Vehicle Weights and Dimensions Study

Implementation Planning Subcommittee

Recommended Regulatory Principles for Interprovincial Heavy Vehicle Weights and Dimensions

September 1987

VEHICLE WEIGHTS AND DIMENSIONS STUDY

IMPLEMENTATION PLANNING SUBCOMMITTEE

RECOMMENDED REGULATORY PRINCIPLES FOR INTERPROVINCIAL HEAVY VEHICLE WEIGHTS AND DIMENSIONS

SEPTEMBER 1987

Preface:

The report which follows constitutes the draft final report of the Implementation Planning Subcommittee of the Joint RTAC/CCMTA Committee on Heavy Vehicle Weights and Dimensions. Following the completion of the Vehicle Weights and Dimensions Research Program, marked by the delivery of the Technical Steering Committee Report in December 1986, the Implementation Planning Subcommittee was charged with the following responsibilities:

1. To develop a plan that will assist each jurisdiction in implementing vehicle weight, dimension and configuration regulatory principles that will lead to national uniformity.

2. To develop schedules for proposed implementation of the recommendations.

3. To monitor the progress of implementation of the recommendations as they may be agreed to by the Council of Ministers Responsible for Transportation and Highway Safety at its meeting in September 1987.

With due consideration to the findings of the research program, and in recognition of the safety of the users of the system, engineering, economic and operational constraints of the highway system, the operational requirements of the trucking industry, and the capabilities of the truck and trailer manufacturing industries, the committee has developed a proposed regulatory environment which provides improved opportunities to safely exploit the available capacities of both the highway system and the motor transport fleet on a national basis.

The regulatory principles and recommended limits have been developed in the context of the following objectives:

1. To encourage the use of the most stable heavy vehicle configurations through the implementation of practical, enforceable weight and dimensions limits.

2. To balance the available capacities of the national highway transportation system by encouraging the use of the most productive vehicle configurations relative to their impact on the infrastructure.

3. To provide the motor transport industry with the ability to serve markets across Canada using safe, productive, nationally acceptable equipment.

The regulatory framework and principles described herein represent the work and collective efforts of all jurisdictions involved in the regulation of highway transport in Canada.

H.K. Walker
Chairman, Implementation Planning Subcommittee

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1.0 Introduction

1.1 Background

In 1984 a joint government/industry research program was launched with the goal of achieving uniformity in interprovincial weights and dimensions regulations. The research was intended to provide insight into and answers to technical questions which stood in the way of obtaining agreement between jurisdictions on acceptable vehicle configurations, axle loadings and spacings, and overall dimensions.

The research conducted under the Vehicle Weights and Dimensions Study constitutes a major advancement in understanding the influence of heavy vehicle weights and dimensions on the stability and controllability of the vehicles which use the highway system and the impacts they have on the system's infrastructure. The research findings have also served to highlight the limitations of the capacities and capabilities of both the vehicles and the highway system itself, while providing direction on opportunities which exist to improve the productivity of the highway transport system.

Weights and dimensions regulations have traditionally been established primarily in consideration of the capacities or expected rate of consumption of the highway system infrastructure. The research program confirmed that a direct relationship also exists between weights, dimensions and vehicle stability. Consequently, any revision of existing limits has implications for the stability of heavy combination vehicles and for the safe operation of the highway system as a whole.

1.2 Vehicle Stability and Control Performance Criteria

The extensive programs of testing and computer simulation carried out under the research program served to document the wide range of stability and control characteristics of vehicles currently found in the commercial transport fleet. In reviewing the findings of the program, it was recognized that both the configuration of the vehicle and the manner in which it is loaded profoundly influence its stability and control characteristics and its compatability with the highway geometry.

The regulatory principles and proposed weight and dimension limits which appear in the following sections have been selected in consideration of each vehicle configuration's demonstrated performance against seven measures. As recommended by the Technical Steering Committee of the research program, vehicles which exhibit performance which meets or exceeds the reference levels for the following measures should be encouraged for use in interprovincial carriage.

It is recognized that the desired targets for vehicle stability and control performance can not, and will not, be achieved solely through the application of weight and dimension limits. However, the influence of weight and dimensions on vehicle stability was carefully considered in developing and selecting the limits proposed in this document. It is recommended that the seven measures of performance described in the following section be considered in any future revisions to heavy truck weights and dimensions, and that the recommended minimum or maximum levels within each be held as desired targets, achieveable through judicious application of regulatory control developed in concert with the manufacturing and operating industries.

Stability and Control Measures:

A. Static Rollover Threshold

The Static Rollover Threshold defines the maximum severity of steady turn which a vehicle can tolerate without rolling over. The measure expresses the level of lateral acceleration, in units of g's of lateral acceleration, beyond which overturn occurs. In general, loaded trucks exhibit rollover threshold values in the range of 0.25 to 0.40 g, a range which lies modestly above the severity levels encountered in the normal driving of passenger cars. This measure of truck roll stability is known to correlate powerfully with the incidence of rollover accidents in highway service.

Target Performance Level:

Vehicles, in the loaded condition, should exhibit a static rollover threshold of 0.4 g or better.

B. Dynamic Load Transfer Ratio

Dynamic Load Transfer Ratio characterizes the extent to which a vehicle approaches the rollover condition in a dynamic steering manoeuver such as in avoiding an obstacle in the roadway. This measure is expressed in terms of the fractional change in tire loads between left- and right-side tires in the manoeuver, thus indicating how close the vehicle came to lifting off all of its tires on one side, and rolling over. The value which is determined reflects the amplification tendencies by which multiple-trailer combinations tend to "crack the whip" in rapid steering manoeuvers. The Load Transfer Ratio is calculated as follows:

$$\text{Load Transfer Ratio} = \text{sum}|F_L - F_R| / \text{sum}(F_L + F_R)$$

where: F_L = Left side tire loads
F_R = Right side tire loads

Target Performance Level:

When a vehicle in the loaded condition negotiates an obstacle avoidance, or lane change manoeuver at highway speeds, the load transfer ratio should not exceed 0.60.

C. Friction Demand in Tight Turns

The measure termed, Friction Demand in a Tight Turn, pertains to the resistance of multiple, non-steered axles to travelling around a tight-radius turn, such as at an intersection. Especially with semitrailers having widely spread axles, the resistance to operating in a curved path results in a requirement, or demand, for tire side force at the tractor's tandem axles. When the pavement friction level is low, such vehicles may exceed the friction which is available and produce a jackknife-type response. The friction demand measure describes the minimum level of pavement friction on which the vehicle can negotiate an intersection turn without suffering such a control loss. When the vehicle design is such that a high friction level is demanded, the vehicle is looked upon as inoperable under lower-friction conditions such as prevail during much of the Canadian wintertime.

Target Performance Level:

When a vehicle negotiates a 90° turn with an outside radius of 11 m, the peak required coefficient of friction of the highway surface to avoid loss of traction by the tractor drive tires should not exceed 0.1.

D. Braking Efficiency

A Braking Efficiency measure is used to indicate the ability of the braking system to fully utilize the tire/pavement friction available at each axle. It is defined as the percentage of available tire/road friction limit that can be utilized in achieving an emergency stop without incurring wheel lockup. For example, a vehicle achieves only a 50% braking efficiency level when it suffers wheel lockup while braking at 0.2 g's on a surface which could ideally support a 0.4 g stop. The braking efficiency measure is meant to characterize the quality of the overall braking system as the primary accident avoidance mechanism.

It is recognised that in-service heavy vehicle braking characteristics are influenced by a multitude of factors including the state of adjustment of the mechanical elements of the braking system, the response characteristics of the air supply system, the type and condition of tires on the vehicle, the load distribution between axles and the characteristics of the road surface. As a consequence, the performance measure described above is somewhat theoretical in nature, and may not be easily verified through physical testing of appropriately configured vehicles. Nonetheless, the Braking Efficiency measure as determined using simulation or analysis techniques does provide a valuable, consistent basis upon which valid comparisons of the braking performance of differing vehicle configurations can be made, and provides a reasonable target performance level which vehicles in the fleet should be capable of achieving.

Target Performance Level:

Vehicles in the loaded or unloaded condition should exhibit braking efficiencies of 70% or better. Braking efficiency is defined as the percentage of available tire/road friction limit that can be utilized in an emergency stop of 0.4 g's deceleration without incurring wheel lockup.

Offtracking Measures:

E. Low Speed Offtracking

Low-Speed Offtracking is defined as the extent of inboard offtracking which occurs in a turn. In a right-hand turn, for example, the rearmost trailer axle follows a path which is well to the right of that of the tractor, thus making demands for lateral clearance in the layout of pavement intersections. This property is of concern to compatability of the vehicle configuration with the general road system and has implications for safety as well as abuse of roadside appurtenances.

