Accommodating Commercial Vehicles in Roundabouts: Discussion Paper

December 2010

235 Martindale Road, Suite 1
St. Catharines, ON L2W 1A5
Tel: (905) 688-7770
Fax: (905) 882-1557
www.hdrinc.com
www.itransconsulting.com

Project # 5998
CLIENT PROJECT TEAM

Project Manager.................................................. Geoffrey Wood

HDR | ITRANS PROJECT TEAM

Project Manager.................................................. Jeff Suggett
Technical Team.................................................. Mat Bilodeau
Melissa Noss
Alan So
Advisor ................................................................. Christopher Kinzel
Quality Control..................................................... Greg Junnor
EXECUTIVE SUMMARY

A. Introduction
A number of existing intersections and roads in new developments have incorporated roundabouts as an alternative means of traffic control. Traffic engineers and designers have embraced roundabouts due to their superior safety and operational performance. As the number of roundabouts increases in Ontario, commercial vehicle operators will more and more be required to manoeuvre through them. However, the specific design features that make the roundabout attractive can be problematic to commercial vehicle operators. Failure to properly account for commercial vehicle traffic in their design has resulted in vehicle damage and damage to fixed objects associated with their design.

Given the increase in the use of roundabouts in Ontario, the Ontario Trucking Association sought to provide municipalities/road authorities with guidance on how commercial vehicles may be accommodated within roundabouts. This discussion paper has:

• Identified design elements that typically constrain the movement of commercial vehicles in roundabouts
• Identified minimum design parameters of single and multi-lane roundabouts that may accommodate commercial vehicles of varying configurations
• Identified features within a roundabout that will maintain desirable attributes while at the same time accommodate commercial vehicles

B. Investigation of existing roundabout designs
In order to determine how existing roundabouts in Ontario accommodate commercial vehicles, four different roundabout designs consisting of two single-lane and two multi-lane roundabouts were investigated. The review of the single and multi-lane roundabouts revealed a number of issues associated with the design of a roundabout and the ability of a commercial vehicle to negotiate through the roundabout unencumbered. In accommodating conventional WB-20 commercial vehicles (53 foot trailers) and A-Train LCV truck configurations (tractors with twin 53 foot trailers), the review of the single lane roundabouts indicated that the path of the commercial vehicle would off track over a curb or another fixed object due to:

• Narrow entry and exit lanes
• Tight radii associated with the entry and exit lanes
• The size of the central island and the truck apron

Overall, the multi-lane roundabouts fared better in accommodating WB-20 commercial vehicles, due to the overall larger diameter, the width of the entry and exit lanes and their larger radius, and the width of the circulatory road. One of the multi-lane roundabouts was able to accommodate both WB-20 and A-Train LCV truck configurations.

C. Best practices
In considering a roundabout in new construction or for replacing a conventional intersection, attention should be given to the amount of commercial traffic that is expected to be using the location and/or the surrounding land use characteristics. Anticipated use or existing use is typically
Executive Summary

The largest motorized vehicle likely to use the intersection is considered to be the design vehicle. Generally speaking, the higher the classification of the roadway, the larger the design vehicle that should be used. Before beginning the design process, the designer must be conscious of the design vehicle and possess the appropriate vehicle turning templates (using a program such as AUTOTURN) to determine the vehicle's swept path through the roundabout.

In designing single-lane roundabouts, the diameter of the roundabout is largely dependent upon the turning requirements of the design vehicle. The diameter must be large enough to accommodate the design vehicle while maintaining adequate deflection (curvature) to ensure safe travel speeds for smaller vehicles. The circulatory roadway width, entry and exit widths, entry and exit radii, and entry and exit angles of a roundabout also play a significant role in accommodating the design vehicle and providing deflection. Usually, the left-turn movement (270 degree turn) is the critical path for determining circulatory roadway width. A minimum clearance of 1.0m should be used between the path of the design vehicle and any fixed object.

No specific guidance was found in the literature regarding the width of the circulatory roadway for multi-lane roundabouts. While logic would dictate that the design should ensure that a passenger vehicle and a commercial vehicle (e.g. a WB-20 design vehicle) should be able to proceed into and through the roundabout side-by-side without coming in contact with each other, this would lead to the (inscribed circle diameter) ICD or the width of the circulatory roadway being excessively wide, leading to additional cost, less deflection (for smaller vehicles) and a diminished safety performance.

A more appropriate response would be to ensure that design allows for two passenger vehicles to make this manoeuvre without conflict and assume that the commercial vehicle would use the entire circulatory roadway and other vehicles would give way. The designer may consider not providing circulatory lane markings within roundabouts that are used by a significant number of commercial vehicles to avoid any confusion with motorists attempting to enter the roundabout at the same time as a commercial vehicle.

