehicle used to tow them.

The majority of truck and pony trailer combinations appear to be used in the construction sector for aggregates and bricks, in the agricultural sector for feeds and grains, and in small numbers as a tanker. There appear to be very few of these combinations in a van body style, at least in Canada, but this concept is now being promoted in the U.S. as a means to maximize the volume for low-density freight within the U.S. weight and dimension framework. The local-use character of pony trailers would be expected to give rise to significant variations in dimensions of such trailers between provinces in Canada, if not in body style, if they became widely used.

It has not been investigated whether any province actually defines a pony trailer. It is thought likely that in most provinces, as in the U.S., that the pony trailer would be captured under the general definition of a semitrailer. However, it is clearly not a semitrailer :

1/ in the sense in which that term is normally used in the trucking industry, as a semitrailer is towed by a tractor, not a straight truck, and a pony trailer is towed by a straight truck, not a tractor;

2/ by the definition of semitrailer in the Memorandum of Understanding, which reads [2] :

> Semitrailer means a vehicle that is designed to be towed by another vehicle and is so designed and used that a substantial part of its weight and load rests on and is carried by the other vehicle or a trailer converter dolly through a fifth wheel and kingpin combination; and

3/ because it has significantly different stability and control characteristics from a semitrailer.

Note that the above definition of semitrailer does capture a pony trailer where the truck uses a fifth wheel to tow the pony trailer, provided the typical 10% or so hitch load of the pony trailer would be deemed "substantial". The pony trailer's typical hitch load also clearly excludes it from the definition of full trailer in the Memorandum of Understanding, which reads [2] :

> Full trailer means a vehicle that is designed to be towed by another vehicle and is so designed and used that the whole of its weight and load is carried on its own axles and includes a combination consisting of a semitrailer and a trailer converter dolly.

The pony trailer is certainly closer to the full trailer definition than the semitrailer definition, but the full trailer has two points of articulation, so the pony trailer is physically and dynamically different due to its single point of articulation.

Having established that the pony trailer is neither a semitrailer or a full trailer, if it is to become a preferred form of trailer, then it is necessary to define it closely and tightly. This will result then in three specific and well-defined members of the trailer class of vehicle : semitrailer, full trailer and pony trailer. Any trailer which is not a semitrailer, full trailer or pony trailer then is a member of the default class of trailer. While a possible amendment to the Memorandum of Understanding might address the three specific and well-defined members of the trailer class of vehicle, it could be left to the provinces to decide how to treat those vehicles that become the residual members of the default class of trailer. They could, for instance, try and ensure that it was empty, or they could assign all trailers not complying with any of the specific definitions to it, and apply restrictions to their allowable gross weight, as was done for the A-train. If the committee prefers not to endorse the truck-pony trailer combination, then no definition is necessary and it may remain either as an obscure relative of the semitrailer, or as part of the default class of trailer.

It must be realized though, that as the defined pieces of equipment become more numerous, and as the definitions become more detailed, there will be more and more equipment that falls between defined classes. There would appear need for a clear set of principles to deal with the default "none of the above" category.

The following definition is offered for a pony trailer :

> Pony trailer means a vehicle that is designed to be towed by another vehicle, is equipped with a drawbar that is rigidly attached to the structure of the trailer, and is so designed and used that the preponderance of its weight and load is carried on its own axles.

The last requirement, that the preponderance of its weight and load should be carried on its own axles, may be redundant. There is some concern in the semitrailer definition whether the reference to a "substantial portion" of load is sufficiently specific to be enforceable. The same problem might apply to the above definition. Note that the definition of drawbar will need to be revised to include reference to the pony trailer.

The length of the pony trailer may also need to be defined. The following is offered :

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

4.2/ Configuration and Dimensions

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 has 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.

There is no difference in principle between a tractor-semitrailer and a truck-pony trailer combination, as each is a combination with a single point of articulation. The stability and control performance of a tractor-semitrailer is generally benign, provided the semitrailer has adequate wheelbase and its centre of gravity is not too high. Consider the salient differences between the tractor-semitrailer and truck-pony trailer combination, and the effect these differences have on the stability and control performance of the truck-pony trailer relative to the tractor-semitrailer.

The tractor-semitrailer has its hitch, the fifth wheel, located with a negative (forward) offset, whereas the truck-pony trailer has its hitch located with a positive (rearward) offset. This provides a modest improvement in low-speed offtracking for the truck-pony trailer, but a significant increase in rearward amplification, over the tractor-semitrailer.

The fifth wheel hitch on the tractor-semitrailer provides roll coupling between the two vehicle units, whereas the pintle hook (with or without a rotary eye) or the ball hitch, used by many truck-pony trailer combinations provides negligible roll coupling.