Target Performance Level:

When a vehicle negotiates a 90 ° turn with an outside radius of 11 m, the maximum extend of lateral excursion of the last axle of the vehicle, relative to the path followed by the tractor steering axle, should not exceed 6 m.

F. High Speed Offtracking

A High-Speed Offtracking measure has been defined as the extent of outboard offtracking of the last axle of the truck combination in a moderate steady turn of 0.2 g's lateral acceleration. This measure is expressed as the lateral offset, in meters, between the trailer and tractor paths. Recognizing that the driver guides the tractor along a desired path, the prospect of trailer tires following a more outboard path that might intersect a curb, or an adjacent vehicle or obstacle poses a clear safety hazard.

Target Performance Level:

When a vehicle negotiates a turn with a radius of 393 m at a speed of 100 km/h, the maximum extent of outboard lateral excursion of the last axle of the vehicle, relative to the path followed by the tractor steering axle, should not exceed 0.46 m.

G. Transient High Speed Offtracking

The Transient High-Speed Offtracking measure is obtained from the same obstacle avoidance manoeuver as that used to define the dynamic rollover stability level and is defined as the peak overshoot in the lateral position of the rearmost trailer axle, following the severe lane-change-type maneuver. The amount of overshoot in the rearmost-axle path can be viewed as a relative indication of the extent of potential intrusion into an adjacent lane of traffic, or the potential for striking a curb (risking an impact-induced rollover). In layman's terms, this measure quantifies the magnitude of the "tail-wagging" in response to a rapid steer input.

Target Performance Level:

When a vehicle negotiates an obstacle avoidance, or lane change, manoeuver at highway speeds, the maximum lateral excursion of the rearmost axle of the vehicle, relative to the final lateral path displacement of the steering axle, should not exceed 0.8 m.

1.3 Regulatory Approach, Rationale and Application

The regulatory principles were established on the basis of the findings of the research program and were used to select weight and dimension limits which have been developed in the context of the following objectives:

1. To encourage the use of the most stable heavy vehicle configurations through the implementation of practical, enforceable weight and dimensions limits.

2. To balance the available capacities of the national highway transportation system by encouraging the use of the most productive vehicle configurations relative to their impact on the infrastructure.

3. To provide the motor transport industry with the ability to serve markets across Canada using safe, productive, nationally acceptable equipment.

The regulatory principles and limits proposed in this document are intended to apply only to those vehicles engaged in interprovincial carriage. These vehicles will fall into one of the following four categories:

a. Tractor Semitrailer

b. A Train Double

c. B Train Double

d. C Train Double

If implemented, the regulatory agreement would permit vehicles which are in compliance to travel unrestricted across each jurisdiction in Canada on a designated system of highways. The regulatory proposals are not intended to inhibit the ability of individual jurisdictions to meet the needs of the transportation system in their region, and to develop appropriate heavy vehicle weights and dimensions for intraprovincial goods movements.

2.0 Discussion of Proposed Regulatory Controls and Limits

Vehicle stability and infrastructure impacts are influenced to varying degrees by many components of the vehicle and the physical configuration of the components. In some cases the research demonstrated a clear and significant correlation between a vehicle parameter and a performance measure, thereby providing an opportunity for effective regulatory control. In other cases the research findings were to a certain extent inconclusive, or raised issues or concerns for which weight and dimension regulatory controls would be ineffective, inappropriate or premature. However, many findings in the latter category should be considered by the manufacturing and operating sectors of the trucking industry in view of the potential benefits to stability and productivity voluntary action would provide.

The research findings and proposed regulatory controls are discussed by vehicle component as follows:

2.1 Tractors:

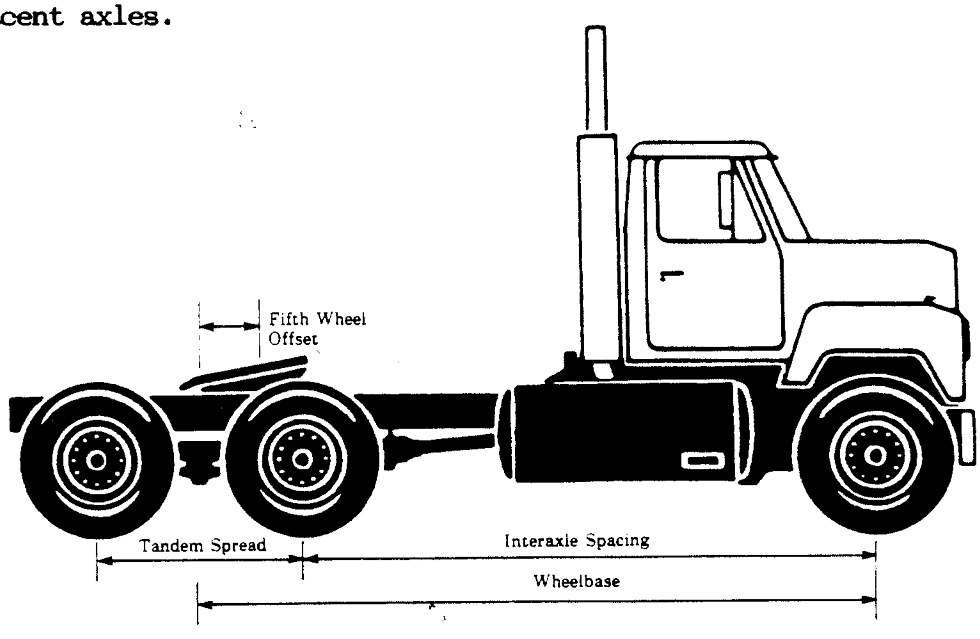
Terminology:

Wheelbase: The longitudinal distance from the centre of the front or steering axle to the geometric centre of the driving axle(s). For tandem drive axle tractors, from the steering axle to the centre of the drive tandem.

Tandem Axle Spread: The longitudinal distance between the axle centres.

Fifth Wheel Offset: The longitudinal distance from the centre of the fifth wheel to the centre of the tandem drive axle group (for two axle tractors, to the centre of the drive axle). Convention: ahead of centre is positive setting, behind centre is negative setting.

Interaxle Spacing: The longitudinal distance between the centres of two adjacent axles.



2.1.1 Wheelbase:

The research demonstrated that the stability of combination vehicles improves with increasing tractor wheelbase. However, the tractor wheelbase also directly influences low speed offtracking performance, ie. longer wheelbases result in a greater degree of offtracking. In consideration of the trucking industry's expressed desire for operational flexibility and interchangability of tractors between configurations, the proposed regulatory controls apply to the tractor in each of the four vehicle categories.

It is proposed that the minimum tractor wheelbase be determined by interaxle spacing requirement (section 2.13) and the maximum be 6.2 m because of the resultant low speed offtracking performance of a tractor semitrailer configuration consisting of a 6.2 m tractor coupled to a 12.5 m wheelbase semitrailer.

2.1.2 Tandem Axle Spread:

The research demonstrated that vehicle stability generally improves with decreasing axle spreads in tandem and tridem groups. On the tractor, the drive axle spacing should be kept as short as possible to reduce the forces required by the steering axle to overcome the "tire scuffing" of the drive axles which occurs in tight turns.

It is proposed that the spacing between the tandem drive axles be controlled, with a minimum of 1.2 m and a maximum of 1.85 m. The intent is to encourage the use of closely spaced axle groups, while providing flexibility to operators who require wider spreads for other reasons.

2.1.3 Interaxle Spacing:

The research determined that vehicle stability degrades with decreasing tractor wheelbase and that a minimum spacing must be maintained between the steering axle of the tractor and the first drive axle with respect to concern for bridge distress under load. A minimum interaxle spacing requirement is proposed on the basis of encouraging the use of more stable vehicle configurations, while reducing the demands on bridge structures.

It is recommended that the interaxle spacing on a tractor be a minimum of 3 m.

2.1.4 Fifth Wheel Offset:

Many tractors are equipped with moveable fifth wheels which enable load distribution between axles on the vehicle to be adjusted. In other instances, the position of the fifth wheel is selected to accommodate special requirements of the vehicle configuration or commodity carried (eg. automobile carriers).

The location of the fifth wheel on the tractor does influence the stability of the entire vehicle configuration. It is recognized that operational flexibility is required by the industry, and for this reason no regulatory control is proposed at this time. However, should industry practice in positioning fifth wheels result in significant degradation of vehicle stability, regulatory control may become necessary.

No control of fifth wheel offset is proposed at the present time.