Vertical design elements can be equally important to providing a roundabout that is able to accommodate commercial vehicles safely. The cross section of the circulatory roadway and the truck apron will affect the available ground clearance in addition to overall commercial vehicle stability. Where aprons are used, they should be designed so that they are traversable by commercial vehicles, but discourage passenger vehicles from using them. Designers should be aware of the type of commercial vehicle expected to be using the roundabout when considering the vertical grade (longitudinal) across the truck apron in addition to the vertical drop between the truck apron and circulatory roadway.

The cross-fall within the circulating roadway cross section, with or without a truck apron, could also affect the stability of the commercial vehicle as it passes through the roundabout. The trailer of commercial vehicles travelling around a roundabout with a truck apron and adverse cross-fall in the circulatory lane (sloping away from the central island) may experience significant lateral forces. As such, the slope of the truck apron and the cross-fall of the circulatory should be examined carefully.
D. Treatments
Numerous modifications can be made that allow commercial vehicles to be accommodated within a roundabout while ensuring deflection for smaller vehicles. These include:

• Widened entry and exit lanes - On single-lane roundabouts with anticipated significant commercial vehicle traffic, commercial vehicle operators may require wider entries to enter the roundabout. Extra turning space can be added by using hatching within the entry and exit lanes providing space for wider right turns

• Truck aprons - Used on the central island to provide an additional paved area to allow off-tracking of commercial vehicles without compromising the deflection of smaller vehicles. Where aprons are used, they should be designed so that they are traversable by commercial vehicles, but discourage passenger vehicles from using them

• Bypass lanes – Used to allow commercial vehicles to entirely bypass the roundabout, passing through a larger radius curve

• Gates for pass through traffic – Used to provide a means by which an oversize/overlength commercial vehicle can pass entirely through the central island

The modifications may only be used on a single approach or multiple approaches where there is commercial traffic anticipated.

E. Design templates
Design templates have been provided in Section 4.5 of this discussion paper for a single and multi-lane roundabout. They contain dimensions based on existing designs and may be used as a starting point for designing a roundabout that accommodates commercial vehicles.

The designer should use AUTOTURN or similar software to confirm that the final design can accommodate the desired commercial vehicle while still maintaining adequate deflection for passenger vehicles.
Accommodating Commercial Vehicles in Roundabouts

Executive Summary

1. Introduction

2. Review of existing roundabout designs

3. Best practices
   3.1 Planning
   3.2 Horizontal design elements
   3.3 Vertical design elements

4. Treatments that will accommodate commercial vehicles
   4.1 Widened entry and exit lane
   4.2 Truck aprons
   4.3 Bypass lanes
   4.4 Gates for pass through traffic
   4.5 Design templates for single and multilane roundabouts

5. Conclusions
   5.1 Investigation of existing roundabout designs
   5.2 Best practices
   5.3 Treatments
   5.4 Design templates

Tables

Table 1 - The relationship between central island diameter, inscribed circle diameter and the width of the circulatory roadway (that will accommodate a WB-20 design vehicle)

Table 2 – Design template for a single lane roundabout that will accommodate a WB-20 commercial vehicle

Table 3 – Design template for a multi-lane roundabout that will accommodate a WB-20 truck and an A-Train LCV
Exhibits

Exhibit 1: Key roundabout features ................................................................. 2
Exhibit 2: AUTOTURN assessment of a right turn ............................................. 3
Exhibit 3: Turning Widths Required for Normal Roundabouts (Ourston, 1996) ....... 6
Exhibit 4: Commercial vehicle entering multi-lane roundabout without lane markings ........ 8
Exhibit 5: Screen shot of education material available on a website warning the public to give way to commercial vehicles in multilane roundabouts ................. 8
Exhibit 6: Illustration of ground clearance issues with oversize/overlength commercial vehicles ................................................................. 9
Exhibit 7: Longitudinal view of commercial vehicle with minimal ground clearance and truck apron ................................................................. 10
Exhibit 8: Cross section view of commercial vehicle with minimal ground clearance and truck apron (and an adverse cross-fall on the circulating roadway) ............ 10
Exhibit 9: Provision of widened entry and exit lanes in a roundabout (shown in yellow on the north and south approaches) ........................................ 11
Exhibit 10: Cross section of truck apron .......................................................... 12
Exhibit 11: Example of a roundabout with a right-turn bypass ....................... 12
Exhibit 12: Pass through for oversize/overlength commercial vehicle (aerial image shown at top and street view shown at bottom) ........................................ 13
1. INTRODUCTION

The use of roundabouts as an alternative traffic control device at an intersection has been steadily growing in popularity. In Ontario, there are a number of municipalities/road authorities that have constructed roundabouts as part of new construction or as a retrofit to an existing intersection. These include the Region of Waterloo, City of Hamilton, Leeds and Grenville County, City of Ottawa, and the Niagara Falls Parks Commission.

