The Effect of Vehicle Length on Traffic on Canadian Two-Lane, Two-Way Roads

Executive Report

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

Since the early 1970's truck size and weight regulations in Canada have evolved rapidly. These changes have not only been with respect to allowable gross vehicle weights, but also in truck lengths. Today, the western provinces permit 25 metre length trucks, while the Atlantic Provinces allow 23 metres under the provisions of the 1988 Memorandum of Understanding on Interprovincial Vehicle Weights and Dimensions which arose from the joint RTAC/CCMTA Research Program on Heavy Vehicle Weights and Dimensions carried out between 1984 and 1986. At the time this report was prepared, Ontario was considering moving to 25 m, while the Province of Quebec allows that length on major elements of its divided highway system.

The research project carried out by RTAC/CCMTA concentrated on investigating the implications of the various truck sizes on vehicle stability and control characteristics, as well as their pavement impacts. Because the interaction of trucks with other vehicles in the traffic stream was not addressed, the RTAC council on Highway and Transportation Research and Development pursued this area as part of its on-going research planning effort. As a result of their efforts, RTAC has commissioned Fiander-Good Associates Ltd., in association with Dr. John Robinson and Clayton, Sparks & Associates Ltd. to investigate two priority areas:

- The Effects of Truck Length on Intersection Operations; and
- The Effects of Truck Length on Passing Operations on Two-Lane Highways.

2.0 OBJECTIVES

The Terms of Reference for this project specified the overall goal as follows:

> **"to evaluate the safety and level of service effects of vehicle length on two-lane, two-way highway traffic in Canada with regard to intersection design and passing operations."**

Based on the above goal, two specific objectives were addressed in this project. They include:

1). To determine if current intersection design and signal timing practices are adequate for vehicles longer than presently permitted.

2). To determine if current passing sight distances and pavement marking practices are adequate for overtaking vehicles longer than those presently outlined in the regulations.

The research statement provided by RTAC indicated that a variety of vehicle lengths, up to 30 metres, should be investigated and that the issues of intersection operations and passing operations not be split, thus the same range of vehicle lengths were utilized in both areas. In addition, the findings and recommendations derived from the project satisfy both the intersection and passing operation conditions simultaneously.

3.0 GENERAL APPROACH AND METHODOLOGY

As indicated previously, this project addressed the impact of larger vehicles on:

1). intersection operations; and
2). two-lane highway passing operations.

A brief description of the general approach and methodology is given below.

Intersection Operations

The impacts of larger vehicles on intersection operations were identified with respect to capacity and level of service at signalized intersections, crossing and turning sight distance requirements at intersections controlled by stop signs on the minor approaches, crossing and clear sight distance requirements at railway crossings and truck manoeuvrability at intersections. Three typical urban signalized intersections were considered with respect to impacts on current signal design practices along with one stop sign controlled intersection for evaluating crossing and turning sight distance requirements. These intersections are illustrated in Figure 1.

The impacts of larger vehicles at signalized intersections were identified with respect to clearance interval and minimum green times. These requirements were then utilized to identify capacity and level of service impacts. The signalized intersection approach and methodology documented in the Highway Capacity Manual - 1985 was employed.

The identification of crossing and turning sight distance requirements at intersections for large trucks was based on methodologies which are utilized by AASHTO and/or RTAC. For railway crossings, the crossing sight distance requirements were identified based on the FHWA Handbook and the AASHTO Green Book while the clear sight distance requirements were identified from the RTAC Geometric Design Manual.

Two-Lane Highways Passing Operations

The passing operations portion of the project focused on developing a clear understanding of the technical issues underlying the passing manoeuvre on two-lane, two-way roads and in particular on the role which vehicle length plays in this manoeuvre. This knowledge was then examined with

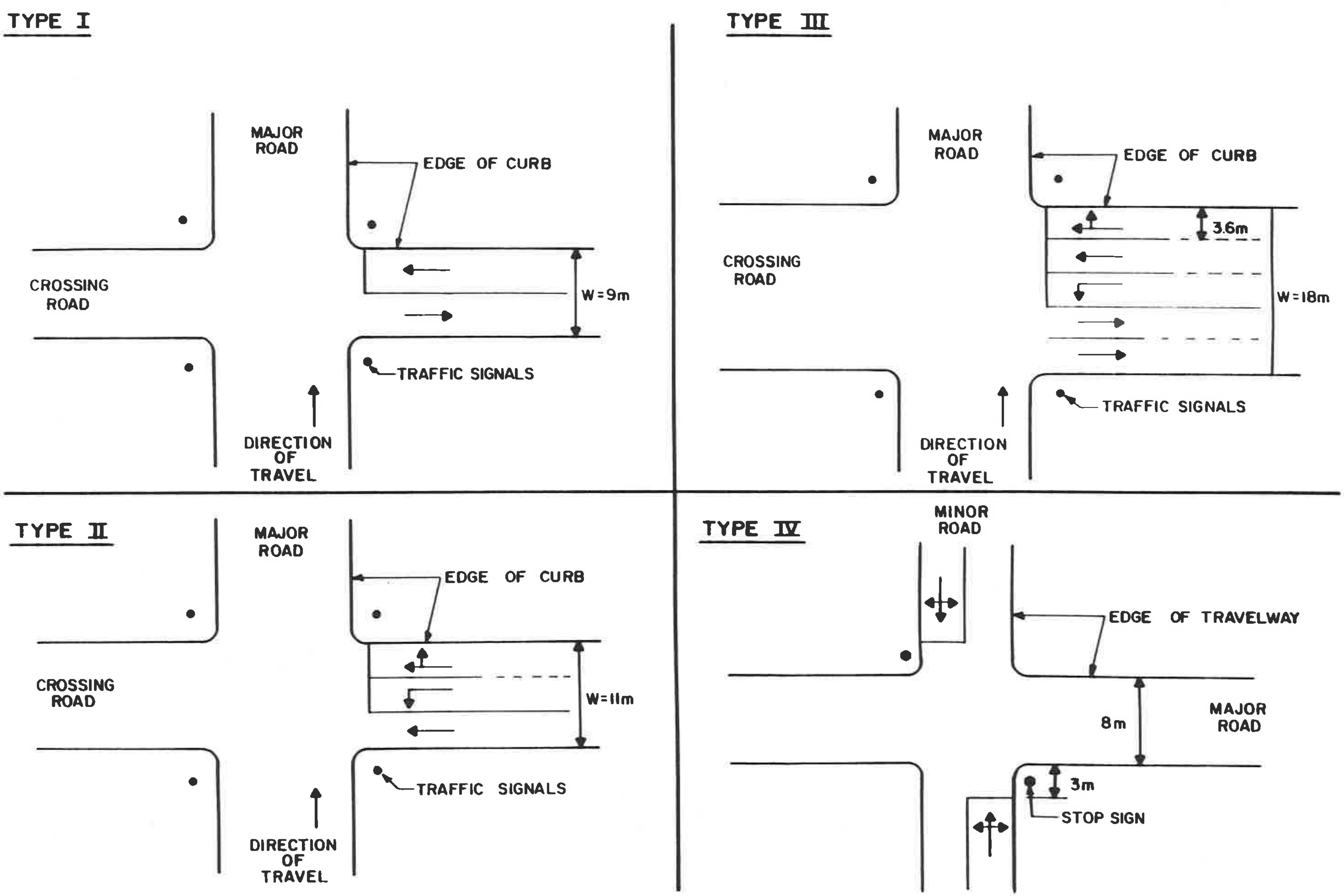


FIGURE 1: TYPICAL URBAN SIGNALIZED AND RURAL INTERSECTIONS

respect to its implications on existing guidelines for design passing sight distance, barrier line marking practice and minimum passing zone length standards for such facilities. The work:

- o Evaluated the assumptions underlying recently developed deterministic models of passing operations with a particular focus on the work of Lieberman, Glennon, Saito, Rilett and Krummins.

- o Performed sensitivity testing on a selected and modified deterministic model formulation in order to identify critical parameters.

- o Formulated and developed probabilistic extensions to the deterministic model to allow for an examination of the impacts of various distributions of parameter values.

- o Performed limited verification testing of the final model formulation using field data that was already available.

- o Used the model for the evaluation of passing operations over a range of vehicle lengths from 4.5 metres (car) to 30.0 metres.

- o Assessed the implications of the analysis on current practice with respect to geometric design for passing sight distance, barrier line marking practice and minimum passing zone lengths for a range of vehicle lengths, but with particular focus on the 25 metre issue.

4.0 TECHNICAL FINDINGS AND CONCLUSIONS FOR INTERSECTION OPERATIONS

Several findings and conclusions have evolved from the various work activities which were completed as part of this project. These findings and conclusion are summarized below under the appropriate headings for intersection operations.

4.1 Signal Design at Intersections

4.1.1 Clearance Interval Times

Summary of Findings

1). The recommended current practice in selecting an appropriate clearance interval time is based on the perception/reaction time of the driver, the approach speed, the intersection width, the approach grade and the vehicle length.

2). Normal practice has been to utilize the automobile as the typical vehicle for selecting a clearance interval time.

3). Based on the three typical signalized urban intersections utilized in this project, and the automobile as the typical design vehicle, current practice suggests the clearance interval time can range from 4.2 to 6.1 seconds on level grade approaches to signalized intersections. These values can increase and/or decrease as a result of grades. Type I intersections require between 4.2 and 5.7 seconds, Type II intersections between 4.4 and 5.8 seconds and Type III intersections between 5.3 and 6.1 seconds.

4). Utilizing truck length as the typical design criteria for selecting the clearance interval results in an increase in requirements over an automobile ranging from .5 to 2.9 seconds. All three typical intersections reflect these types of increases in clearance interval times.

5). Within the 18 to 30 metre range of truck lengths, clearance interval increase requirements range from .5 to 1.5 seconds. All three intersection types reflect this range of increase.

6). When increasing truck sizes from a maximum of 23 metres to a maximum of 25 metres clearance interval requirements increase from 0 to .3 seconds for all three intersection types.

7). Clearance intervals greater than six seconds should be examined critically to ensure need before implementation because of safety implications and the tendency of drivers to utilize a portion of this time as effective green time.

8). Clearance intervals longer than four seconds should be split in two parts, with an amber period of four seconds and an all red interval of the necessary length to make up the total required time.

<u>**Summary of Conclusions**</u>

1). Changing the typical design vehicle for selecting the clearance interval from the current practice of an automobile to a truck results in a large increase in the clearance interval requirements for all three typical intersections.

2). The increase in truck length from a maximum of 23 metres to a maximum of 25 metres has very little affect on the clearance interval time requirements at all three typical intersections.

3). A clearance interval of no greater than six seconds should be considered with the amber portion no longer than four seconds, unless unusual circumstances dictate so. To ensure the maximum clearance interval timing of six seconds can accommodate various truck lengths for different intersection conditions, a combination of approach speed reductions and/or traffic control warning signs on the approaches should be considered.

4). At signalized intersections where approach speeds are 70 km/h or greater, PREPARE TO STOP signs on the approaches should be interconnected with the traffic controller at the intersection to reduce dilemma zone incidents.

4.1.2 Minimum Green Time

Summary of Findings

1). Current practice has minimum green times ranging from approximately 8 seconds to 22 seconds. Generally, minimum green time requirements in urban areas are controlled by the walk time requirement of pedestrians. This minimum walk time is a function of the street width and the pedestrian walking speed.

2). When considering the three typical intersections utilized in this project, minimum green times for different truck lengths with different acceleration capabilities range between 10.7 and 16.6 seconds at level grade intersections. The minimum green time requirements dictated by trucks fall within the current minimum green time design practices.

Trucks at Type I intersections require between 10.7 and 15.1 seconds minimum green time. At Type II and III intersections, minimum green times range from 11.1 to 15.4 seconds and 12.2 to 16.6 seconds, respectively.

3). A 25 metre truck would require approximately .4 seconds more minimum green time than a 23 metre truck at any of the three typical intersections.

4). At actuated signal installations, large trucks can reduce required green times dictated by large traffic volume demand because of their slow acceleration capabilities. The slow acceleration of large trucks can result in large time headways which in turn terminates the green phase prematurely, especially with respect to an actuated left turn phase. This can then result in larger left turning queues and greater storage lane requirements.

Conclusions

1). Although minimum green times at intersections are normally not dictated by truck acceleration requirements, a large portion of the green time available at a typical signalized intersection can be utilized by a truck accelerating from a stopped position, thus reducing capacity.

2). A change in truck length from 23 to 25 metres has very little impact on minimum green time requirements at any of the three typical intersections.

3). Actuated signal installations should be designed to reduce the impact the larger trucks in the traffic stream have on decreasing green times below actual traffic demand requirements, especially with respect to separate left turn phases.

4.1.3 Capacity and Level of Service

Summary of Findings

1). Changing the clearance interval times between 4.5 and 7.0 seconds at the 9 metre wide typical intersection (Type I) results in no change in the level of service category. At the 11 metre wide intersection (Type II), there is a one level of service category drop from LOS C to D as the clearance interval time changes from 7.0 to 7.5 seconds. A change in the clearance interval time between 4.5 and 8.0 seconds at the 18 metre wide intersection (Type III) results in a level of service reduction from C to E, a two category drop.

2). The decrease in level of service as a result of increasing the clearance interval time can be attributed directly to the difference between automobile and truck clearance interval requirements.

3). The impact of a 25 metre truck versus a 23 metre truck on level of service and capacity at a signalized intersection is not measurable at any of the three typical intersections within the general accuracy of the analysis methodology.