2.1.5 Track Width:

Research has demonstrated that the stability of the tractor and the combination vehicle as a whole improves with increases in the track width, or overall width across the tires. Wider track axles are not currently available in quanitity for tractor steering and drive axles, and their use would require engineering modifications to existing tractor designs.

Although it is not proposed to control the track width of tractors at this time, it is recommended that the industry be encouraged to use wider track axles which provide a nominal width across the tires of 2.6 m to obtain the benefits of improved stability. It is further recommended that the Government of Canada work with the Government of the United States to pursue more rapid development of wider track axles for tractors.

2.1.6 Weight to Power Ratio:

While no regulatory requirement is proposed at this time respecting the horsepower of the tractor relative to the Gross Combination Weight, it should be recognized that interprovincial carriage through the province of British Columbia must meet that jurisdiction's regulatory requirement of a maximum of 150 kg/hp and the requirement for tandem drive axles on the tractor if the vehicle's Gross Combination Weight exceeds 38 000 kg.

2.2 Semitrailers:

Terminology:

Length: The longitudinal distance from the front to the rearmost point of the semitrailer.

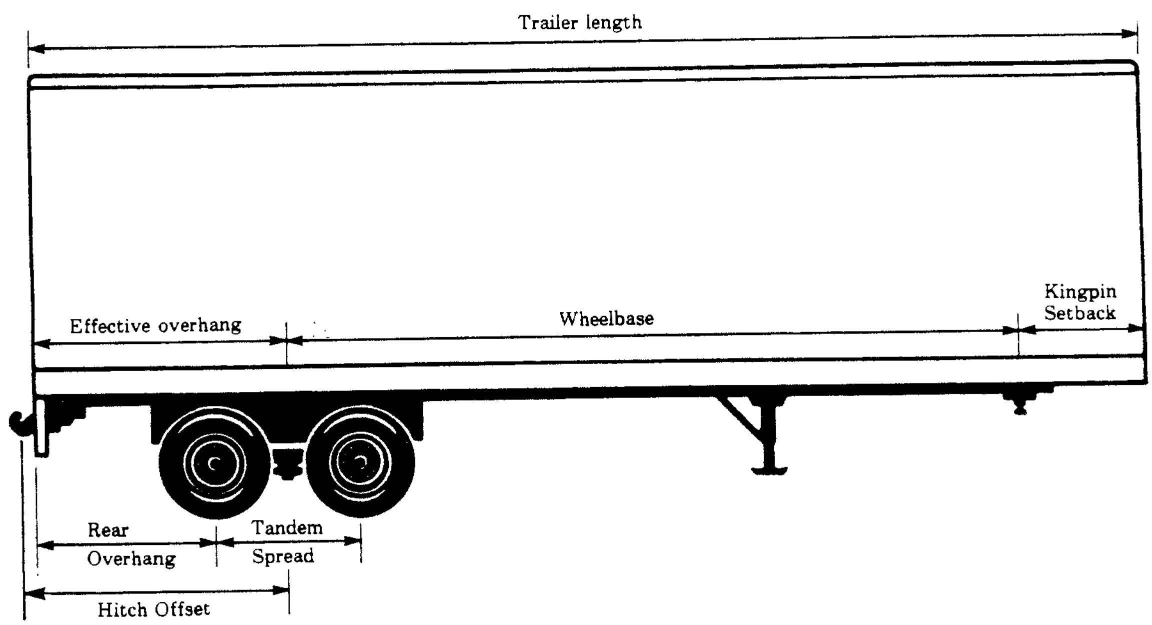
Kingpin Setback: The longitudinal distance from the front of the semitrailer to the centre of the kingpin.

Wheelbase: The longitudinal distance from the kingpin to the turn centre of the semitrailer. For the purposes of this regulatory proposal, the turn centre is considered to be the geometric centre of the axle group on the semitrailer.

Rear Overhang: The longitudinal distance from the centre of the last axle to the rearmost point on the semitrailer (or load).

Effective Rear Overhang: The longitudinal distance from the turn centre of the semitrailer to the rearmost point on the semitrailer (or load).

Hitch Offset: The longitudinal distance from the turn centre of the semitrailer to the centre of the hitching mechanism provided for towing an additional trailer (typically a pintle hook).



2.2.1 Length:

The research did not illustrate any direct relationship between trailer length and any of the performance measures. However, there are other criteria which must be considered in establishing size and weight limits, including enforcement concerns, the influence of overall vehicle length on highway capacity and level of service, and operational and manufacturing limitations.

It is recommended that the length of semitrailers be controlled under the limits developed for each type of configuration addressed in this proposal.

2.2.2 Wheelbase:

The research demonstrated that the wheelbase of a semitrailer has a direct influence on the stability of combination vehicles. Longer wheelbases improve dynamic stability while providing an opportunity to reduce the height of the centre of gravity of the payload. However, as wheelbases are increased the low speed offtracking is also increased. Generally, semitrailer wheelbases should be kept as long as possible, within the constraint of acceptable limits of low speed offtracking. As wheelbases decrease, the dynamic stability degrades and the friction demands on tractor drive axles in low speed turns increase (for multiple axle semitrailers).

It is recommended that the minimum and maximum wheelbases of semitrailers be controlled in all configurations, with appropriate limits selected in consideration of the inherent stability characteristics of the configuration.

2.2.3 Kingpin Setback:

As the distance from the front of the semitrailer to the kingpin is increased, the potential for the front corner of the semitrailer to intrude into adjacent traffic lanes in tight turning manoeuvers increases.

It is recommended that the kingpin setback on semitrailers in tractor semitrailer configurations and the first semitrailer in double configurations be controlled to limit lane intrusion in turning manoeuvers. It is recommended that no part of the trailer forward of the kingpin protrude beyond an arc of 2.0 m radius drawn about the centre of the kingpin.

2.2.4 Effective Rear Overhang:

The length of the trailer or load which extends beyond the turn centre of a semitrailer determines whether intrusion into adjacent lanes of the rear corner of the trailer or load will occur when a turn is negotiated. Because of the turning characteristics of longer wheelbase semitrailers, this problem is only of concern with the tractor semitrailer configuration.

It is recommended that the effective overhang on semitrailers in tractor semitrailer configurations be limited to a maximum of 35% of the wheelbase.

2.2.5 Rear Overhang:

In consideration of the proposed control of effective rear overhang, there is no proposed control of rear overhang. However, it is recommended that the development and implementation of standards for improved rear underride protection be undertaken by the Federal Government in concert with the Provincial Governments and the manufacturing industry.

2.2.6 Tandem and Tridem Axle Spreads:

The research demonstrated that the stability of semitrailers improves with decreasing axle spreads on multiple axle groups. Increased axle spreads also demand higher friction levels between tractor drive axles and the road surface in tight turning manoeuvers, consequently the maximum spread which can be recommended for a tandem or tridem is also dependent on the wheelbase of the semitrailer on which it is installed. However, bridge capacity considerations require that axle spreads be increased to accept particular loading levels. In addition, pavement damage increases with very wide axle spreads. To accommodate these conflicting objectives, and to provide maximum utility of vehicles in the trucking fleet, minimum and maximum axle spread limits are proposed for both tandem and tridem axle groups.

It is proposed that the maximum and minimum spreads of tandem and tridem axle groups be controlled with limits established for each vehicle configuration.

2.2.7 Track Width:

The research demonstrated that significant improvements in vehicle stability can be obtained by increasing the track width, or overall width across the tires, of all axles on a semitrailer. The full stability benefit of the increased axle width is only realised with a comensurate increase in the spacing between the attachment points of the suspension on the axle. While this dimension is considered to be outside the practical limits of enforceable weights and dimensions controls at the present time, manufacturers are encouraged to exploit the full stability enhancement available through increased axle and suspension width.