The benefits of roundabouts are well known. Roundabouts have been shown to improve safety at intersections by reducing crash risk and severity. In addition, they can improve intersection capacity thereby reducing delays and queuing at intersections with traditional forms of traffic control (e.g. Stop control or signalization). More broadly, roundabouts have been embraced by municipalities and road authorities as a means of traffic calming, as a gateway feature, or improving the aesthetics of an area.

Roundabouts have specific design and traffic control features as shown in Exhibit 1. These features include yield control of all entering traffic, channelized approaches and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway are typically less than 50 km/h. This is achieved through horizontal deflection. Horizontal deflection is the path a vehicle takes through the roundabout. The driver should be required to make a set of relatively sharp turns to guarantee a relatively low speed entering, proceeding through and exiting the roundabout.

As the number of roundabouts has increased in Ontario, commercial vehicle operators have more often encountered them and have in some instances expressed concern to the Ontario Trucking Association regarding their design. In assuring a low travel speed on the circulatory roadway through deflection, commercial vehicle operators have had difficulty manoeuvring through the roundabout without damaging their vehicle or adjacent fixed objects associated with their design.
Given the increase in the use of roundabouts in Ontario, the Ontario Trucking Association wishes to provide municipalities/road authorities with guidance on how commercial vehicles can be accommodated within roundabouts. The purpose of this discussion paper is to:

- Identify design elements that typically constrain the movement of commercial vehicles in roundabouts
- Identify minimum design parameters of a single and multi-lane roundabout that can accommodate commercial vehicles of varying configurations
- Identify features within a roundabout that will maintain desirable attributes while at the same time accommodate larger vehicles

Exhibit 1: Key roundabout features

Excerpt from FHWA document FHWA-RD-00-067, Roundabouts: An Informative Guide, p6
2. REVIEW OF EXISTING ROUNDABOUT DESIGNS

In preparation for this discussion paper, HDR | iTRANS assessed the design of four existing roundabouts in Ontario in terms of their ability to accommodate commercial vehicles. The project team requested orthophotos from the Ministry of Transportation or design drawings for each of the locations. The four locations chosen were two single lane and two multi-lane (two-lane) roundabouts.

Using a software program called AUTOTURN, the project team assessed the ability of commercial vehicles of different configurations to travel through each of the roundabouts without coming into contact with any fixed object (e.g. the curb adjacent to the entry lane, the outside of the circulatory roadway or the central island). AUTOTURN is a software program that determines the space required for a vehicle to negotiate a turn based on inputs provided by the user. These inputs include trailer and tractor length, wheel base, and turning radius. The inputs used in AUTOTURN represented the ‘worst case’ scenario for the configuration in question, that is, inputs that would result in the commercial vehicle requiring the maximum amount of space to complete a turn while still meeting provincial standards.

AUTOTURN is particularly useful in assessing the degree of offtracking that occurs in commercial vehicles, given that the rear trailer (or trailers) will not follow the same path as the cab – rather they tend to ‘off-track’ towards the inside of the turn (at low speeds). This is illustrated in Exhibit 2 which shows the output from an AUTOTURN assessment of a right turn. The pink line indicates the centre of the cab, the green lines represent the furthest extent of the path of the commercial vehicle (on the inside and outside of the turn), and the dashed blue lines show a 0.5m buffer.

Exhibit 2: AUTOTURN assessment of a right turn
The ability of the commercial vehicle to manoeuvre through the roundabouts was assessed for all approaches for 90, 180 and 270 degree turns for conventional WB-20 trucks (tractors with 53 foot trailers) and longer commercial vehicle (LCV A-Train) configurations (tractors with twin 53 foot trailers in A-Train configuration). The LCV was only assessed if the design of the roundabout was able to accommodate a WB-20 commercial vehicle. The configuration of a WB-20 commercial vehicle can be found in Regulation 413/05 of the Highway Traffic Act -- SPIF Designated Combination #1. The configuration of an LCV A-Train commercial vehicle can be found in the Ministry of Transportation, Ontario document Longer Commercial Vehicle Program Conditions found at http://www.mto.gov.on.ca/english/trucks/lcv/lcv-conditions.pdf. The turning characteristics for a WB-20 commercial vehicle would off track more than a regular RTAC B-Train commercial vehicle (at a 25m overall length).

The LCV B-Train configuration was not explicitly reviewed as part of this exercise. Given they off track slightly more than LCV A-Trains, it is expected that they would require slightly more space.