4). The analysis reveals that the passenger car equivalent of trucks can impact on level of service and capacity more so than the clearance interval requirements. Current practice incorporates a passenger car equivalent for trucks between 1.5 and 2.0 throughout the analysis procedure. These values are based on the assumption that truck traffic is generally comprised of small trucks, such as single unit trucks and delivery type trucks. Very little data presently exist to enable a more accurate assessment to be made of a more realistic passenger car equivalent for the current truck traffic stream to reflect the increase in larger trucks in the urban environment.

5). The increase in the volume and length of large trucks, along with their reduced acceleration capabilities, suggest that the passenger car equivalent should be greater. For comparison purposes, it was assumed larger trucks could have passenger car equivalents of 4 to 5. Level of service and capacity analysis were completed based on the assumption that half of the trucks in the traffic stream would have a 4 to 5 passenger car equivalent.

6). The results of the passenger car equivalent analysis indicate that level of service dropped one category for Type I intersections and two categories for Type II and III intersections below the standard analysis which utilized a passenger car equivalent factor between 1.5 and 2.0.

Conclusions

1). The potential increase in passenger car equivalents of trucks from the current practice of 1.5 to 2.0 to a larger value can substantially influence level of service and capacity at any of the three typical intersections.

2). More data and research is required to identify realistic passenger car equivalents for the present and future truck traffic stream at urban intersections.

4.2 Crossing and Turning Sight Distance At Unsignalized Intersections

4.2.1 Crossing Sight Distance

Summary of Findings

1). Current practice at unsignalized intersections controlled by stop signs on the minor approaches is to provide sufficient crossing sight distance to allow a vehicle to cross the major road before the arrival of a vehicle approaching the intersection. It is assumed that the progress of the vehicle on the major road is not impeded.

2). The RTAC manual provides sufficient information to determine the crossing sight distance requirements for passenger cars, single unit trucks and tractor-trailers (WB15).

3). Over a design speed range of 50 to 110 km/h, passenger cars require 99 to 217 metres crossing sight distance to negotiate an 8 metre wide intersection. The WB15 tractor-trailer requires between 172 and 378 metres over the same design speed range, which represents approximately a 75 percent increase.

4). Although both length and acceleration capabilities influence the crossing sight distance requirements for trucks, crossing sight distance is more sensitive to the acceleration capabilities of vehicles.

5). Within the 18 metre to 30 metre truck length range, crossing sight distance requirements can increase from 61 to 132 metres over a design speed range of 50 to 110 km/h. This represents an average increase of 35 percent.

6). For an increase in truck length from 23 metres to 25 metres, the increase in minimum crossing sight distance is between 5 and 12 metres, a 2.5 percent increase.

7). At intersections with upgrades in the 4 percent area, crossing sight distance requirements for trucks are in the 700 to 830 metre range. These distances would be very difficult to judge by the driver wishing to negotiate a crossing manoeuvre without impeding the on-coming vehicle.

Conclusions

1). Trucks in general require substantial increases in minimum crossing sight distance at unsignalized intersections controlled by a stop sign on the minor approaches.

2). An increase in truck length from a maximum of 23 metres to 25 metres would result in a 5 to 12 metre increase in crossing sight distance.

3). At existing and potential sights where crossing sight distance requirements are such that distances would be difficult for truck drivers to judge, consideration should be given to providing advanced warning signs, reducing the speed limit or signalization of the intersection if truck traffic volumes or safety considerations warrant such an installation. Signal installation warrants would have to be reviewed and reevaluated to reflect this situation. It should be noted that reducing the speed limit has proven ineffective in the past as a traffic control measure.

4.2.2 Turning Sight Distance

Summary of Findings

1). Current practice with respect to turning sight distance requirements at unsignalized intersections controlled by a stop sign suggest that a turning vehicle should have sufficient time to complete the turning manoeuvre and/or to accelerate to a normal running speed without influencing the passage of through vehicles approaching from either direction.

2). The RTAC manual provides the turning sight distance requirements for passenger cars making left turns at unsignalized intersections. Values range from 125 to 435 metres for design speeds on the major highway between 50 and 110 km/h for vehicles turning left to a vehicle approaching from the right. The sight distance for a passenger car turning left to a vehicle approaching from the left range from 115 to 235 metres over a design speed range of 50 to 110 km/h.

3). The turning sight distance requirements for trucks is substantially greater than for passenger cars. An 18 metre truck negotiating a left turn requires 249 to 1,005 metres turning sight distance to a vehicle approaching from the right for design speeds between 50 and 110 km/h. This represents an increase over passenger car requirements of between 99 and 131 percent.

4). An 18 metre truck making a left turn requires 213 to 468 metres turning sight distance to a vehicle approaching from the left for design speeds between 50 and 110 km/h. This represents an increase over passenger cars between 85 and 99 percent.

5). Turning sight distance requirements for trucks is much more sensitive to acceleration capabilities than length. A 23 metre truck with a lower acceleration rate than a 20 metre truck requires 109 to 513 metres more turning sight distance for vehicles approaching from the right and 59 to 132 metres for vehicles approaching from the left.

6). A 25 metre truck with the same acceleration capabilities as a 23 metre truck requires between 2 and 9 metres more turning sight distance for vehicles approaching from either direction.

7). The turning sight distance requirements for the larger trucks at the higher design speeds when vehicles are approaching from the right are at values which probably cannot be accurately judged by truck drivers.

Conclusions

1). Trucks require substantially more turning sight distance than passenger cars.

2). A 25 metre truck requires approximately the same turning sight distance as a 23 metre truck.

3). The turning sight distance requirements for the larger trucks at the higher design speeds, when vehicles are approaching from the right, probably can not be accurately judged by the driver wishing to negotiate a turning manoeuvre. This implies that one or more of the following actions be taken:

a). review the current RTAC criterion which states that the progress of the vehicle on the major road should not be impeded;
b). reduce the posted speed limits on the major road;
c). provide adequate acceleration lanes;
d). provide advance warning signs to reduce speed; and/or
e). reevaluate the signal installation warrants to reflect the turning movement requirements of large trucks.

It should be noted that reducing the posted speed limit has been ineffective in the past as a traffic control measure.

4.3 Sight Distance at Railway Crossings

4.3.1 Crossing Sight Distance

Summary of Findings

1). The minimum crossing sight distance requirements at unsignalized railway crossings are greater for trucks than for passenger cars.

2). Crossing sight distance requirements are more sensitive to the acceleration capability of trucks than length.

3). A 25 metre truck with the same acceleration capabilities as a 23 metre truck requires 6 to 33 metres more crossing sight distance over a 30 to 150 km/h train speed.

4). Crossing sight distance requirements for trucks stopped at a railway crossing increase greatly with train speed. It is doubtful these larger distances can be judged accurately and safely by truck drivers.