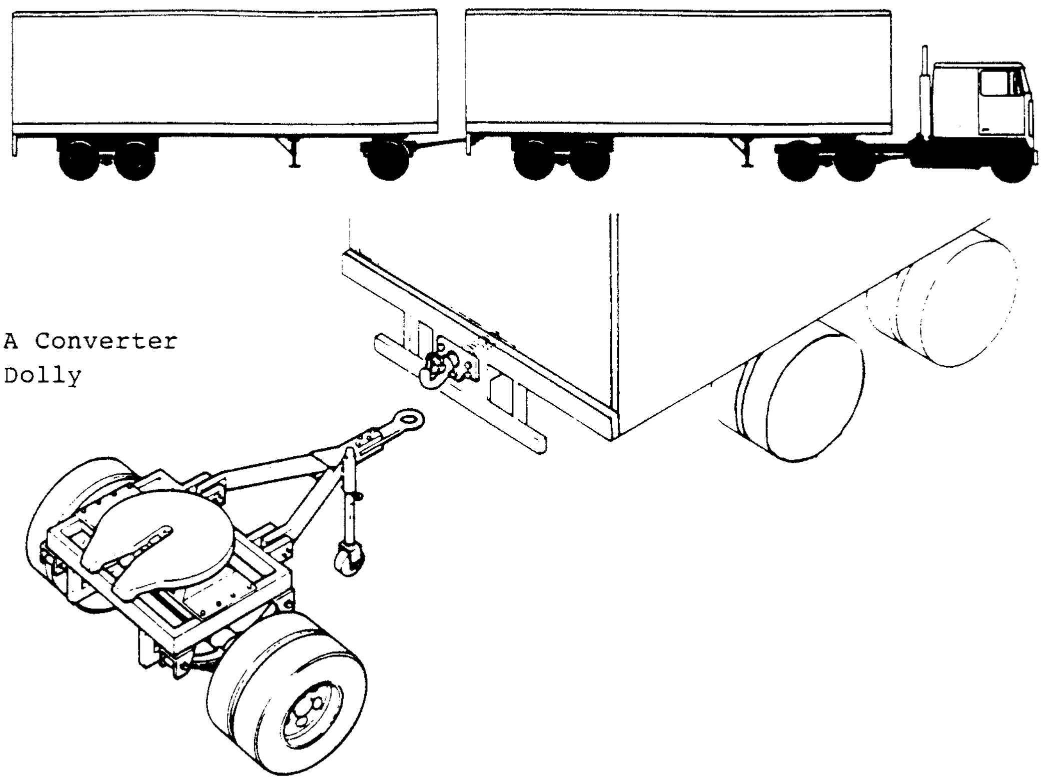
It is recommended that wider track axles be used on trailers and semitrailers in all configurations, and that a nominal width across the tires of 2.6 m be required.

2.2.8 Hitch Offset (Double Trailer Configurations):

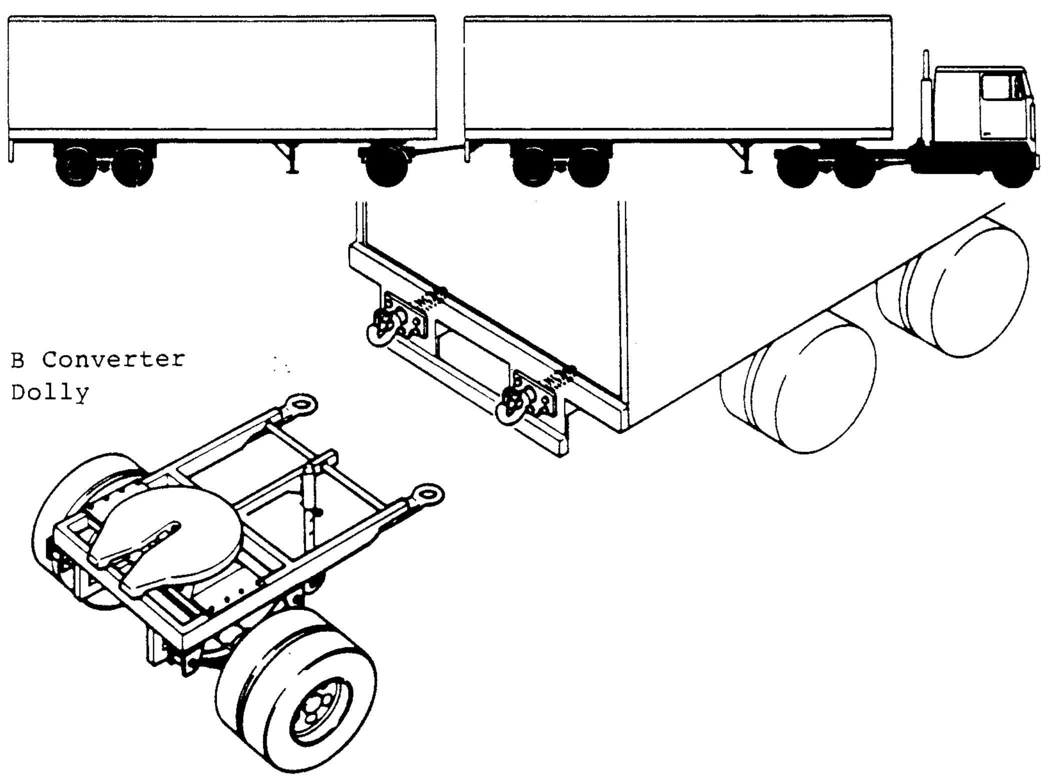
Where semitrailers are used in double trailer operations, the distance from the turn centre of the semitrailer to the hitching mechanism for the dolly drawbar(s) is related to the stability of the combination. Generally, this dimension should be kept as short as possible for the A Train Double and in particular for the C Train Double. As this dimension increases, the dynamic stability of both A and C Train Doubles, in terms of load transfer ratio and transient high speed offtracking, degrades markedly.

It is proposed that the distance from the effective turn centre of the semitrailer to the location of the hitching mechanism for dolly drawbars be kept as short as possible, and be limited to a maximum of 1.8 m.

2.3 Converter Dollies:



A Converter Dolly



B Converter Dolly

2.3.1 Drawbar Length: A Converter Dollies

The research did not provide conclusive evidence that the length of the drawbar on A Converter Dollies directly affected the stability and control performance of combination vehicles. As a consequence, and in view of other overall dimensional constraints on the A Train category, no control is **recommended for the length of drawbar on A** Converter Dollies.

2.3.2 Drawbar Length: B Converter Dollies

The research established a direct relationship between the length of the drawbar on the double drawbar or B converter dolly and the stability of the second trailer in a double configuration. Generally, as the drawbar length decreases, the dynamic highspeed offtracking improves. There are practical limits to the minimum length of drawbar, dictated in part by inter-trailer clearance requirements and by minimum interaxle spacing requirements determined by bridge capacity considerations.

It is **recommended that a maximum allowable drawbar length of 2.4 m be established for B Converter Dollies.**

2.3.3 Double Drawbar or B Dolly Converters:

The research determined that significant stability improvements can be achieved in double trailer configurations through the substitution of a properly designed and installed B Dolly for a conventional A Dolly. However the research also highlighted the complexities of the B Dolly design, and demonstrated instances where improperly designed dollies can render the stability performance of the "C Train" inferior to that of the "A Train".

In the absence of design and operational guidelines for the B Converter Dolly, it is recommended that the use of the C Train not be encouraged at the present time and that the size and weight restrictions on this configuration remain as described for the A Train Double. It is further recommended that high priority be given to developing such guidelines and implementing a means of ensuring manufacturing and operational compliance.

2.3.4 Number of Axles:

While the research did not provide evidence to suggest that multiple axle dollies exhibit undesirable performance characteristics, the stability limitations of the A Train Double and the as yet uncertain engineering requirements of the B Converter Dolly would suggest that additional load carrying capability by the dolly is unnecessary, and generally not desirable. The proposed weight restriction on the second trailer of A and C Train Doubles provides no incentive or requirement for additional load carrying capability.

To discourage excessive loading of the second trailer of A Train Doubles, and in view of the uncertain requirements of B Dolly design, it is proposed that only single axle converter dollies be allowed on A and C Train Double Configurations.

2.4 General Considerations:

2.4.1 Interaxle Spacing:

The distance between axles and axle groups on a heavy vehicle affects the response of the pavement and bridge structure to the loading of the vehicle, and hence its destructive effects. From the standpoint of bridge capacity constraints, there are minimum spacing requirements between axles which must be respected, regardless of vehicle configuration.

It is proposed that interaxle spacings be controlled in accordance with the following table:

Single Axle - Single Axle	**Min 3.0 m**
Single Axle - Tandem Axle	**Min 3.0 m**
Tandem Axle - Tandem Axle	**Min 5.0 m**
Tandem Axle - Tridem Axle	**Min 5.5 m**
Tridem Axle - Tridem Axle	**Min 6.0 m**

2.4.2 Suspension Type and Mix:

The research demonstrated that stability performance can be significantly affected by the varying characteristics of the range of suspensions commonly available to the fleet operator. In particular, it is evident that the stability of all four categories of vehicles can be improved through careful selection of compatible tractor and semitrailer suspensions. Conversely poor compatibility of suspensions can significantly degrade vehicle stability.

The research also provided preliminary insights to the relative potential damaging effects of differing suspensions types on the infrastructure due to dynamic loadings. The research suggested that certain types of suspensions would appear to inflict unnecessarily high dynamic loadings on the pavement and bridges as road roughness and vehicle speeds increase.