The review of the single and multi-lane roundabouts revealed a number of issues associated with the design of a roundabout and the ability of a commercial vehicle to negotiate through the roundabout unencumbered. In accommodating conventional WB-20 and LCV A-Train commercial vehicle configurations, the review of the single lane roundabouts indicated that the path of the commercial vehicle would off track over a curb or another fixed object due to:

- Narrow entry and exit lanes
- Tight radii associated with the entry and exit lanes
- The size of the central island and the truck apron

Overall, the multi-lane roundabouts fared better in accommodating WB-20 commercial vehicles, due to the overall larger diameter, the width of the entry and exit lanes and their larger radius, and the width of the circulatory road. One of the roundabouts was found to be suitable for all movements for both WB-20 and LCV A-Train commercial vehicles.
3. BEST PRACTICES

This section reviews best practices with regard to accommodating commercial vehicles within roundabouts, specifically with regard to planning, horizontal design elements, vertical design elements and measures that may be added to the design of a roundabout or as a retrofit (post-construction) that can assist commercial vehicle operators in negotiating through a roundabout.

3.1 Planning

In considering a roundabout in new construction or for replacing a conventional intersection, attention should be given to the amount of commercial traffic that is expected to be using the location and/or the surrounding land use characteristics. Anticipated use or existing use is typically seen as a legitimate measure in determining the design of a roundabout.

The largest motorized vehicle likely to use the intersection is considered to be the design vehicle. Generally speaking, the higher the classification of the roadway, the larger the design vehicle that should be used. WB-20 commercial vehicles should be considered along arterial routes or roads servicing industrial areas. In Ontario, with the advent of the Ministry of Transportation introducing longer commercial vehicles to the province, consideration should be given to accommodating LCV A-Train and B-Train commercial vehicles at roundabouts to be located in industrial areas.

Before beginning the design process, the designer must be conscious of the design vehicle and possess the appropriate vehicle turning templates (using a program such as AUTOTURN) to determine the vehicle’s swept path through the roundabout.

As part of public consultation, the road authority should consider inviting affected truck carriers to participate in the consultation process. This will help the road authority to identify potential design issues and issues with accommodating vehicles of a particular dimension (e.g. oversize/overlength vehicles).

In general, larger roundabouts need to be used to accommodate large commercial vehicles while maintaining low speeds for passenger vehicles – otherwise the circulating roadway must be widened or the central island must shrink to allow the passage of the commercial vehicle unimpeded. However, widening the circulating roadway or shrinking the central island will increase the difficulty in providing an entry path deflection for passenger vehicles.

A number of different design features may be used to address the above issue as discussed in Section 3.4.

3.2 Horizontal design elements

In designing single-lane roundabouts, the diameter of the roundabout is largely dependent upon the turning requirements of the design vehicle. The diameter must be large enough to accommodate the design vehicle while maintaining adequate deflection (curvature) to ensure safe travel speeds for smaller vehicles.

Exhibit 3 illustrates the turning width required within a roundabout for a particular design vehicle. The circulatory roadway width, entry and exit widths, entry and exit radii, and entry and exit angles of a roundabout also play a significant role in accommodating the design vehicle and providing deflection.
Roundabouts using a WB-20 design vehicle typically have an ICD diameter of 35 – 40m for a single-lane and 55 – 60m for a double-lane roundabout.

Table 1 shows the central island diameter, inscribed circle diameter in metres and the corresponding width of the circulatory roadway for a roundabout that will accommodate a WB-20 design vehicle (in the circulatory roadway). At an ICD of 30m or less, it would be not feasible to design a roundabout that would accommodate a WB-20 design vehicle.

In single-lane roundabouts, the circulatory roadway should just accommodate the design vehicle. AUTOTURN should be used to determine the swept path of the design vehicle through each of the turning movements. Usually, the left-turn movement (270 degree turn) is the critical path for determining the circulatory roadway width. A minimum clearance of 1.0m should be used between the path of the design vehicle and any fixed object.

In order to maximize the safety of a roundabout, the entry and exit width should be kept to a minimum. However, the turning requirements of the design vehicle will limit the minimum entry and exit lane width. Typical entry lane widths for a single lane roundabout are between 4.3 – 4.9m.

No specific guidance was found in the literature regarding the width of the circulatory roadway for multi-lane roundabouts. While logic would dictate that the design should ensure that a passenger vehicle and a commercial vehicle (e.g. a WB-20 design vehicle) should be able to proceed into and through the roundabout side-by-side without coming in contact with each other, this would lead to the ICD or the width of the circulatory roadway being excessively wide, leading to additional cost, less deflection (for smaller vehicles) and a diminished safety performance. A more appropriate

Legend
- a Raised central island.
- b Low profile mountable apron.
- c Remaining circulatory roadway width, 1.0-1.2 times the maximum entry width.
- d Design vehicle.
- e 1 meter clearance minimum.
- f Inscribed circle diameter (ICD)
- g Width between curbs.