Conclusions

1). In general, trucks stopped at railway crossings require substantially more crossing sight distance than passenger cars.

2). An increase in maximum truck length from 23 to 25 metres requires 6 to 33 metres more crossing sight distance at unsignalized railway crossings.

3). At railway crossings where train speeds result in crossing sight distance requirements which cannot be judged accurately by drivers, active traffic control signals should be installed.

4). In urban areas where a railway crossing is located 60 metres or less from a signalized intersection, the railway crossing should be signalized and interconnected with the traffic controller of the nearby street intersection to enable the street signals to be preempted to clear the intersection leg prior to the arrival of a train.

4.3.2 Clear Sight Distance

Summary of Findings

1). The clear sight distance requirements at an unsignalized railway crossing is primarily a function of the design speed of the highway, the perception/reaction time of the driver, coefficient of friction used in braking and the train speed. Vehicle length is not a factor.

2). There has been some tests and analytical studies which indicate large trucks are unable to achieve current braking standards, except under ideal conditions.

Conclusions

1). Vehicle length is not a factor when determining clear sight distance requirements at unsignalized railway crossings.

2). More research is needed on the braking capability of trucks under various roadway and load conditions.

4.4 Truck Manoeuvrability at Intersections

Summary of Findings:

1). The performance criteria established for transient low-speed offtracking in the course of the RTAC/CCMTA Vehicle Weights and Dimensions Study are linked to current intersection design standards used in both the U.S. and Canada and are appropriate for application in this work.

2). Low-speed transient offtracking - the criteria used to assess truck manoeuvrability is a complex phenomenon that is related to a number of different parameters of truck configuration.

3). Semi-trailer wheelbase and tractor wheelbase are primary variables affecting offtracking performance, however increases in overall vehicle combination length do not necessarily mean that offtracking performance worsens. The presence of additional articulation points and other factors such as fifth wheel offset, kingpin setback, maximum allowable overhangs, the addition of axles to semitrailers, use of steerable axles, variations in dolly and hitch types in multiple combination vehicles can also affect such performance to greater or lesser degrees, depending on the interactions of the various factors in a specific truck layout.

4). The tractor-semitrailer vehicle will not in all likelihood exceed 25 metres in length if a maximum trailer length of 16.2 metres is permitted and all other provisions of the MoU, except current overall length limitations are retained. The 16.2 metre ceiling on semitrailer length has been suggested as the practical upper limit for that unit based on tare versus payload weight ratio efficiencies.

5). Some vehicle configurations do not perform within the desired performance limitations. Generally speaking, as overall lengths exceed 25 metres, it becomes more difficult to design a vehicle that will perform satisfactorily in terms of offtracking and still meet the other essential performance criteria stipulated in the RTAC/CCMTA MoU.

6). One tractor-semitrailer unit using a 16.2 metre trailer did exceed the maximum allowable offtracking criteria. However, in this case, the maximum trailer wheelbase provision of the MoU was not adhered to. If it had been, the offtracking of that vehicle would have been within performance limits.

7). Provided all of the other aspects of the RTAC/CCMTA MoU are adhered to, increases in vehicle length up to 25 metres and concomitant increases in semi-trailer and box-lengths can generally be accommodated within the offtracking performance criteria which form the basis for that MoU.

8). Beyond 25 metres in overall length it becomes more difficult to ensure that vehicles can meet both the offtracking and the other criteria used as the basis for the RTAC/CCMTA MoU.

Conclusions:

1). The offtracking performance criteria used in the RTAC/CCMTA Vehicle Weights and Dimensions Study should continue to represent one basis upon which consideration of vehicle length increases are judged.

2). Other performance criteria underlie the current MoU provisions. Any increases in vehicle and/or box length which might be allowed should be done in the context of ensuring that all of these other criteria are still satisfied. While generally speaking, this is achievable within limits, proposals for such changes should be carefully reviewed by the existing interjurisdictional committee on heavy vehicle weights and dimensions in this regard.

3). Many vehicles currently allowed under existing regulations in individual jurisdictions do not perform within the low-speed offtracking limits defined under the MoU because they do not conform to the MoU dimensional limits. Increases to overall conformity to the MoU provisions could actually reduce the number of poorly performing vehicles on the road over time.

4). From the standpoint of truck manoeuvrability as defined by transient low-speed offtracking performance, an increase in allowable overall length from 23 metres to 25 metres in the context of adhering to all other provisions of the MoU can be accommodated on the existing road system without hardship.

5.0 TECHNICAL FINDINGS AND CONCLUSIONS FOR PASSING OPERATIONS

5.1 Passing Operations: Three Interrelated Components

The typical passing manoeuvre is comprised of three interrelated components.

- o the distance to get to the critical position,
- o the critical sight distance which determines the barrier line passing sight distance requirements, and
- o the design passing sight distance which is simply the algebraic sum of the first two components.

The Design Passing Sight Distance (DPSD) is the total sight distance required to safely complete a pass. This distance is utilized in the geometric design of highways to ensure the provision of adequate passing opportunities and to improve traffic safety and the level of service to users of the facility.

The critical sight distance is the sight distance required by a driver at the critical position. The critical position is defined as that point in the passing manoeuvre where the distance required to abort the pass is equal to the distance required to complete the pass. The critical sight distance is used in the determination of no-passing zone pavement markings - in effect to trigger the presence of barrier lines. Hence, this distance is referred to as the Barrier Line Passing Sight Distance (BLPSD) in this report.

The distance to get to the critical position is simply the algebraic difference of the first two components. This distance defines (by default) the minimum length of the passing zone. Further discussions in this paper are restricted to the DPSD and BLPSD since the minimum passing zone length is directly related to these two primary factors used in design and operations and can be deduced from them.

5.2 Design Passing Sight Distance

Summary of Findings

1). The important variables in determining the design passing sight distance requirements are:

a). the velocity of the impeding vehicle and the velocity of the passing vehicle;

b). the length of the impeding vehicle;

c). clearance at the end of the pass between the passing vehicle and the opposing vehicle;

d). clearance at the end of the pass between the passing vehicle and the impeding vehicle; and

e). the perception/reaction time of the driver in the abort mode.

2). Of the variables listed above, only the length of the impeding vehicle can be considered to be "controllable" in the sense that minimum design passing sight distance requirements may be specified based on a regulated maximum vehicle length.

3). Minimum DPSD requirements increase as the length of the impeding vehicle increases.