The tractor-semitrailer has its axle unit at the rear of the trailer, whereas the truck-pony trailer has its axle unit located in the middle of the trailer. This provides a significant improvement in low-speed offtracking for the truck-pony trailer, but the much shorter wheelbase results in a significant increase in rearward amplification, over the tractor-semitrailer.

The semitrailer is long, so has a large yaw moment of inertia, and responds relatively slowly to lateral/directional steer inputs. The pony trailer is short, so has a low yaw moment of inertia, and it will respond relatively quickly to lateral/directional steer inputs. The truck, though, has a relatively high yaw moment of inertia, so may not be able to

Table 7/ Performance Measures of Truck with Tandem Axle Pony Trailer

Hitch Offset (m)	Wheelbase (m)	Inter-Axle (m)	Load Tr Ratio	Friction Demand (deg)
0.00	4.51	3.60	0.596	5.58
0.76	4.51	3.60	0.678	6.09
1.52	4.51	3.60	0.831	6.78
1.52	4.51	3.60	0.831	6.78
1.52	4.91	4.00	0.777	6.56
1.52	5.91	5.00	0.718	6.08
1.52	6.91	6.00	0.684	5.88

provide inputs in the frequency range of the pony trailer.

In all respects, therefore, the truck-pony trailer combination appears a more responsive, or less stable, combination than the tractor-semitrailer.

Table 7 is a summary of the parametric variation on hitch offset and trailer wheelbase conducted for the truck-pony trailer combination SD4D in [3]. This is a three axle straight truck pulling a tandem axle pony trailer.

Table 7 shows that load transfer ratio and friction demand are both improved as hitch offset is reduced, and as trailer wheelbase is increased. Linear interpolations within the extent of this table gives the relationships :

Load transfer ratio = 0.871 + 0.155*hitch offset - 0.061*wheelbase
Friction demand = 7.27 + 0.709*hitch offset - 0.375*wheelbase

There appears no practical reason why the hitch offset should not be well within 1.2 m for a pintle hook or ball hitch, even with a 1.83 m (72 in) drive axle spread. A fifth wheel requires a little more clearance, and 1.5 m should be an equally practical upper limit in this case. Note that few straight trucks have a drive axle spread greater than 1.52 m (60 in), so in most cases these limits provide some extra tolerance.

The performance standard for load transfer ratio can just be met at a hitch offset of 1.2 m with a pony trailer wheelbase of 7.5 m, and at a hitch offset of 1.5 m with an 8.3 m wheelbase. Both these also meet the tandem-tandem inter-axle spacing of 5.0 m. These dimensions easily ensure the friction demand performance standard, less than 6 degrees slip angle at the drive axles, is met. It results in quite a long drawbar.

There are four fairly obvious options :

1/ 7.5 m minimum wheelbase, which meets all the performance standards;

2/ 6.5 m minimum wheelbase, the same as the tandem axle semitrailer, which gives a more compact trailer but compromises the load transfer ratio slightly;

3/ Endorse the configuration, but with a reduced gross weight in recognition of its responsiveness, as was done for the A-train; or

4/ Do not endorse this configuration.

In many cases, hitch offset can be less than the limits assumed here, and use of a lesser axle spread on the trailer than the 1.83 m used in this analysis will tend to improve the performance. These positive factors could be used to try and justify the second option. However, the results are based on sparse data, which are both quite specific and very general; payloads can be less dense, with higher centre of gravity; and not all factors will necessarily be positive.

If this configuration is to be endorsed, it should have a minimum wheelbase of 7.5 m to ensure the performance standard is met.

Table 8/ Performance Measures of Truck with Tridem Axle Pony Trailer

Axle Spread (m)	Axle Load (kg)	Hitch Offset (m)	Wheelbase (m)	Inter-Axle (m)	Load Tr Ratio	Friction Demand (deg)
3.05	23000	0.76	5.88	3.60	1.000	9.28
3.05	23000	0.76	6.78	4.50	0.598	8.39
3.05	23000	0.76	7.78	5.50	0.550	7.72
3.05	23000	0.76	8.78	6.50	0.508	7.21
2.44	21000	0.76	5.88	3.60	0.831	7.35
3.05	23000	0.76	5.88	3.60	1.000	9.28
3.66	24000	0.76	5.88	3.60	1.000	10.66

Table 8 is a summary of the parametric variation on wheelbase and axle spread/axle load conducted for the truck-pony trailer combination SD4M in [3]. This is a three axle straight truck pulling a tridem axle pony trailer.