NOTE: Splitter islands should not protrude into the inscribed circle if the roundabout is designed tightly as illustrated here, allowing only the minimum width g.

Exhibit 3: Turning Widths Required for Normal Roundabouts (Ourston, 1996)²

² “Relative Safety of Modern Roundabouts and Signalized Cross Intersections,” Leif Ourston, P. E., Santa Barbara, California, 1996

³ Federal Highway Administration, Roundabouts: An Informational Guide, Washington, D. C., p 146
The above is illustrated in Exhibit 4 where lane markings are not provided within the circulatory roadway. The commercial vehicle entering the roundabout required the entire circulatory roadway to negotiate through the roundabout and the motorist on the left hand side of the photo was required to give way.

Table 1 - The relationship between central island diameter, inscribed circle diameter and the width of the circulatory roadway (that will accommodate a WB-20 design vehicle)

<table>
<thead>
<tr>
<th>Central island diameter (Maximum a) in metres</th>
<th>Inscribed circle diameter (f) in metres</th>
<th>Width of circulatory roadway (g) (including truck apron) in metres for a WB-20 design vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>91</td>
<td>7</td>
</tr>
<tr>
<td>72</td>
<td>85</td>
<td>7</td>
</tr>
<tr>
<td>65</td>
<td>79</td>
<td>7</td>
</tr>
<tr>
<td>58</td>
<td>73</td>
<td>7</td>
</tr>
<tr>
<td>52</td>
<td>67</td>
<td>8</td>
</tr>
<tr>
<td>45</td>
<td>61</td>
<td>8</td>
</tr>
<tr>
<td>41</td>
<td>58</td>
<td>8</td>
</tr>
<tr>
<td>37</td>
<td>55</td>
<td>9</td>
</tr>
<tr>
<td>34</td>
<td>52</td>
<td>9</td>
</tr>
<tr>
<td>30</td>
<td>49</td>
<td>9</td>
</tr>
<tr>
<td>26</td>
<td>46</td>
<td>10</td>
</tr>
<tr>
<td>23</td>
<td>43</td>
<td>10</td>
</tr>
<tr>
<td>17</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>37</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>*</td>
<td>30</td>
<td>*</td>
</tr>
<tr>
<td>*</td>
<td>29</td>
<td>*</td>
</tr>
</tbody>
</table>

response would be to ensure that design allows for two passenger vehicles to make this manoeuvre without conflict and assume that a commercial vehicle would use the entire circulatory roadway and other vehicles would give way. This issue has led to significant discussion in the engineering community regarding striping the circulatory roadway in double lane roundabouts. Multi-lane roundabouts with striping in the circulatory roadway can be misleading for motorists entering at the same time as a commercial vehicle operator. The motorist may assume that they may pass through the roundabout side by side with the commercial vehicle (given the markings in the circulatory roadway). Given that the commercial vehicle operator will likely require the entire circulatory roadway to negotiate through the roundabout, there is a potential for a sideswipe collision between the two vehicles. The designer may consider not providing circulatory lane markings within roundabouts that are used by a significant number of commercial vehicles.

Adapted from Mike Brown, The Design of Roundabouts, State of the Art Review, 1995 – Imperial units converted to metric

Federal Highway Administration, Roundabouts: An Informational Guide, Washington, D. C., p 147
Accommodating Commercial Vehicles in Roundabouts

Best Practices

Accommodating Commercial Vehicles in Roundabouts

Exhibit 4: Commercial vehicle entering multi-lane roundabout without lane markings

Some jurisdictions have resorted to posting signs within multi-lane roundabouts warning of the issue of a passenger vehicle driver attempting to travel alongside a commercial vehicle in a roundabout. Other jurisdictions have warned the general public of this issue, through preparing educational materials, such as shown in Exhibit 5, for a multi-lane roundabout in Alaska, advising passenger vehicle drivers to give way to commercial vehicles in roundabouts.

Exhibit 5: Screen shot of education material available on a website warning the public to give way to commercial vehicles in multilane roundabouts

3.3 Vertical design elements

Vertical design elements can be equally important to providing a roundabout that is able to accommodate commercial vehicles safely. The cross section of the circulatory roadway and the truck apron will affect the available ground clearance in addition to overall commercial vehicle stability.

Commercial vehicles with minimal ground clearance (e.g. lowboy commercial vehicles, car haulers and some types of oversize/overlength vehicles) can have problems negotiating through a roundabout with a truck apron as illustrated in Exhibit 6.