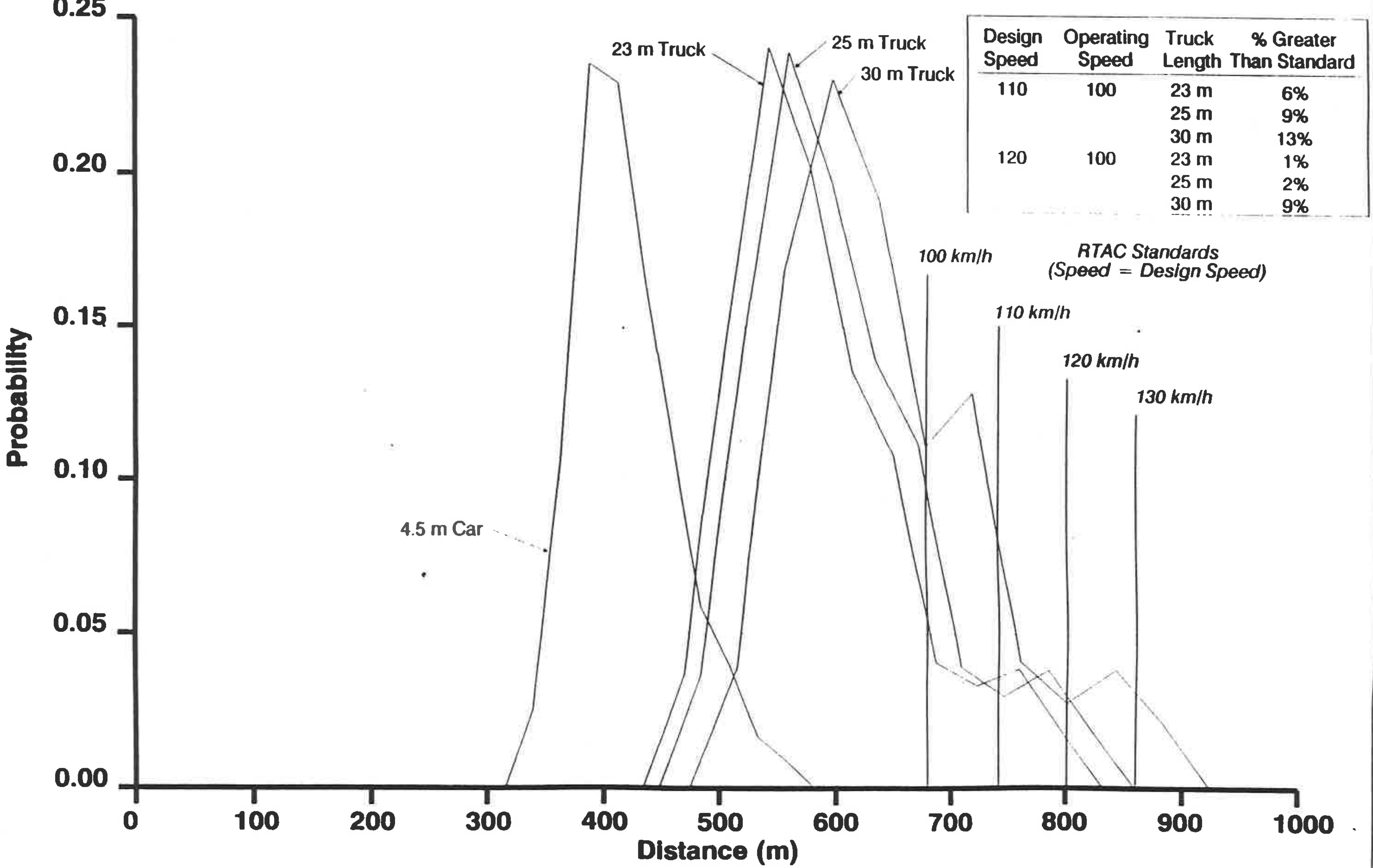
4). Increasing the impeding vehicle length from 23 metres to 25 metres for a highway with posted speed of 100 km/h increases the average required DPSD by 17 metres.

5). Minimum design passing sight distance requirements increase as the vehicle operating speeds (posted highway speeds) increase.

6). Current minimum passing sight distance standards set by RTAC appear to match well with requirements predicted by the model for two-way, two-lane rural highways with operating speeds of 80 km/h and for passing manoeuvres involving truck lengths of up to 25 m, given a minimum differential of 10 km/h between the design speed and posted or operating speed of the highway.

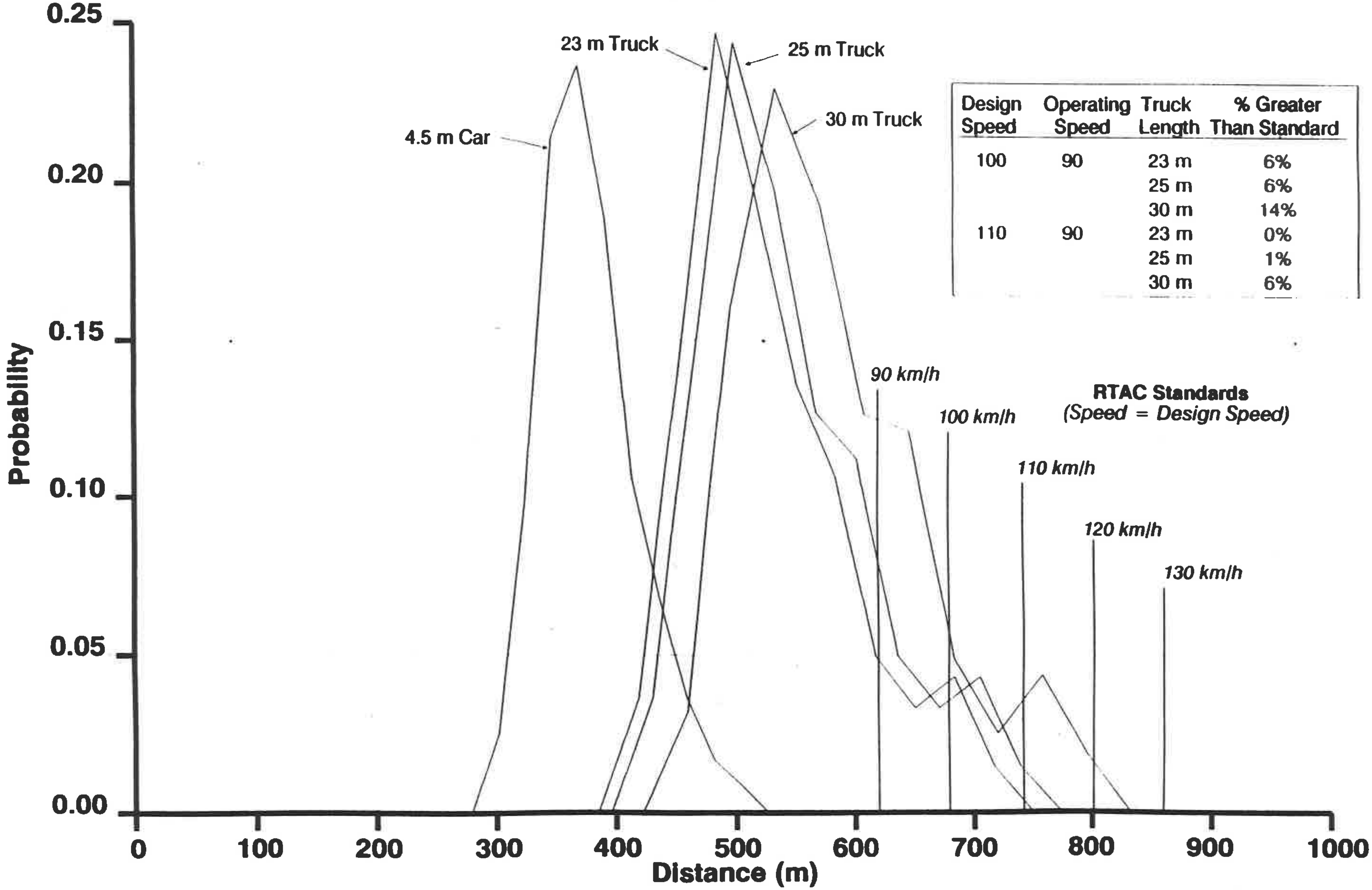
7). For passing manoeuvres where the impeding vehicle is a truck and where operating speeds are 90 or 100 km/h, RTAC minimum passing sight distance standards do not always provide as much sight distance as the model predicts would be required given a 10 km/h differential between the design speed and the posted or operating speed. (See Figure 2 and Figure 3).