While no regulatory controls are proposed at this time for suspension types or mixes, it is recommended that further research be conducted in this area to determine whether regulatory controls are appropriate or warrant development.

2.4.3 Tire Type:

The research demonstrated that the use of radial tires can improve the dynamic stability of heavy vehicles, particularly the double trailer configurations.

While no regulatory controls are proposed at this time for the type of tire to be used on combination vehicles, the use of radial tires in all axle locations is encouraged.

3.0 Recommended Regulatory Principles

The regulatory principles described in the following section are recommended for adoption by all jurisdictions responsible for the regulation of interprovincial weights and dimensions, and are intended to apply to each of the four categories of vehicles under consideration.

3.1 Vehicle Categories:

Vehicles used in interprovincial carriage that are affected by the recommendations contained herein will fall into one of four categories:

Category 1: Tractor Semitrailer
Category 2: A Train Double
Category 3: B Train Double
Category 4: C Train Double

Commentary:

Each category will be subject to size and weight constraints developed in recognition of the impact the vehicles in the category have on the highway infrastructure and the inherent stability and control characteristics of the vehicle type. For example, in recognition of the superior stability and handling characteristics of the B Train Double, relative to other double configurations, additional Gross Combination Weight allowances will be provided.

3.2 Overall Vehicle Height

The maximum height of any part of a combination vehicle included in this regulatory proposal will not exceed 4.15 m.

Commentary:

The clearance available under existing highway structures prohibits further increases in the allowable height of vehicles. In addition, research has shown that the most powerful determinant of vehicle stability is the height of the payload centre of gravity.

3.3 Overall Vehicle Width

The maximum overall width of any combination vehicle, including load or contents, will be 2.6 m, exclusive of mirrors, lamps, and load covering or securing devices.

Commentary:

The width of lanes on highways currently found on the interprovincial system precludes the use of vehicles wider than 2.6 m.

3.4 Overall Vehicle Length

The maximum overall length of any combination vehicle will be 25 m. Other dimensional constraints may preclude some vehicle types from achieving this overall length.

Commentary:

The overall length of heavy vehicle combinations affects the capacity and level of service provided by the highway system, particularly two lane, two way rural highways. Research has also demonstrated that the inherent stability of articulated vehicle combinations improves as the wheelbases of the tractor and semitrailers increases. Consequently, the recommended overall length limit of 25 m is viewed as providing an opportunity to improve vehicle stability without unduly degrading highway system capacity. It reflects the necessity to ensure that tractor design is not restricted by overall length concerns, and that adequate space is available to provide improved crash protection for occupants of trucks or cars.

Should further increases in this limit be considered in the future, it is recommended that the new length limit be supported by conclusive evidence or research on the effects of vehicle length on the traffic stream and highway capacity.

3.5 Gross Combination Weight

The maximum gross combination weight limit being recommended for each of the four categories is as follows:

Tractor Semitrailer	46 500 kg
A Train Double	53 500 kg
B Train Double	62 500 kg
C Train Double	53 500 kg

Commentary:

Gross combination weight limits have been recommended in consideration of the stability and control characteristics of the four types of vehicle configurations and the practical capacity limits of bridges on the interprovincial highway system. In this context, the Gross Combination Weight of the B Train is limited by bridge constraints, while the other configurations are constrained by limits derived from stability and control concerns.

3.6 Generic Axle Load Limits

The following axle load limits will apply regardless of configuration:

Tractor Steering Axle	**= 5500 kg**
Single Axle (Dual Tires)	**= 9100 kg**
Tandem Axle Group (1.2 m to 1.85 m spread)	**= 17 000 kg.**

In addition, the maximum allowable axle load will be limited to the maximum rated capacity of any single component of the axle, suspension or braking systems, the rated capacity of the tires, or 10 kg per mm. of tire width (with a minimum tire width of 150 mm), whichever is the lesser. It is also recommended that no single tire loading shall be allowed to exceed 3000 kg.

Commentary:

The preceding axle and axle group load limits were derived from concerns for the destructive effects of heavy loads on the highway infrastructure. In particular cases, the stability and control characteristics of a vehicle configuration will impose additional or more restrictive limits on axle load limits. Past research has shown that the use of wide base single tires as substitutes for conventional dual tire arrangements is more damaging to pavement structures(at equivalent axle load levels) and, for this reason, wide base or super single tires will not be permitted.

3.7 Axle and GCW Tolerances

The axle loads and GCW's referred to in this proposal shall be regarded as absolute maximums with no legislated or published tolerances.

Commentary:

Research has shown that the destructive effect of an axle, axle group or the entire loaded vehicle on the highway infrastructure is highly sensitive to changes in axle loading. Violations of the recommended load limits can imply substantially higher infrastructure costs than have been considered in developing these recommendations.

3.8 Lift Axles

Lift axles will not be permitted on any vehicles used in interprovincial carriage considered in the context of this regulatory proposal.

Commentary:

Lift axles have been deemed undesirable for the following reasons:

1. Research has shown that symmetrically spaced axles in load equalized groups are less destructive to the highway infrastructure than a group of asymetrically spaced, independently suspended axles collectively loaded to the same level.

2. The necessity to lift one or more axles on heavy vehicles to negotiate turns typically results in overloading of the axles which remain in contact with the ground thereby causing unnecessary distress to the highway infrastructure and degrading the stability of the vehicle.

3.9 Self Steering Axles

Self steering axles will not be permitted on semitrailers or trailers used in interprovincial carriage, pending completion of further research.

Commentary:

Currently technologies in self-steering axles do not provide sufficient articulation angles necessary to negotiate tight turns, and consequently are typically installed with lift mechanisms.

Should research findings demonstrate that current operational problems can be overcome without the use of lift mechanisms, or should new technologies emerge, the prohibition on the use of self steering axles should be reconsidered.

3.10 Axle Groups on Semitrailers

Each semitrailer will be permitted to have only one axle group consisting of either a single axle or a tandem or tridem group that will achieve equalized load sharing between axles in the group. This does not necessarily preclude the use of independently suspended axles or axle groups in the tandem or tridem categories, provided load equalization can be demonstrated.

Commentary:

Research has shown that load equalization in multiple axle groups is desirable to minimize the impacts of the vehicle on the highway infrastructure. In addition, for the ranges of semitrailer wheelbases being considered, no more than three fixed axles (within the range of spreads recommended for the tridem) can be installed without degrading the stability of the vehicle while negotiating tight turns.

3.11 Load Equalization in Multiple Axle Groups

Maximum allowable loadings for individual axles in tandem or tridem groups will be controlled, in addition to the maximum allowable load for the group. In this regard, it is proposed that there shall be no more than 1000 kg difference in loading between two adjacent axles in a tandem or tridem group.

Commentary:

This principle is included as a means of enforcing the requirement for load equalization in multiple axle groups.

3.12 Effective Rear Overhang for Tractor Semitrailers

The maximum effective overhang permitted on semitrailers in the Tractor Semitrailer configuration will be 35% of the effective wheelbase of the semitrailer. The effective overhang will be measured from the turn centre of the semitrailer to the rearmost point of the semitrailer or load, whichever is greater.

Commentary:

The effective rear overhang on semitrailers in Tractor Semitrailer configurations is controlled to minimize the possibility of the rear of the trailer or its load entering adjacent lanes during turning manoeuvers. This is accomplished by limiting the extent of effective rear overhang (ie. the turn centre to rear of trailer or rear of load dimension) relative to the wheelbase.