Exhibit 6: Illustration of ground clearance issues with oversize/overlength commercial vehicles

Where aprons are used, they should be designed so that they are traversable by commercial vehicles, but discourage passenger vehicles from using them. They should generally be 1 to 4m in width and have a cross slope of 3 to 4 percent away from the central island. To discourage use by passenger vehicles, the outer edge of the apron should be raised a minimum of 30mm above the circulatory roadway surface.

Designers should be aware of the type of commercial vehicle expected to be using the roundabout when considering the vertical grade (longitudinal) across the truck apron in addition to the vertical drop between the truck apron and circulatory roadway, as illustrated in Exhibit 7 and Exhibit 8.

The cross-fall within the circulating roadway cross section, with or without a truck apron, could also affect the stability of the commercial vehicle as it passes through the roundabout. According to Waddell et al 2009, the cab of the commercial vehicle and the trailer will experience different forces depending on the cross-fall provided. The trailer of commercial vehicles travelling around a roundabout with a truck apron and adverse cross-fall in the circulatory lane (sloping away from the central island) may experience significant lateral forces.

---


8 Federal Highway Administration, Roundabouts: An Informational Guide, Washington, D. C., p 151
As such, the slope of the truck apron and the cross-fall of the circulatory road should be examined carefully. Alternative designs include designing a circulatory roadway that has a crown profile, a banked circulating roadway (sloping inward towards the central island), or having an adverse cross-fall with no truck apron.

Exhibit 7: Longitudinal view of commercial vehicle with minimal ground clearance and truck apron

Exhibit 8: Cross section view of commercial vehicle with minimal ground clearance and truck apron (and an adverse cross-fall on the circulating roadway)

---


4. TREATMENTS THAT WILL ACCOMMODATE COMMERCIAL VEHICLES

Numerous modifications can be made that allow commercial vehicles to be accommodated within a roundabout while ensuring deflection for smaller vehicles. These include:

- Widened entry lanes
- Truck aprons
- Bypass lanes
- Gates for pass throughs

The modifications may only be used on a single approach or approaches where there is commercial traffic anticipated. Each of these are discussed in further detail below.

4.1 Widened entry and exit lane

At single-lane roundabouts with anticipated significant commercial vehicle traffic, commercial vehicle operators may require wider entry and exit lane to enter the roundabout. Extra turning space can be added by using hatching between entry and exit lanes, providing space for wider right turns. Hatching encourages smaller vehicles to make a tighter radius turn when entering and exiting the single-lane roundabout. Exhibit 9 shows an example of how a roundabout was modified to accommodate an oversize/overlength commercial vehicle by widening the entry and exit lane (but providing hatching as guidance for smaller vehicles).

Exhibit 9: Provision of widened entry and exit lanes in a roundabout (shown in yellow on the north and south approaches)

4.2 Truck aprons

As discussed in Section 3.3, truck aprons have been used to provide an additional paved area to allow off-tracking of commercial vehicles without compromising the deflection of smaller vehicles. Where aprons are used, they should be designed so that they are traversable by commercial vehicles, but discourage passenger vehicles from using them. A typical cross section of a roundabout with a truck apron is shown in Exhibit 10.
A truck apron may be used to provide an additional traversable area around the central island for large commercial vehicles, assisting with some movements. Truck aprons, though, provide a lower level of operation than standard non-mountable islands (with curbs) and should be used only when there is no other means of providing adequate deflection while accommodating the design vehicle. Truck aprons that are too aesthetic (e.g. with brick inlays) may be mistaken by some commercial vehicle operators as being non-traversable. As well, as indicated earlier, truck aprons may cause commercial vehicle instability or under-clearance problems.

### 4.3 Bypass lanes

While some road agencies have used a right-turn bypass lane as a design feature in a roundabout; they are generally seen as not being a desirable feature as they encourage higher speeds and are less safe for pedestrians and cyclists. However, they have been used in locations where the geometry for right turns is too tight to allow commercial vehicles to turn within the roundabout. The radius of the bypass lane will be larger than the entry and exit lane within the roundabout itself – but will encourage higher speeds among all vehicle types. An example of a roundabout with a bypass lane (where traffic in the bypass lane yields to traffic exiting the roundabout) is shown in Exhibit 11.

---


4.4 Gates for pass through traffic
A final treatment that has been used in roundabouts for accommodating oversize/overlength commercial vehicles is providing a gate / lane through the central island as illustrated in Exhibit 12. This has been used in Europe in situations where oversize/overlength commercial vehicles are required to travel through a roundabout on a recurring basis and due to space constraints and concerns with maintaining sufficient deflection, the road authority felt that the roundabout ICD could not be enlarged. Gates would be provided on either side of the central island and kept locked until such time that the oversize/overlength commercial vehicle is approaching the roundabout. While not aesthetically pleasing, the concept may be appropriate at large diameter roundabouts in industrial areas.