FIGURE 2
Comparison of Model Output and RTAC Standards
Design Passing Sight Distance
Posted Speed = Operating Speed = 100 km/h



Design Speed	Operating Speed	Truck Length	% Greater Than Standard
110	100	23 m	6%
		25 m	9%
		30 m	13%
120	100	23 m	1%
		25 m	2%
		30 m	9%

FIGURE 3
Comparison of Model Output and RTAC Standards
Design Passing Sight Distance
Posted Speed = Operating Speed = 90 km/h



Design Speed	Operating Speed	Truck Length	% Greater Than Standard
100	90	23 m	6%
		25 m	6%
		30 m	14%
110	90	23 m	0%
		25 m	1%
		30 m	6%

Conclusions

1). The maximum length of vehicles which can safely use the highway system is directly related to the geometric design of the facility. As the upper limit of acceptable length as determined by geometric design is approached the potential for a passing manoeuvre to take place with unsafe passing sight distances increases.

2). As is the case at the present time, maximum allowable vehicle lengths must continue to be controlled through size and weight regulation at levels concomitant with the ability of various road designs to accommodate them in safety.

3). Some question appears to exist as to the acceptability of current geometric design practice with respect to the 23 metre limit for certain operating speed ranges (see Figures 2 and 3).

4). If the currently allowed 23 metres maximum vehicle lengths are judged acceptable, then increasing maximum lengths from 23 metres to 25 metres creates a marginal change in DPSD requirements that can probably be considered acceptable.

5). Additional research is required to further validate the model used in this work. This validation should focus on the development of additional data to help establish the ranges of values used for selected input variables. Detailed discussion of this conclusion will be found in the Technical Report for this project.

6). Current RTAC Design Passing Sight Distance requirements should be subject to a rigorous technical review and if necessary revised to reflect changing individual vehicle dimensions and fleet average characteristics with respect to length.

5.3 Barrier Line Passing Sight Distance

Summary of Findings

1). The important variables in determining the barrier line passing sight distance requirements are:

a). the perception/reaction time of the driver;

b). the deceleration rate of the passing vehicle;

c). the length of the impeding vehicle;

d). the clearance at the end of the pass between the passing and impeding vehicles; and

e). the velocity of the passing vehicle and the velocity of the opposing vehicle.

2). Of the variables listed above, only the length of the impeding vehicle can be considered to be "controllable" in the sense that minimum BLPSD requirements may be specified based on a regulated maximum vehicle length.

3). Barrier line passing sight distance requirements increase as the length of the impeding vehicle increases.

4). Increasing the impeding vehicle length from 23 metres to 25 metres for a highway with a posted speed of 100 km/h increases the barrier line requirements by 10 metres.

5). BLPSD requirements increase as vehicle operating speeds (posted highway speeds) increase.

6). Current barrier line sight distance standards set by RTAC do not provide as much BLPSD as would be predicted by the model in order to ensure that passes can be completed safely on two-way, two-lane rural highways.

Conclusions

1). The pavement markings used to indicate passing and no-passing zones are one important determinant of the maximum length of vehicles which can safely use the highway system. As the upper limit of acceptable length as determined by these requirements is approached the potential for a passing manoeuvre to take place under unsafe conditions increases.

2). As is the case at the present time, maximum allowable vehicle lengths must continue to be controlled through size and weight regulation at levels concomitant with the ability of various operational measures to accommodate them in safety.

3). Under certain conditions, serious questions appear to exist as to the acceptability of current barrier line marking practice with respect to the current 23 metre limit. (See Figures 4, 5 and 6).

4). If the currently allowed 23 metre maximum vehicle lengths are judged acceptable, then increasing maximum lengths from 23 metres to 25 metres creates a marginal change in BLPSD requirements that can probably be considered acceptable.