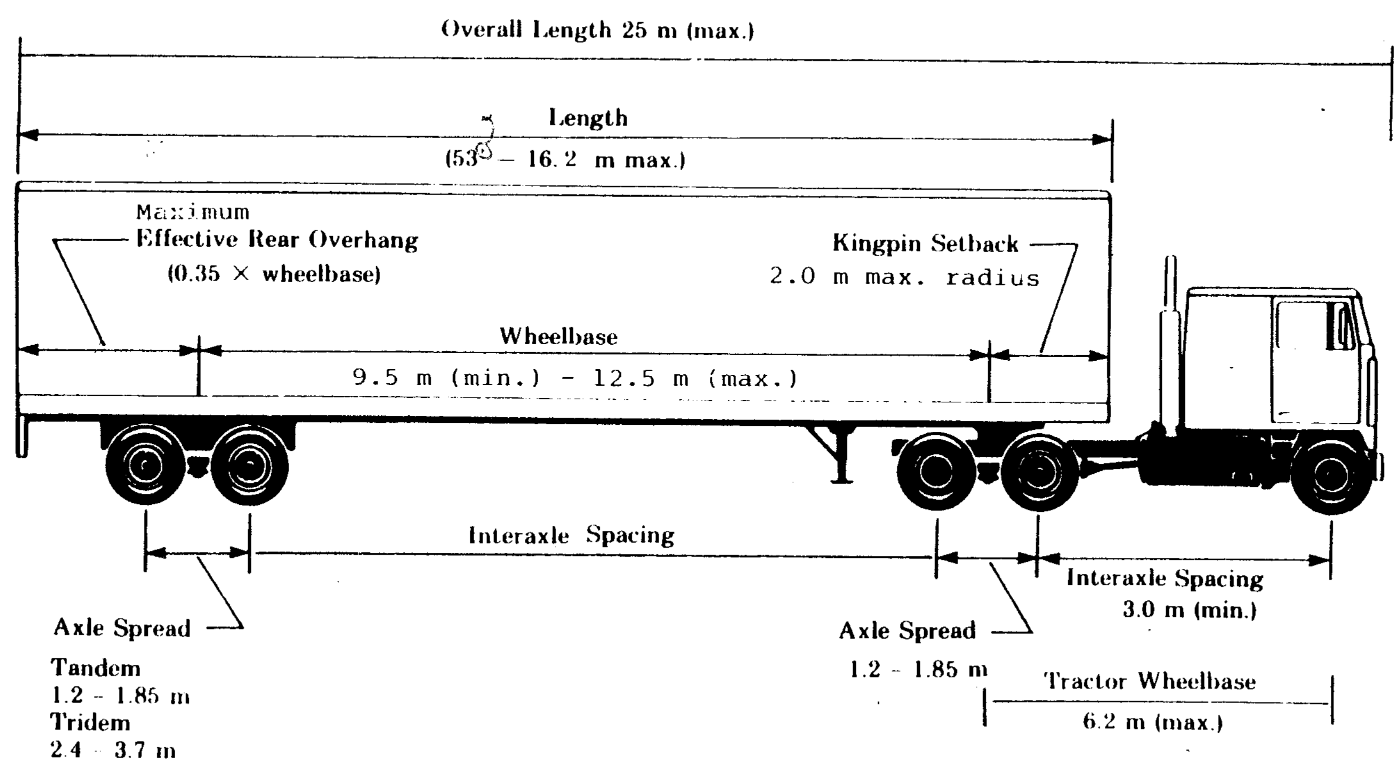
Although not proposed for regulatory control at this time, it is recommended that the development and use of improved rear underride protection be undertaken.

4.0 Summary of Proposed Regulatory Controls by Configuration

4.1 Category 1: Tractor Semitrailer

The research program demonstrated that the most inherently stable vehicle configuration of the four types examined is the tractor semitrailer. It has served in the past as the predominant vehicle type used in interprovincial carriage because of its high productivity and flexibility. The proposed regulatory principles and limits are intended to encourage the continued use of this configuration, within the bounds of acceptable stability performance and infrastructure impacts.

The elements of the configuration which are proposed for regulatory control and the proposed limits are summarised in the table and diagram which follow.



Tractor Semi-trailer

CATEGORY 1: TRACTOR SEMITRAILER SUMMARY

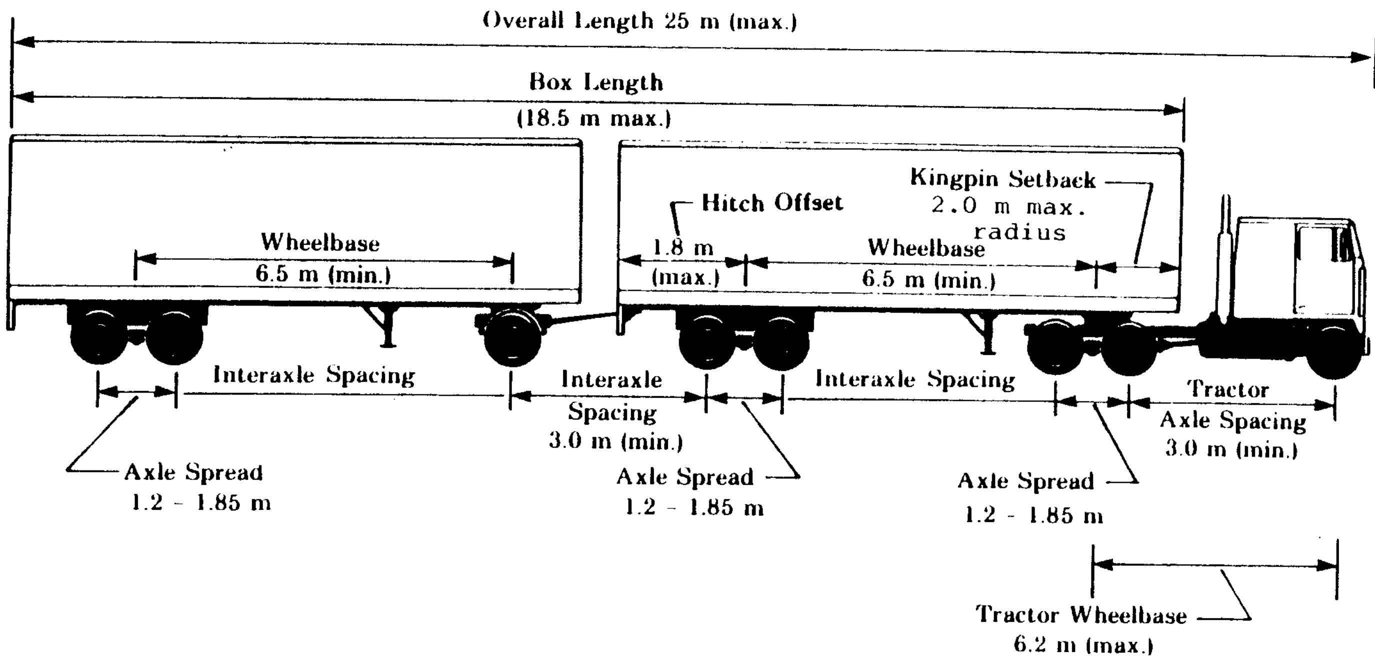
Parameter	Control Proposed	Proposed Limits
DIMENSIONS		
Tractor:		
Wheelbase	Yes	Max 6.2m
Tandem Spread	Yes	Min 1.2 m / Max 1.85 m
Fifth Wheel Offset	No	
Interaxle Spacing	Yes	Min 3 m
Semitrailer:		
Length	Yes	Max 16.2 m
Wheelbase	Yes	Min 9.5m to Max 12.5m
Kingpin Setback	Yes	Max 2.0 m radius
Effective Overhang	Yes	Max 35% of wheelbase
Rear Overhang	No	
Tandem Axle Spread	Yes	Min 1.2 m / Max 1.85 m
Tridem Spread	Yes	Min 2.4 m / Max 3.7 m
Overall Length	Yes	Max 25 m
Track Width:		
Tractors	No	
Trailers	Yes	Min 2.5 m / Max 2.6 m
Suspension Mix	No	
Tire Type	No	
WEIGHTS		
Axle Loads:		
Steering Axle	Yes	Max 5500 kg
Single Axle (dual tires)	Yes	Max 9100 kg
Tandem Axle	Yes	
Tandem Drive		Max 17 000 kg
Tandem Trailer		Max 17 000 kg
Tridem Axle	Yes	
Spread 2.4 m - less than 3.0 m		Max 21 000 kg
Spread 3.0 m - less than 3.6 m		Max 23 000 kg
Spread 3.6 m to 3.7 m		Max 24 000 kg
Interaxle Spacings:		
Single - Single	Yes	Min 3 m
Single - Tandem	Yes	Min 3 m
Tandem - Tandem	Yes	Min 5 m
Tandem - Tridem	Yes	Min 5.5 m
Gross Combination Weight	Yes	Max 46 500 kg

4.2 Category 2: A Train Double Configurations

The A Train Double configuration was shown to have potentially serious performance limitations. This configuration's performance consistently falls short of the desired levels, particularly with respect to the Dynamic Load Transfer Ratio and the Transient High Speed Offtracking. Increasing the semitrailer wheelbases does alleviate these problems to a certain extent, however the minimum required wheelbases result in a configuration which exceeds permissable overall length limitations, and also degrade its low speed offtracking performance beyond the acceptable limit.

As a consequence, the regulatory principles and proposed limits do not provide incentives to the use of the A Train Double.

The elements of the configuration which are proposed for regulatory control and the proposed limits are summarized in the table and diagram which follow.