The wheelbase variation in the upper part of the table was conducted with a 3.05 m tridem spread loaded at 23000 kg. If the very short wheelbase configuration (which rolled over) is excepted, this vehicle met the load transfer ratio performance standard. However, it was far from meeting the friction demand standard, which would require a wheelbase estimated as 11-12 m. This translates into a drawbar of about 8 m (26 ft) length ahead of the load box, which is considered excessive, though the vehicle is still within overall dimensional limits.

The axle spread/load variation in the upper lower part of the table was conducted with the shortest wheelbase trailer. While the two larger spreads and loads are clearly not acceptable on either performance count, the smaller spread provides results very close to those of the tandem 1.83 m spread pony trailer in Table 7. Extrapolating, therefore, it might be expected this configuration would also be acceptable with a minimum wheelbase of 7.5 m.

The tridem pony trailer configuration might only be endorsed if its tridem axle is restricted to a spread between 2.4 and 2.5 m, and the tridem axle load is strictly limited to 21000 kg. Wider spreads, or higher loads, should not be permitted by local option where such equipment does not already exist.

It is necessary to look at the overall dimensions of the truck-pony trailer combination. A cube van truck-pony trailer is currently being marketed, with designs providing a box length up to 18.1 m (59 ft 6 in) within an overall length of 19.8 m (65 ft). This truck is claimed to be compatible with the dimension regulations of all states and provinces.

Within an overall length of 23 m (75 ft 6 in), it is possible to generate a "box length" of nearly 21 m (69 ft), with a bed length of over 20 m (65 ft 6 in), more than allowed for the B-train. This may be attractive to some.

First, however, the length of the pony trailer must be established. There are two obvious values that might be assigned to this : 12.5 m, the single unit vehicle length, or 14.65 m, the semitrailer length. The former may be a little restrictive for the cube van, and is generally believed to be intended to apply to motor vehicles, not trailers. The latter should not be at all restrictive within the other dimensional limits discussed below. If those are accepted, there would be no case for any greater length. Compatibility with longer 16.2 m (53 ft) semitrailers is not an issue.

Where an operator can use trucks of two different configurations, the preferred configuration will be that offering greatest volume (box length), gross weight or axle capacity. Since the dynamic performance of the truck-pony trailer combination is only marginally acceptable at best, and it will potentially accrue greater gross weight than the corresponding five-axle tractor-semitrailer, it appears clear that the vehicle should be restricted to a box length less than the 20 m allowed to the B-train. The value of 18.5 m (60 ft 8 in), selected for the A-train, is close to that of the largest known current vehicle, although larger vehicles would be legal. A value of 14.65 m (48 ft) is too short based on the minimum dimensions suggested above; a minimum practical box length is about 15.5 m. However, note that this would restrict use of this combination either to dense commodities only, or to low-density commodities with a short truck and a long trailer.

The box length of a truck-pony trailer combination should be not more than 18.5 m.

5/ TRUCK AND FULL TRAILER COMBINATION ISSUES

5.1/ Definitions

All foregoing additions and amendments to definitions appear to cover the requirements for the truck and full trailer combination. The definition of full trailer appears adequate.

However, the length of a full trailer may need to be defined. There are two choices :

1/ from the front of the drawbar to the rear of the trailer; or

2/ from the front of the trailer (i.e., excluding the dolly, or what would be a dolly if it was not permanently attached) to the rear of the trailer, with the usual exclusions.

The former is consistent with the definition proposed for the pony trailer. However, if the value is set so that there is a restriction on coupling the maximum length semitrailer to any dolly, there will be an unnecessary inconsistency. It would really be easier to deem all permanently coupled full trailers as composed of a dolly and a trailer, and regulate each separately. The latter addresses this, and is preferred.

The following definition is offered :

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

5.2/ Configuration and Dimensions

There are four apparent full trailer axle arrangements :

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

The latter in particular might generate particular interest among heavy haulers, as if a truck front axle load greater than 5500 kg is allowed, then with its eight axles, it has the axle capacity to generate a gross weight potentially in excess of 62500 kg. However, it was not covered in the preceding study [3], and is not further discussed.

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. This is because the C-dolly drawbar effectively provides the truck with a self-steering tag axle set far back from the drive axles. This can seriously degrade its handling and lateral/directional stability of the vehicle [3,10].

The simulation results for parametric variations on hitch offset, drawbar length and wheelbase are presented in Tables 9, 10 and 11 for two (single-single), three (single-tandem) and four (tandem-tandem) axle full trailers, respectively.

The hitch offset considerations are the same as for the truck-pony trailer combination.

These tables generally show that stability is improved if trailer drawbar length is increased, and if trailer wheelbase is increased.