FIGURE 4

Comparison of Model Output and RTAC Standards

Barrier Line Passing Sight Distance

Posted Speed = Operating Speed = 100 km/h

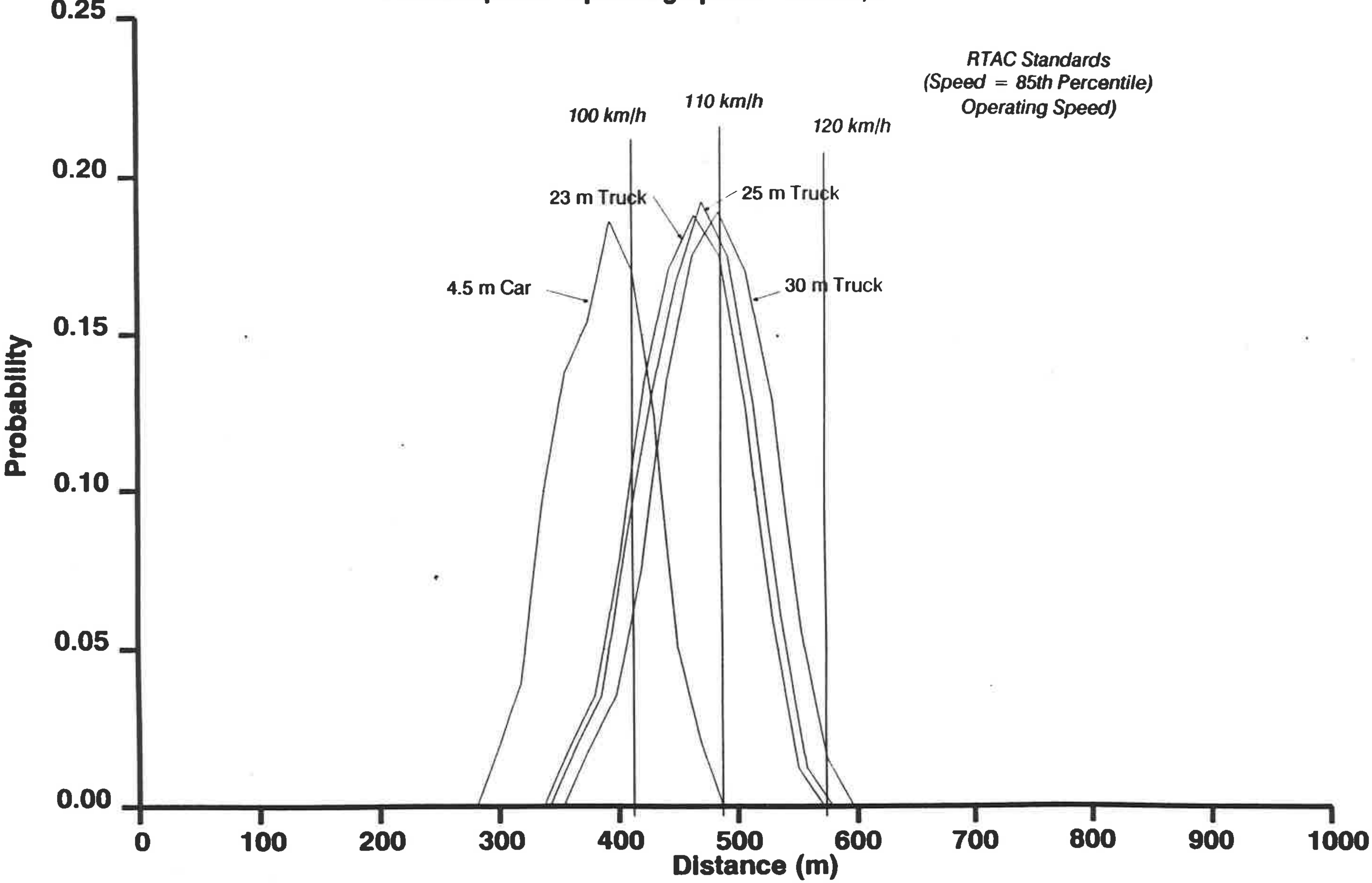


FIGURE 5
Comparison of Model Output and RTAC Standards
Barrier Line Passing Sight Distance
Posted Speed = Operating Speed = 90 km/h

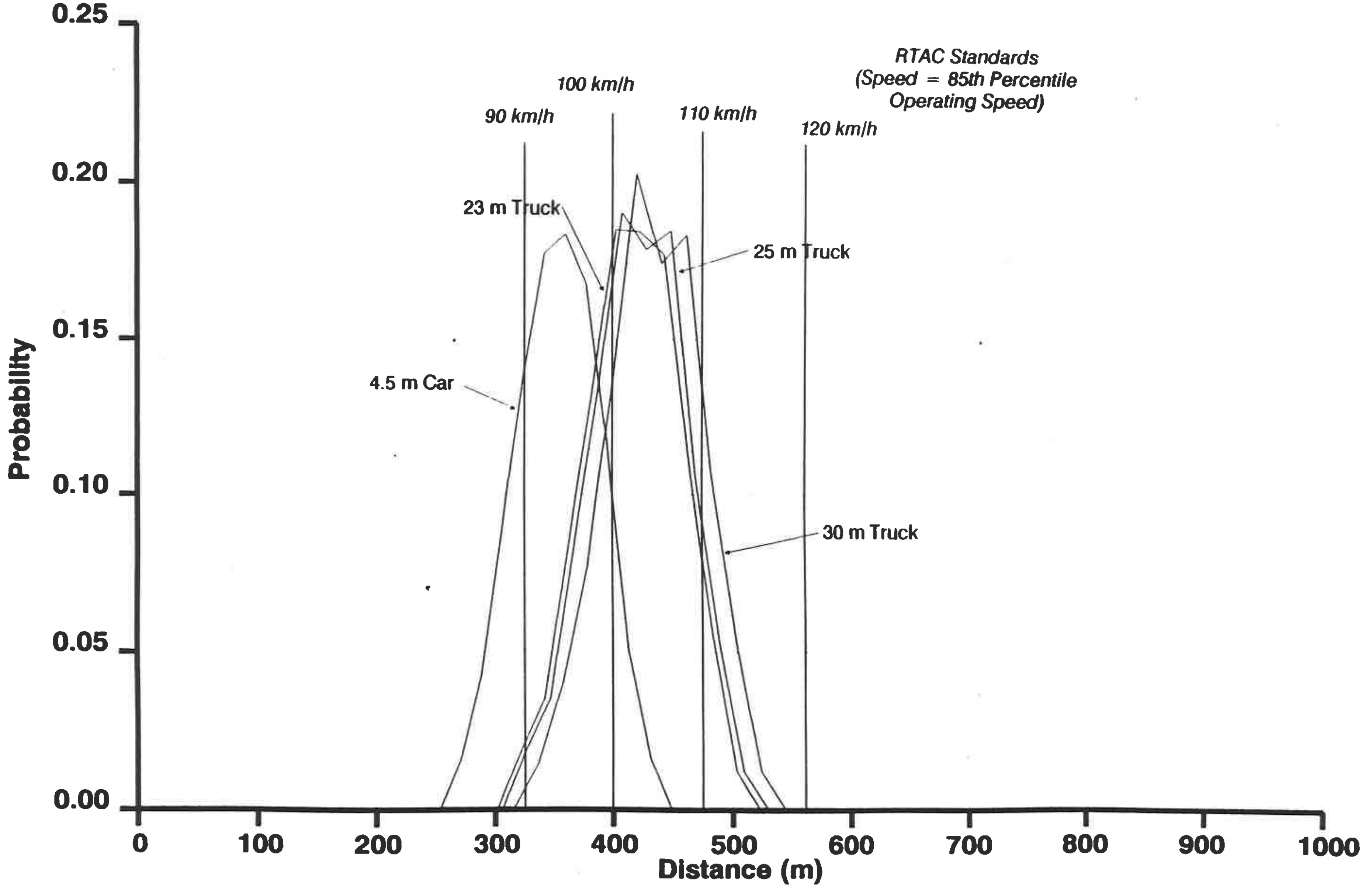
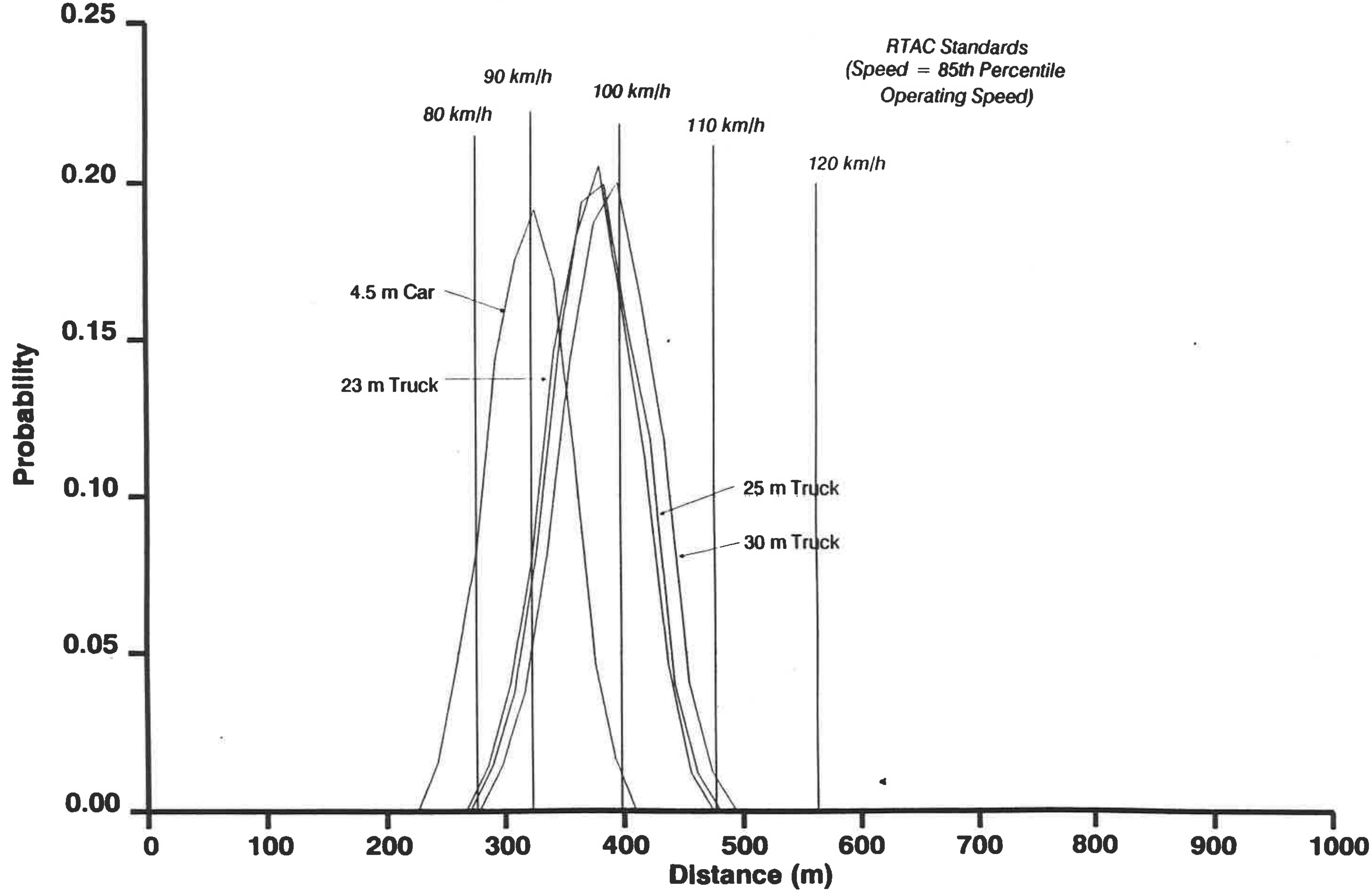