Overall Length 25 m (max.)
Box Length
(18.5 m max.)
Kingpin Setback
2.0 m max.
radius
Hitch Offset
1.8 m
(max.)
Wheelbase
6.5 m (min.)
Wheelbase
6.5 m (min.)
Interaxle Spacing
Interaxle
Spacing
3.0 m (min.)
Interaxle Spacing
Tractor
Axle Spacing
3.0 m (min.)
Axle Spread
1.2 - 1.85 m
Axle Spread
1.2 - 1.85 m
Axle Spread
1.2 - 1.85 m
Tractor Wheelbase
6.2 m (max.)

A-Train

CATEGORY 2: A TRAIN CONFIGURATIONS

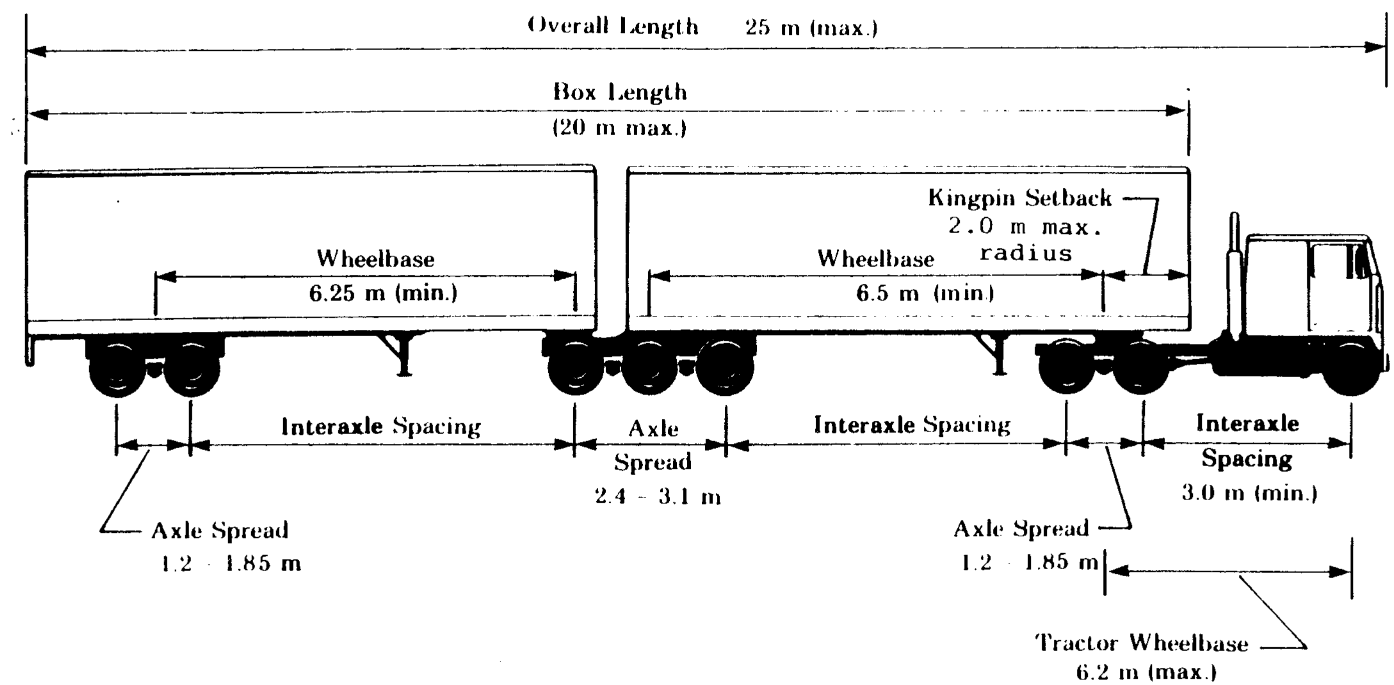
Parameter	Control Proposed	Proposed Limits
DIMENSIONS		
Tractor:		
Wheelbase	Yes	Max 6.2 m
Tandem Spread	Yes	Min 1.2 m / Max 1.85 m
Fifth Wheel Offset	No	
Interaxle Spacing	Yes	Min 3 m
First Semitrailer:		
Length	No	
Wheelbase	Yes	Min 6.5 m
Kingpin Setback	Yes	Max 2.0 m radius
Effective Overhang	No	
Rear Overhang	No	
Tandem Axle Spread	Yes	Min 1.2 m / Max 1.85 m
Hitch Offset	Yes	Max 1.8 m
Second Semitrailer:		
Length	No	
Wheelbase	Yes	Min 6.5 m
Kingpin Setback	No	
Effective Overhang	No	
Rear Overhang	No	
Tandem Axle Spread	Yes	Min 1.2 m / Max 1.85 m
Distance from Front of Lead Trailer to Rear of Second Trailer	Yes	Max 18.5 m
Dolly:		
Drawbar Length	Yes	Max 3.0 m
Overall Length	Yes	Max 25 m
Track Width:		
Tractors	No	
Trailers	Yes	Min 2.5 m / Max 2.6 m
Suspension Mix	No	
WEIGHTS		
Axle Loads:		
Steering Axle	Yes	Max 5500 kg
Single Axle	Yes	Max 9100 kg
Tandem Axle	Yes	Max 17 000 kg
Sum of Axle Loads Second Trailer		Max 16 000 kg
Interaxle Spacings:		
Single - Single	Yes	Min 3 m
Single - Tandem	Yes	Min 3 m
Tandem - Tandem	Yes	Min 5 m
Gross Combination Weight	Yes	Max 53 500 kg

4.3 Category 3: B Train Double Configurations

The B Train Double configuration has been shown to be the most stable of the currently available double trailer configurations, and has demonstrated a capacity to accomodate further increases in both size and allowable weights without unduly compromising its desirable performance. The superior performance of the B Train is derived from the removal of one point of articulation in the vehicle, and the roll coupling of the tractor with the two semitrailers.

While its use in Canada has been largely limited to carriage of bulk commodities in tanks, and for commodities transportable on flatbed trailers, the technology can be, and has been, adapted to the van configuration. The proposed regulatory principles and limits are intended to encourage the use of this configuration, within the bounds of acceptable stability performance and infrastructure impacts.

The elements of the configuration which are proposed for regulatory control and the proposed limits are summarized in the table and diagram which follow.


Overall Length 25 m (max.)
Box Length
(20 m max.)
Kingpin Setback
2.0 m max.
radius
Wheelbase
6.25 m (min.)
Wheelbase
6.5 m (min)
Interaxle Spacing
Axle
Spread
2.4 - 3.1 m
Interaxle Spacing
Interaxle
Spacing
3.0 m (min.)
Axle Spread
1.2 - 1.85 m
Axle Spread
1.2 - 1.85 m
Tractor Wheelbase
6.2 m (max.)

B-Train

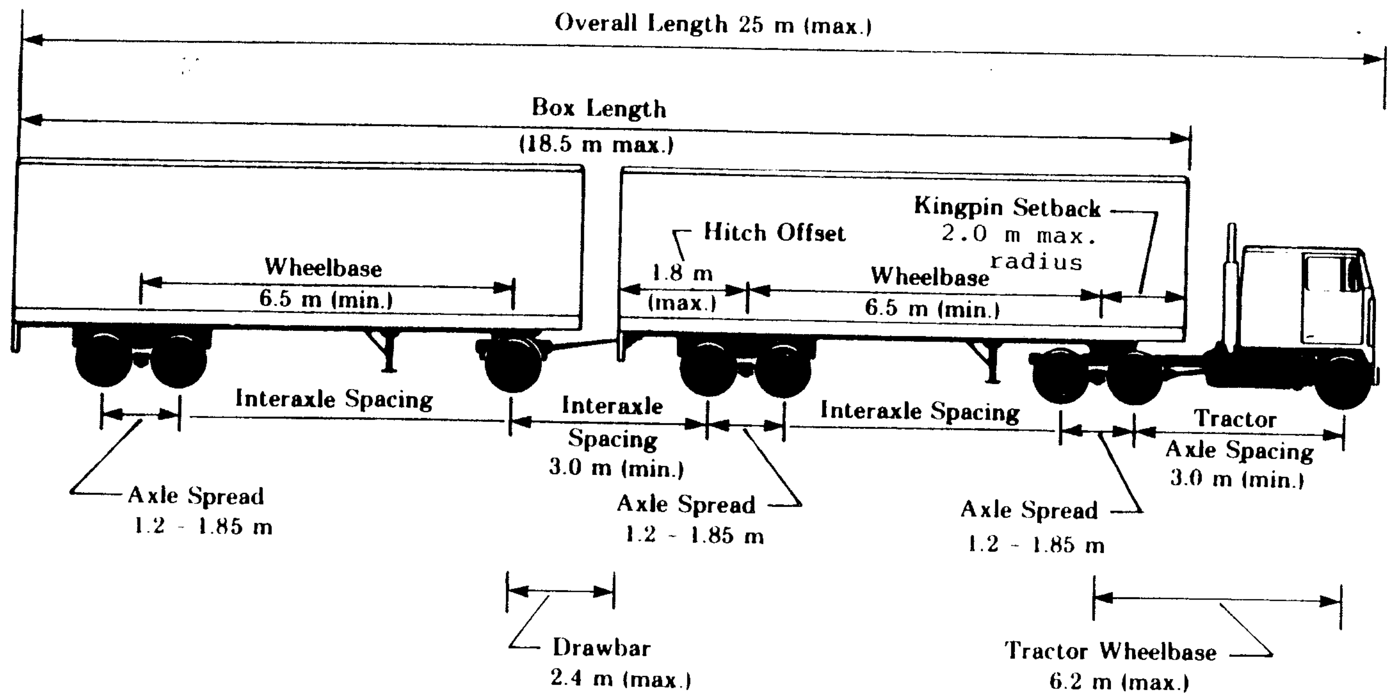
CATEGORY 3: B TRAIN CONFIGURATION SUMMARY