Exhibit 12: Pass through for oversize/overlength commercial vehicle (aerial image shown at top and street view shown at bottom)  

4.5 Design templates for single and multilane roundabouts

Single-lane roundabouts that have been designed to be accommodating of commercial vehicles, such as WB-20 commercial vehicles, will most likely require a truck apron and the entry lane and will need to be widened such as presented in Section 4.1 by means of hatched pavement markings.

The following design template shown in Table 2, has been provided as a starting point for designing a roundabout that should be able to accommodate a WB-20 commercial vehicle for all combinations of turns, assuming that the commercial vehicle operator may use the truck apron and the entry and exit lanes have been widened by means of hatched pavement markings. The designer should use AUTOTURN to confirm that the final design can accommodate a WB-20 commercial vehicle while still maintaining adequate deflection for passenger vehicles.

Multi-lane roundabouts typically do not require truck aprons, given the width of the circulatory roadway. The roundabout shown in Exhibit 4 (a multi-lane roundabout without lane markings) is an example of a roundabout that has been able to successfully accommodate commercial vehicles of all configurations up to an A-Train LCV. The following design template, shown in Table 3, is based on this roundabout. This multi-lane roundabout does not have a truck apron, given its large ICD, wide entry and exit lanes, and relatively large radius curves associated with the entry and exit lanes. It should be noted that the radius on the entry lanes and exit lanes vary widely due to the skewed nature of this roundabout – however, none of the turns investigated were problematic. The dimensions has been provided as a starting point for designing a roundabout that should be able to accommodate a WB-20 commercial vehicle or an A-Train LCV for all combinations of turns. The designer should use AUTOTURN to confirm that the final design can accommodate an A-Train LCV while still maintaining adequate deflection for passenger vehicles.

<table>
<thead>
<tr>
<th>Table 2 – Design template for a single lane roundabout that will accommodate a WB-20 commercial vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>Overall diameter (ICD)</td>
</tr>
<tr>
<td>Radius on entry lanes</td>
</tr>
<tr>
<td>Width of entry lanes (not including hatched pavement markings)</td>
</tr>
<tr>
<td>Width of entry lanes (including hatched pavement markings)</td>
</tr>
<tr>
<td>Radius on exit lanes</td>
</tr>
<tr>
<td>Width of exit lanes (not including hatched pavement markings)</td>
</tr>
<tr>
<td>Width of exit lanes (including hatched pavement markings)</td>
</tr>
<tr>
<td>Width of circulatory road</td>
</tr>
<tr>
<td>Width of truck apron</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3 – Design template for a multi-lane roundabout that will accommodate a WB-20 truck and an A-Train LCV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>Overall diameter (ICD)</td>
</tr>
<tr>
<td>Radius on entry lanes</td>
</tr>
<tr>
<td>Width of entry lanes</td>
</tr>
<tr>
<td>Radius on exit lanes</td>
</tr>
<tr>
<td>Width of exit lanes</td>
</tr>
<tr>
<td>Width of circulatory road</td>
</tr>
<tr>
<td>Width of truck apron</td>
</tr>
</tbody>
</table>
5. CONCLUSIONS

A number of existing intersections and roads in new developments have incorporated roundabouts as an alternative means of traffic control. Traffic engineers and designers have embraced roundabouts due to their superior safety and operational performance. As the number of roundabouts increases in Ontario, commercial vehicle operators will more and more be required to manoeuvre through them. However, the specific design features that make the roundabout attractive can be problematic to commercial vehicle operators. Failure to properly account for commercial vehicle traffic in their design has resulted in vehicle damage and damage to fixed objects associated with their design.

Given the increase in the use of roundabouts in Ontario, the Ontario Trucking Association sought to provide municipalities/road authorities with guidance on how commercial vehicles may be accommodated within roundabouts. This discussion paper has:

- Identified design elements that typically constrain the movement of commercial vehicles in roundabouts
- Identified minimum design parameters of single and multi-lane roundabouts that may accommodate commercial vehicles of varying configurations
- Identified features within a roundabout that will maintain desirable attributes while at the same time accommodate commercial vehicles

5.1 Investigation of existing roundabout designs

In order to determine how existing roundabouts in Ontario accommodate commercial vehicles, four different roundabout designs consisting of two single-lane and two multi-lane roundabouts were investigated. The review of the single and multi-lane roundabouts revealed a number of issues associated with the design of a roundabout and the ability of a commercial vehicle to negotiate through the roundabout unencumbered. In accommodating conventional WB-20 commercial vehicles (tractors with 53 foot trailers) and A-Train LCV truck configurations (tractors with twin 53 foot trailers), the review of the single lane roundabouts indicated that the path of the commercial vehicle would off-track over a curb or another fixed object due to:

- Narrow entry and exit lanes
- Tight radii associated with the entry and exit lanes
- The size of the central island and the truck apron

Overall, the multi-lane roundabouts fared better in accommodating WB-20 commercial vehicles, due to the overall larger diameter, the width of the entry and exit lanes and their larger radius, and the width of the circulatory road. One of the multi-lane roundabouts was able to accommodate both WB-20 and A-Train LCV truck configurations.