For the two axle full trailer, and following the procedure for the pony trailer, the following relationship is developed by linear interpolation within the extent of Table 9 :

Load transfer ratio = 0.829 + 0.072*hitch offset - 0.048*wheelbase

Notice that this vehicle is not particularly sensitive to drawbar length. With a maximum hitch offset of 1.2 m, it can just meet the load transfer ratio performance standard of 0.6 with a wheelbase of 6.5 m. This would result in a trailer length of about 8 m (26 ft), which is considerably greater than the typical length of about 4.5-5 m (15-16 ft) for such trailers.

Similarly, for the three axle full trailer, the following relationship is developed by linear interpolation within the extent of Table 10 :

Load transfer ratio = 0.948 + 0.036*hitch offset - 0.049*wheelbase

Notice that this vehicle is also not sensitive to drawbar length. With a maximum hitch offset of 1.2 m, it can just meet the load transfer ratio performance standard of 0.6 with a wheelbase of 8 m. This would result in a trailer length of about 9.5 m (32 ft), which is considerably greater than the typical length of about 6.5-8 m (21-26 ft) for such trailers.

Similarly, for the four axle full trailer, the following relationship is developed by linear interpolation within the extent of Table 11 :

Load transfer ratio = 1.041 + 0.080*hitch offset - 0.060*wheelbase - 0.018*drawbar

Notice that this vehicle is sensitive to drawbar length, and stability improves as drawbar length is increased. With a maximum hitch offset of 1.2 m, and a drawbar length of 5 m (which provides the minimum tandem-tandem inter-axle spacing of 5 m), it can just meet the load transfer ratio performance standard of 0.6 with a wheelbase of 7.5 m. This would result in a trailer length of about 10.5 m (35 ft), which is considerably greater than the typical length of about 8-9 m (26-30 ft) for such trailers.

For both the two and three axle trailers, if the front axle is attached by means of a turntable or other coupling that does not provide pitch freedom, then a hinged drawbar

Table 9/ Performance Measures of Truck with Two Axle Full Trailer

Hitch Offset (m)	Drawbar Length (m)	Wheelbase (m)	Load Transfer Ratio
0.00	2.84	3.65	0.654
0.76	2.84	3.65	0.716
1.52	2.84	3.65	0.763
1.52	2.35	3.65	0.739
1.52	2.84	3.65	0.763
1.52	3.35	3.65	0.768
1.52	4.24	3.65	0.764
1.52	2.84	3.65	0.763
1.52	2.84	4.56	0.713
1.52	2.84	5.79	0.659

Table 10/ Performance Measures of Truck with Three Axle Full Trailer

Hitch Offset (m)	Drawbar Length (m)	Wheelbase (m)	Load Transfer Ratio
0.00	2.84	3.65	0.649
0.76	2.84	3.65	0.660
1.52	2.84	3.65	0.704
1.52	2.35	3.65	0.704
1.52	2.84	3.65	0.704
1.52	3.35	3.65	0.707
1.52	2.84	6.10	0.704
1.52	2.84	7.31	0.649
1.52	2.84	7.62	0.629

Table 11/ Performance Measures of Truck with Four Axle Full Trailer

Hitch Offset (m)	Drawbar Length (m)	Wheelbase (m)	Load Transfer Ratio
0.00	3.60	6.08	0.611
0.76	3.60	6.08	0.670
1.52	3.60	6.08	0.733
1.52	3.60	6.08	0.733
1.52	4.00	6.08	0.727
1.52	5.00	6.08	0.708
1.52	3.60	6.08	0.733
1.52	3.60	6.68	0.694
1.52	3.60	7.62	0.641

should be used to avoid imposing excessive vertical load on the truck hitch. A hinged drawbar should also be used on a tandem axle dolly, for the same reason.

It appears generally that drawbar length is not a strong factor as far as load transfer ratio is concerned. This parameter therefore need not be directly controlled. The inter-axle spacing will control design. Not specifying drawbar length is a distinct simplification, as it avoids possible conflict between hitch offset, drawbar length and inter-axle spacing for different trucks which may tow the same trailer.

A minimum wheelbase of 6.5 m should be required for a two-axle full trailer. A minimum wheelbase of at least 7.5 or 8 m should be required for a traileer having more than two axles.

Essentially the same overall dimensional arguments apply to this combination as to the truck-pony trailer. The trailer length should be limited at 14.65 m (not 16.2 m), and the box length should be limited at 18.5 m.

5.3/ Hitches

The C-dolly study identified the crucial issue of hitch standards [10]. While the hitches of truck-trailer combinations are not nearly as critical as those of the C-dolly, they are nevertheless an integral part of the combination, and an area where there should be some uniformity. The following recommendations of the earlier study still remain [3] :

1/ A standard should be set for the minimum upward vertical load capacity of the hitch used to tow a pony trailer.