FIGURE 6
Comparison of Model Output and RTAC Standards
Barrier Line Passing Sight Distance
Posted Speed = Operating Speed = 80 km/h



5). Additional research is required to further validate the model used in this work. This validation should focus on the development of additional data to help establish the ranges of values used for selected input variables. Detailed discussion of this conclusion will be found in the Technical Report for this project.

5). Current RTAC Barrier Line Passing Sight Distance requirements should be subject to a rigorous technical review and if necessary revised to reflect changing individual vehicle dimensions and fleet average characteristics with respect to length. Since a number of jurisdictions in Canada have BLPSD requirements that differ from RTAC, these agencies may wish to review their current practices in light of the findings of this project.

6.0 CONCLUDING OBSERVATIONS

The issue of increasing maximum allowable vehicle lengths is highly complex. In the context of this project, two questions were addressed:

1) The assessment of the general question of the impact of vehicle length on intersections and on passing operations.

2). The question of whether or not increases in overall vehicle length from 23 metres to 25 metres is appropriate.

The research clearly demonstrated that vehicle length is an important determinant of both design and operations practice for intersections and for passing operations on two-lane, two-way highways. It generally also showed that there was a clear distinction between the results of using of a car as a design vehicle and the use of a truck for design purposes. This issue is fundamental to the problem of overall length simply because many of our design and operations practices today reflect the use of the automobile as the controlling vehicle. Given the enormous preponderance of this vehicle in the total vehicle fleet, this is probably appropriate.

Nonetheless, it is standard practice in traffic engineering to tailor design and operations solutions to the types of vehicles in the traffic stream and it is probably unreasonable to expect that one standard based on one type of design vehicle is necessarily appropriate for all intersections or for all two-lane, two-way roads. Canada has a wide variety of traffic and topographical conditions which will necessarily mitigate against uniformity in some cases in favour of safety and economy. It is thus logical to expect that in some cases, increases in length could be accommodated, whereas in others such increases may not be appropriate.

The research also indicated that the results of the work were in some cases at variance with current practice for design and operations in intersections and on two-lane highways. This does not necessarily mean that current practice is not appropriate. It does suggest however, that where this occurs the standards merit closer scrutiny.

Glennon offers some cogent advice in a paper dealing with an analysis of the U.S. situation with respect to passing operations on two-lane highways and the possible need to modify existing sight distance standards:

> "...The results indicate that if a passenger car passing a passenger car is retained as the design situation, only minor modifications are needed to the MUTCD passing sight distance criteria. If a more critical design situation is selected (e.g. a passenger car passing a truck) passing sight distances up to 250 ft longer than the current MUTCD criteria would be required. It is important to recognize that such a change in passing zone criteria would completely eliminate some existing passing zones and shorten others, even though passenger cars can safely pass other passenger cars in those zones. Clearly, this would reduce the level of service on two-lane highways. This reduction in level of service would only be justified if there were also demonstrated safety benefits. The current state-of-the-art of two-lane highway safety research has not addressed whether there are such benefits. We do not know whether passenger car drivers have more difficulty in judging the criticality of passing manoeuvres when the passed vehicle is a truck than when the passed vehicle is a passenger car. Research on these safety issues should be undertaken before any change in passing sight distance criteria to accommodate passenger cars passing trucks as the design situation."