5.2 Best practices

In considering a roundabout in new construction or for replacing a conventional intersection, attention should be given to the amount of commercial traffic that is expected to be using the location and/or the surrounding land use characteristics. Anticipated use or existing use is typically seen as a legitimate measure in determining the design of a roundabout.
The largest motorized vehicle likely to use the intersection is considered to be the design vehicle. Generally speaking, the higher the classification of the roadway, the larger the design vehicle that should be used. Before beginning the design process, the designer must be conscious of the design vehicle and possess the appropriate vehicle turning templates (using a program such as AUTOTURN) to determine the vehicle’s swept path through the roundabout.

In designing single-lane roundabouts, the diameter of the roundabout is largely dependent upon the turning requirements of the design vehicle. The diameter must be large enough to accommodate the design vehicle while maintaining adequate deflection (curvature) to ensure safe travel speeds for smaller vehicles. The circulatory roadway width, entry and exit widths, entry and exit radii, and entry and exit angles of a roundabout also play a significant role in accommodating the design vehicle and providing deflection. Usually, the left-turn movement (270 degree turn) is the critical path for determining circulatory roadway width. A minimum clearance of 1.0m should be used between the path of the design vehicle and any fixed object.

No specific guidance was found in the literature regarding the width of the circulatory roadway for multi-lane roundabouts. While logic would dictate that the design should ensure that a passenger vehicle and a commercial vehicle (e.g. a WB-20 design vehicle) should be able to proceed into and through the roundabout side-by-side without coming in contact with each other, this would lead to the (inscribed circle diameter) ICD or the width of the circulatory roadway being excessively wide, leading to additional cost, less deflection (for smaller vehicles) and a diminished safety performance. A more appropriate response would be to ensure that design allows for two passenger vehicles to make this manoeuvre without conflict and assume that the commercial vehicle would use the entire circulatory roadway and other vehicles would give way. The designer may consider not providing circulatory lane markings within roundabouts that are used by a significant number of commercial vehicles to avoid any confusion with motorists attempting to enter the roundabout at the same time as a commercial vehicle.

Vertical design elements can be equally important to providing a roundabout that is able to accommodate commercial vehicles safely. The cross section of the circulatory roadway and the truck apron will affect the available ground clearance in addition to overall commercial vehicle stability. Where aprons are used, they should be designed so that they are traversable by commercial vehicles, but discourage passenger vehicles from using them. Designers should be aware of the type of commercial vehicle expected to be using the roundabout when considering the vertical grade (longitudinal) across the truck apron in addition to the vertical drop between the truck apron and circulatory roadway.

The cross-fall within the circulating roadway cross section, with or without a truck apron, could also affect the stability of the commercial vehicle as it passes through the roundabout. The trailer of commercial vehicles travelling around a roundabout with a truck apron and adverse cross-fall in the circulatory lane (sloping away from the central island) may experience significant lateral forces. As such, the slope of the truck apron and the cross-fall of the circulatory should be examined carefully.
5.3 Treatments
Numerous modifications can be made that allow commercial vehicles to be accommodated within a roundabout while ensuring deflection for smaller vehicles. These include:

- **Widened entry and exit lanes** - On single-lane roundabouts with anticipated significant commercial vehicle traffic, commercial vehicle operators may require wider entries to enter the roundabout. Extra turning space can be added by using hatching within the entry and exit lanes providing space for wider right turns.

- **Truck aprons** - Used on the central island to provide an additional paved area to allow off-tracking of commercial vehicles without compromising the deflection of smaller vehicles. Where aprons are used, they should be designed so that they are traversable by commercial vehicles, but discourage passenger vehicles from using them.

- **Bypass lanes** – Used to allow commercial vehicles to entirely bypass the roundabout, passing through a larger radius curve.

- **Gates for pass through traffic** – Used to provide a means by which an oversize/overlength commercial vehicle can pass entirely through the central island.

The modifications may only be used on a single approach or multiple approaches where there is commercial traffic anticipated.

5.4 Design templates
Design templates have been provided in Section 4.5 of this discussion paper for a single and multi-lane roundabout. They contain dimensions based on existing designs and may be used as a starting point for designing a roundabout that accommodates commercial vehicles.

The designer should use AUTOTURN or similar software to confirm that the final design can accommodate the desired commercial vehicle while still maintaining adequate deflection for passenger vehicles.