2/ Hitches of the "no-slack" type should be used.

3/ A hinged drawbar should be used on a tandem axle dolly, or where a single front axle is attached to the trailer by a turntable or other coupling that does not provide the pitch freedom of a fifth wheel.

4/ A uniform standard should be set for performance and design of drawbars, hitches and secondary attachments.

6/ BUS ISSUES

6.1/ Dimensions

Ontario and Quebec both prescribe a vehicle unit length limit of 12.5 m (41 ft) for all vehicles, but exclude its application to the bus, semitrailer and other specified classes of vehicle. A separate length limit is applied the bus, but it is the same 12.5 m as the general class of vehicle. There is an exclusion from this for an articulated bus, limited to 18.5 m in Quebec, and to the general overall length limit of 23 m in Ontario. The dimension regulations of Ontario and Quebec therefore both recognize the bus as a specified class of vehicle, but in fact do not allow the single-unit bus any greater length than the general class of vehicle. The regulatory structure already in place in these two provinces provides the means for the bus to have a different length limit than the general class of vehicle.

It is presumed that most other provinces already define a bus as a specific class of motor vehicle, for reasons other than weights and dimensions. If they do not have specific provisions like those of Ontario and Quebec, the existence of a definition would facilitate the same form of regulation, should it be necessary.

Most inter-city, transit and school busses use almost all of the 12.5 m (41 ft) length available to a single unit vehicle under provincial length allowances. In contrast, the majority of straight trucks are 7.5-9 m (25-30 ft) long, considerably less than the maximum allowed.

The bus dimension issue emanates from development of a 13.7 m (45 ft) long inter-city bus, sponsored by Transport Canada. The additional length over the standard 12.19 m (40 ft) length is intended to provide space and accessibility features for disabled passengers. In addition, a small number of 13.7 m (45 ft) long inter-city busses have been imported and are being used in Saskatchewan, presumably under special permit. Further, it is believed at least thirteen U.S. states allow operation of busses longer than 12.5 m (41 ft), though the exact terms and conditions are unknown.

The bus dimension issues are, at first sight, the same as the truck issues, discussed above. There is no a priori reason why the single unit bus should not have the same dimensions as the largest feasible truck, from the point of view of turning. However, other issue would seem to take priority.

6.2/ Loads

The issue of bus loads arises directly from the foregoing dimension issues. It relates primarily to the lack of both enforcement and compliance on axle and gross weight observed for inter-city and transit busses. There are no known data regarding school busses.

The typical transit bus has about 44 seats, and a crush capacity of about 100 passengers. It has a tare weight around 10900 kg (24000 lb). If the front axle has 300 mm (12 in) tires, this gives an allowable axle load of 6000 kg (13227 lb), assuming the tire and front axle rating both exceed this. The drive axle has an allowable axle load of 9100 kg (20062 lb), so the allowable gross weight is 15100 kg (33289 lb). This provides a payload of 4200 kg (9259 lb). At a standard passenger weight of 68 kg (150 lb), the bus reaches its allowable gross weight with about 62 passengers, and at this weight would be very likely to have an axle overload because the passengers stand where they want to, and not where proper axle weight distribution would demand. A 100 passenger crush load is not only quite feasible, it is quite common in rush hour, and results in an overload of 2600 kg (5730 lb) on gross weight, or 17% of allowable gross weight. Since axle overloads could be considerably greater than 17%, the attribution of rutting in municipal roads to busses appears not unreasonable. Similar overloads apply throughout the U.S., where there is a 9072 kg (20000 lb) single axle load. The overloads are slightly less in Ontario and Quebec, where a 10000 kg (22046 lb) single axle is permitted. However, there are some busses with higher tare weight than assumed here, but the same passenger capacity. These will have a proportionately greater overload. It is believed that bus manufacturers generally provide adequate tire and axle rating to support the practical maximum, rather than the allowable maximum, axle loads.

The potential gross and axle overloads on some models of articulated transit bus are believed to be even higher than those of the single unit bus.

Suppose the length of a single unit transit bus is allowed to increase to 13.7 m (45 ft). Assume this increases its tare weight by 500 kg (1100 lb) to 11400 kg, and its crush load capacity by 16 to 116. This results in a crush loaded gross weight of about 19300 kg (42500 lb), or 28% over the allowable gross weight, and probably some even greater axle overload.

In the absence of weight enforcement in most municipalities, there is no evidence that any municipal bus operator is particularly concerned with gross or axle weight compliance. There would likely be strong resistance to addition of an extra axle to provide adequate axle load capacity, as it would probably require a complete re-design of the bus, for a considerable increase in tare weight, and an even greater increase in cost.