Parameter	Control Proposed	Proposed Limits
DIMENSIONS		
Tractor:		
Wheelbase	Yes	Max 6.2 m
Tandem Spread	Yes	Min 1.2 m / Max 1.85 m
Fifth Wheel Offset	No	
Interaxle Spacing	Yes	Min 3 m
First Semitrailer:		
Length	No	
Wheelbase	Yes	Min 6.5 m
Kingpin Setback	Yes	Max 2.0 m radius
Tandem Axle Spread	Yes	Min 1.2 m / Max 1.85 m
Tridem Axle Spread	Yes	Max 3.1 m
Second Semitrailer:		
Length	No	
Wheelbase	Yes	Min 6.25 m
Kingpin Setback	No	
Effective Overhang	No	
Rear Overhang	No	
Tandem Axle Spread	Yes	Min 1.2 m / Max 1.85 m
Distance from Front of Lead Trailer to Rear of Second Trailer	Yes	Max 20 m
Overall Length	Yes	Max 25 m
Track Width:		
Tractors	No	
Trailers	Yes	Min 2.5 m / Max 2.6 m
Suspension Mix	No	
Tire Type	No	
WEIGHTS		
Axle Loads:		
Steering Axle	Yes	Max 5500 kg
Single Axle (dual tires)	Yes	Max 9100 kg
Tandem Axle	Yes	Max 17 000 kg
Tridem Axle	Yes	
Spread 2.4 m to less than 3.0 m		Max 21 000 kg
Spread 3.0 m to 3.1 m		Max 23 000 kg
Interaxle Spacings:		
Single - Single	Yes	Min 3 m
Single - Tandem	Yes	Min 3 m
Tandem - Tandem	Yes	Min 5 m
Tandem - Tridem	Yes	Min 5.5 m
Tridem - Tridem	Yes	Min 6.0 m
Gross Combination Weight	Yes	Max 62500 kg

4.4 Category 4: C Train Double Configurations

The C Train Double configuration holds great promise as a configuration which overcomes some of the operational difficulties of the B Train while demonstrating superior stability performance to the A Train. however the research underlined the necessity for proper B Dolly design and application to obtain the improved stability characteristic.
Until a regulatory mechanism is developed and implemented which will guarantee performance targets can be met, it would be premature to encourage more widespread usage of the C Train. For this reason the proposed regulatory principles and controls governing A Train configurations are also recommended for the C Train.

The elements of the configuration which are proposed for regulatory control and the proposed limits are summarized in the table and diagram which follow.



Overall Length 25 m (max.)
Box Length
(18.5 m max.)
Kingpin Setback
2.0 m max.
radius
Hitch Offset
1.8 m
(max.)
Wheelbase
6.5 m (min.)
Wheelbase
6.5 m (min.)
Interaxle Spacing
Interaxle
Spacing
3.0 m (min.)
Interaxle Spacing
Tractor
Axle Spacing
3.0 m (min.)
Axle Spread
1.2 - 1.85 m
Axle Spread
1.2 - 1.85 m
Axle Spread
1.2 - 1.85 m
Drawbar
2.4 m (max.)
Tractor Wheelbase
6.2 m (max.)

C-Train

CATEGORY 4: C TRAIN CONFIGURATIONS

Parameter	Control Proposed	Proposed Limits
DIMENSIONS		
Tractor:		
Wheelbase	Yes	Max 6.2 m
Tandem Spread	Yes	Min 1.2 m / Max 1.85 m
Fifth Wheel Offset	No	
Interaxle Spacing	Yes	Min 3 m
First Semitrailer:		
Length	No	
Wheelbase	Yes	Min 6.5 m
Kingpin Setback	Yes	Max 2.0 m radius
Effective Overhang	No	
Rear Overhang	No	
Tandem Axle Spread	Yes	Min 1.2 m / Max 1.85 m
Hitch Offset	Yes	Max 1.8 m
Second Semitrailer:		
Length	No	
Wheelbase	Yes	Min 6.5 m
Kingpin Setback	No	
Effective Overhang	No	
Rear Overhang	No	
Tandem Axle Spread	Yes	Min 1.2 m / Max 1.85 m
Distance from Front of Lead Trailer to Rear of Second Trailer	Yes	Max 18.5 m *
Dolly:		
Drawbar Length	Yes	Max 2.4 m
Overall Length	Yes	Max 25 m
Track Width:		
Tractors	No	
Trailers	Yes	Min 2.5 m / Max 2.6 m
Suspension Mix	No	
Tire Type	No	
WEIGHTS		
Axle Loads:		
Steering Axle	Yes	Max 5500 kg
Single Axle	Yes	Max 9100 kg
Tandem Axle	Yes	Max 17 000 kg
Sum of Axle Loads Second Trailer		Max 16 000 kg *
Interaxle Spacings:		
Single - Single	Yes	Min 3 m
Single - Tandem	Yes	Min 3 m
Tandem - Tandem	Yes	Min 5 m
Gross Combination Weight	Yes	Max 53 500 kg *

(*) Subject to review upon implementation of compliance standard for B Converter Dollies

5.0 Conclusions and Recommendations

5.1 Interprovincial Weights and Dimensions

It is recommended that the preceding regulatory principles and weight and dimension limits be adopted by all jurisdictions to govern interprovincial highway transport movements. A proposed schedule for implementation is currently being developed in consideration of the legislative practices of each jurisdiction, along with the identification of a preliminary system of designated highways to which the proposed agreement will apply. It is also presumed that the designated highway system will evolve and expand over the years to come as infrastructure is strengthened or upgraded.

5.2 Extended Length Vehicles

In consideration of representations received regarding the use, on a national basis, of certain configurations of extended length vehicles, the Implementation Planning Subcommittee intends to recommend the following:

1. That the highest priority be accorded to resolving and recommending regulatory principles and limits for the four categories of vehicles decribed in the preceding sections, for consideration by the Council of Ministers Responsible for Transportation and Highway Safety in September 1987.

2. That in consideration of the low speed offtracking characteristics of the Turnpike Doubles, they not be considered for special permitting on two lane, two way rural highways.

3. That in consideration of the demonstrated deficiencies in the stability and controllability of the A and C Train Triple configurations, they not be considered for special permitting provisions.

4. That the extended length and low speed offtracking characteristics of Rocky Mountain Doubles and Turnpike Doubles requires that their usage be prohibited in regular unrestricted applications. In pursuit of improved uniformity, the Implementation Planning Subcommittee has begun work on developing standards, conditions and requirements for possible use in granting permits in those jurisdictions where these vehicles are now permitted.

5.3 Recommendations for Further Research

a. It is recommended that high priority be given to developing design and operational guidelines for the double drawbar, or B Converter Dolly and implementing a means of ensuring manufacturing and operational compliance.

b. It is recommended that further research be conducted into the influence of differing suspension types on vehicle stability and on pavement damage to determine whether regulatory controls are appropriate or warrant development.

c. It is recommended that research be carried out in support of developing weight and dimension limits for vehicle configurations not addressed in the past program or in this proposal, including:

a. Straight Trucks
b. Truck and Full Trailer

5.4 Recommendations for Action Required by the Government of Canada

a. It is recommended that the Government of Canada work with the Government of the United States to pursue more rapid development of wider track axles for tractors.

b. It is recommended that the development and implementation of standards for improved rear underride protection be undertaken by the Federal Government in concert with the Provincial Governments and the manufacturing industry.