There is also no evidence that any inter-city bus operator is particularly concerned with gross or axle weight compliance. Recent study shows that gross weight compliance of inter-city busses is marginal at best, and axle weight compliance is poor. In particular, the tag axle common on inter-city busses is best described as a variable load axle. By design, it does not come close to the definition of a tandem axle. On this basis alone, it is difficult to see how the the existing common design of inter-city bus, let alone an extended version of greater tare weight and presumably poorer axle load control, can be endorsed.

There is already plenty of existing law and regulation that is intended to control the loads on vehicles. It is evident that this has had little effect on either the design or operation of busses. It is difficult to see what further standards could, would or should be set to ensure a new generation of busses with some passing likelihood of meeting the law. Since the Canadian market is a relatively small part of the North American market, forcing the bus manufacturers to develop vehicles that can be properly loaded will be a severe economic penalty on both them and the operators. Such busses would simply not sell in the U.S., unless some agency there also forced their adoption.

6.3/ Other Issues

It is recognized that different commodities result in different vehicle configurations that consume different quantities of the highway system resource. Each commodity could use a different "small" increase in the weight or dimension envelope, for its own productivity. However, it is difficult to argue why, if a benefit is given in one form to one commodity, it should not be given in another form to another commodity. To avoid potential anarchy from the ratchet effect of one commodity group against another, weight and dimension regulations must be based on the relationships between vehicle design characteristics, roadway system characteristics, and safety. They must apply equally, to all vehicles, as vehicles, and independent of commodity.

Passengers in a bus are simply one of many commodities that are transported on the highway system. The bus, as one commodity-specific vehicle, should be treated no differently than any other single unit vehicle.

Improving accessibility of transportation for the disabled is an important social objective of governments. The group of bus passengers who are disabled is simply a sub-group of the passenger commodity. Clearly, if weight and dimension regulations do not recognize commodity, they should not recognize sub groups of a commodity. Further, the basis of weight and dimension regulations is safety, not social policy, however important the objective.

Regulatory principles for a longer bus could presumably be specified so that it satisfied the standard performance measures, as discussed above for straight trucks. There would be no real reason to allow that longer bus only if it were equipped with accessibility features. The performance measures are immune to variations in such equipment. If some greater length was suitable for a bus with accessibility features, it would also be suitable for any other bus, or any other single unit vehicle. A length restriction based on a requirement to provide facilities for the disabled is not very practical. It is not a feature that provincial inspection staff are necessarily able to check, so it would be likely that these longer busses would simply be built and operated without the accessibility feature.

A bus is a vehicle intended for the transportation of passengers. If the single unit bus is given any greater length than any other single unit vehicle, and a "bus vehicle" that is longer than the standard single unit vehicle is not used as a bus, it cannot be sold new, or converted as a motor vehicle which is not a bus.

Special permits are not considered a solution to the issues of either greater bus length, or gross and axle overloads. They do not solve the issues, they merely "legalize" them, and probably postpone the day when they need to be faced.

There is evidently some potential for an increase in bus length, if there is real demand for it. At this time, demand is being created by individual vehicles. It is not reasonable to make weight and dimension regulations specific to the products of particular bus manufacturers. It is suggested that unless bus manufacturers and operators can address the issue of axle load distribution and gross weight, no increase in length should be considered for any bus at this time.

7/ REGULATORY PRINCIPLES

7.1/ Definitions

This work requires definitions to be amended from or additional to those in the Memorandum of Understanding.

The following amendments to existing definitions are proposed :

Drawbar	means a structural member of a full trailer, pony trailer or trailer converter dolly that includes a device for the purpose of coupling with a trailer hitch.
Hitch offset	means the longitudinal distance from the towing vehicle turn centre to the articulation point of the hitch used to tow the trailing unit.
Trailer turn centre	may be replaced by the more general definition of turn centre.
Trailer wheelbase	means the longitudinal distance from the centre of the kingpin of a semitrailer, or the centre of the turntable of a full trailer, or the centre of the hitching device on a pony trailer, to the trailer turn centre.

The following new definitions are proposed :

Length (full trailer)	means the longitudinal dimension from the front of the cargo carrying section of the full trailer to its rear, exclusive of any extension in length caused by auxiliary equipment or machinery at the front that is not designed for the transportation of goods.
Length (pony trailer)	means the longitudinal dimension from the front of the drawbar of the pony trailer to its rear.
Pony trailer	means a vehicle that is designed to be towed by another vehicle, is equipped with a drawbar that is rigidly attached to the structure of the trailer, and is so designed and used that the preponderance of its weight and load is carried on its own axles.
Truck	means a motor vehicle that is either permanently fitted with a special-purpose device, or is designed to and normally used to carry load, that may operate as a single unit or may pull a trailer other than a semitrailer.
Turn centre	means the geometric centre of the axle group on a semitrailer or pony trailer or the rear axle group on a truck, tractor or full trailer.
Truck wheelbase	means the longitudinal distance from the centre of the steering axle to the truck turn centre.

7.2/ Straight Truck

7.2.1/ Number of Axles

The straight truck shall be limited to a single front steering axle, with single tires, and either a single or tandem drive axle unit.

Commentary

Twin-steer allows considerably more load on the truck, but the added axle provides negligible additional increase in roll resistance. These trucks therefore have a higher centre of gravity, and a significantly reduced rollover threshold. Most twin-steer arrangements are not true load-sharing tandem axles.

Tridem drive axles are not yet proven, and the tridem drive truck fails the friction demand criterion.

The committee might be receptive to designs for either twin-steer or tridem drive that might rectify the performance deficiencies. This is another clear area where a regulatory rollover standard might help.

7.2.2/ Front Axle Load

The maximum front axle load shall not be less than (a value to be selected).

Commentary

This appears to be a free choice, within practical constraints of typical tire widths, tire loads and suspension ratings.

7.2.3/ Overall Length

The maximum overall length for a straight truck shall not exceed 12.5 m

Commentary

This dimension exceeds the majority of current equipment. It is sufficient to ensure the truck turns within current roadway geometrics.

7.2.4/ Wheelbase

There need be no limit on straight truck wheelbase.

Commentary

No minimum wheelbase is considered necessary, as the inter-axle spacing provides a satisfactory lower limit. The maximum wheelbase is constrained by overall length and other practical dimensions within a range that ensures the truck turns within roadway geometric limits.

7.2.5/ Rear Overhang

The rear overhang, from the turn centre of the truck drive axle unit to the end of the truck, shall not exceed 3.6 m.

Commentary

This provides a simple design constraint to control outswing in a tight turn.

7.2.6/ Variable Load and Self-steering Tag Axles

The last axle (the "tag" axle position) on a straight truck shall not be a variable load axle, or a liftable axle or a self-steering axle, or any combination of these.

Commentary

The Memorandum of Understanding states that no province need allow liftable or self-steering axles. Despite this, trucks with self-steering liftable axles do exist. The technical study found major stability and control deficiencies with these trucks, particularly as the spacing of the tag axle from the drive axles increased. This recommendation goes beyond the general limitation of the Memorandum, and is addressed to provinces where liftable or self-steering axles are not prohibited, or are allowed by special permit. These provinces should consider positive near-term action to constrain the use of such tag axles.

7.2.7/ Loadability

The allowable gross weight for bulk commodities shall not exceed that possible with a water level loading where no allowable axle load is exceeded.

Commentary

This is intended to ensure design for proper load distribution.

7.3/ Truck and Pony Trailer Combination

7.3.1/ Hitch Offset

Truck hitch offset shall be the minimum possible, but not more than 1.5 m for a fifth wheel, nor 1.2 m for any other design of hitch.

Commentary

This is intended to ensure a minimum practical hitch offset.

7.2.2/ Number of Axles

The pony trailer shall be fitted with a tandem axle unit with a spread between 1.2 and 1.85 m, or a tridem axle unit with a spread between 2.4 and 2.5 m.

Commentary

The pony trailer cannot meet the friction demand performance standard when fitted with any wider spread tridem, for any reasonable wheelbase.

7.3.3/ Pony Trailer Wheelbase

The wheelbase of a pony trailer shall be not less than 7.5 m.

Commentary

This value ensures the vehicle meets the load transfer ratio and friction demand performance standards.

7.3.4/ Pony Trailer Length

The length of a pony trailer shall not exceed 14.65 m.

Commentary

This provides adequate length for any configuration of truck-pony trailer combination.

7.3.5/ Box Length

The box length of a truck-pony trailer combination should be not more than 18.5 m.

Commentary

This recognizes that the truck-pony trailer is a combination with some marginal stability properties, and attempts to ensure that it does not supplant the B-train as the high-cube vehicle of choice.

7.4/ Truck and Full Trailer Combination

7.4.1/ C-dolly

The full trailer shall not use a C-dolly, or any other non-articulating converter dolly.

Commentary

This recognizes that the C-dolly drawbar can result effectively in the truck having a self-steering tag axle set far back from the drive axles. This can seriously degrade the handling and lateral/directional stability of the vehicle. The principles should include this as a clear prohibition.

7.4.2/ Hitch Offset

Hitch offset shall be the minimum possible, but not more than 1.5 m for a fifth wheel, nor 1.2 m for any other design of hitch.

Commentary

This is intended to ensure a minimum practical hitch offset.

7.4.3/ Number of Axles

The full trailer shall be allowed only the following axle arrangements :

1/ single axle dolly and single axle trailer;
2/ single axle dolly and tandem axle trailer; or
3/ tandem axle dolly and tandem axle trailer

The tandem axle spread shall be limited between 1.2 and 1.85 m

Commentary

Tight configuration controls are necessary.

7.4.4/ Full Trailer Length

The length of a full trailer shall not exceed 14.65 m.

Commentary

This provides more than adequate length for any configuration of truck-full trailer combination. There is no real need to provide for a 16.2 m (53 ft) trailer due to the box length restriction.

7.4.5/ Full Trailer Drawbar Length

This parameter need not be controlled.

Commentary

Load transfer ratio is not strongly affected by drawbar length. The minimum inter-axle spacing will govern design, which is a potential simplification for both design and enforcement.

7.4.6/ Full Trailer Wheelbase

The wheelbase of a two axle full trailer shall be not less than 6.5 m, and the wheelbase of a full trailer with more than two axles shall be not less than (7.5 or 8) m.

Commentary

These values ensure the vehicle meets the load transfer ratio performance standard.

7.4.7/ Box Length

The box length of a truck-full trailer combination should be not more than 18.5 m.

Commentary

This recognizes that the truck-full trailer is a combination with some marginal stability properties, and attempts to ensure that it does not supplant the B-train as the high-cube vehicle of choice.

7.4.8/ Hinged Drawbar

A hinged drawbar shall be used on a tandem axle dolly, or where a single front axle is attached to the trailer by a turntable or other coupling that does not provide the pitch freedom of a fifth wheel.

Commentary

This avoids imposing large unnecessary upward vertical loads on the truck hitch.

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[4] LeBlanc P.A. and El-Gindy M., "Rollover and Directional Stability of a Straight Truck Equipped with a Self-Steering Axle", National Research Council, Vehicle Dynamics Laboratory, Report TR-VDL-004, August 1990.

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[6] Billing J.R., Lam C.P. and Couture J., "Development of Regulatory Principles for Multi-Axle Semitrailers", Paper presented at the Second International Symposium on Heavy Vehicle Weights and Dimensions, Kelowna, B.C., June 1989.

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[10] Woodrooffe J.H.F., LeBlanc P.A. and El-Gindy M., "Technical Analysis and Recommended Practice for the Double Drawbar Dolly Using Self-steering Axles", Roads and Transportation Association of Canada, Ottawa, Technical Report, 1990.

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	Maximum 3.6 m
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 ???? kg
Single Axle	Maximum 9100 kg
Tandem Axle	Maximum 17000 kg
Gross Vehicle Weight	Maximum ????? kg

Category 6 : Straight Truck and Pony Trailer Combination

Parameter	Limit
DIMENSIONS	
Truck :	
Length	Maximum 12.5 m
Wheelbase	No limit
Tandem Axle Spread	Minimum 1.2 m, maximum 1.85 m
Rear Overhang	Maximum 3.6 m
Hitch Offset	Minimum practical Less than 1.5 m with fifth wheel Less than 1.2 m with other hitch
Pony Trailer :	
Length	Maximum 14.65 m
Wheelbase	Minimum 7.5 m
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
Box Length	Maximum 18.5 m
Overall Length	Maximum 23 m
Overall Width	Maximum 2.6 m
Overall Height	Maximum 4.15 m
WEIGHTS	
Axle Weights :	
Steering Axle	Maximum ???? kg
Single Axle	Maximum 9100 kg
Tandem Axle	Maximum 17000 kg
Tridem Axle	Maximum 21000 kg
Gross Combination Weight	Maximum ????? kg

Category 7 : Straight Truck and Full Trailer Combination

Parameter	Limit
DIMENSIONS	
Truck :	
Length	Maximum 12.5 m
Wheelbase	No limit
Tandem Axle Spread	Minimum 1.2 m, maximum 1.85 m
Rear Overhang	Maximum 3.6 m
Hitch Offset	Minimum practical Less than 1.5 m with fifth wheel Less than 1.2 m with other hitch
Full Trailer :	
Length	Maximum 14.65 m
Wheelbase	Minimum 6.5 m with two axles Minimum ??? m over two axles
Tandem Axle Spread	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
Box Length	Maximum 18.5 m
Overall Length	Maximum 23 m
Overall Width	Maximum 2.6 m
Overall Height	Maximum 4.15 m
WEIGHTS	
Axle Weights :	
Steering Axle	Maximum ???? kg
Single Axle	Maximum 9100 kg
Tandem Axle	Maximum 17000 kg
Gross Combination Weight	Maximum ????? kg