Transportation Association of Canada

Truck Lanes in Canadian Urban Areas

RESOURCE DOCUMENT

July 2014

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Abstract

Truck lanes are defined as a lane for preferential truck use where trucks are separated from other traffic either through physical or operational treatments. The purpose of these lanes is to reduce travel time, improve system reliability and safety, and reduce emissions in the movement of goods in urban areas.

This document is intended to assist transportation professionals to make more informed decisions regarding the potential use of truck lanes in Canadian urban areas. It is based on the findings of a literature review, stakeholder interviews, and analyses of various truck lane configurations in different Canadian cities conducted specifically for this document.

Truck lanes are a relatively new concept and there is little information about them, particularly for Canadian urban areas. The document identifies eight truck lane types and describes case studies in Canadian cities for six of these types to reveal new planning, design, operation, analysis, and evaluation considerations for urban truck lanes in Canada. The document finds many critical knowledge gaps regarding truck lanes and recommends research and next steps to address these gaps.

Keywords

- Efficiency
- Goods Movement
- Lorry
- Planning
- Safety
- Traffic Lane
- Urban area

Supplementary Information

Detailed findings from the literature review and stakeholder interviews are contained in the Truck Lanes in Canadian Urban Areas: Technical Report, which is provided as an attachment to the Resource Document.

GUIDANCE TO USERS

The Truck Lanes in Canadian Urban Areas Resource Document is intended to assist transportation professionals to make more informed decisions regarding the potential use of truck lanes as a tool for efficient sharing of facilities by all road users in Canadian urban areas. This document is specific to the Canadian context in terms of population, traffic volumes, truck traffic volumes, truck configurations, and urban roadway design and operation. It does not address the structural or geometric design of truck lanes.

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CHAPTER 1 – INTRODUCTION

1.1 PURPOSE OF THE RESOURCE DOCUMENT

The Resource Document is intended to assist transportation professionals to make more informed decisions regarding the potential use of truck lanes as a tool for efficient sharing of facilities by all road users in Canadian urban areas. It is specific to the Canadian context in terms of population, traffic volumes, truck traffic volumes, truck configurations, and urban roadway design and operation. It does not address the structural or detailed geometric design of truck lanes. This document may also be of value to stakeholders from the goods movement industry and academia.

The Resource Document is based on the findings of a literature review, stakeholder interviews, and analyses of various truck lane configurations in different Canadian cities conducted specifically for this document. The findings from the literature review and stakeholder interviews are contained in the *Investigating the Potential for Truck Lanes in Urban Areas Technical Report*, provided as an attachment to this document. The truck lane analyses are contained in Appendices A to F.

1.2 DEFINITIONS

The following definitions define the scope of this document.

Urban Truck Lane: This is a lane for preferential truck use where trucks are separated from other traffic either through physical or operational treatments. The purpose of these lanes is to reduce travel time, improve system reliability and safety, and reduce emissions in the movement of goods in urban areas.

Truck: This is a freight carrying vehicle with at least six tires and that is regulated by truck size and weight laws.

Urban: The term “urban” used in this document is flexible and generally refers to areas that are, or are expected to be, built-up. This document investigates the potential of truck lanes in Canadian urban areas. This excludes rural areas and implementation of truck lanes on rural highways.

1.3 ACCOMMODATING TRUCKS IN URBAN AREAS

Truck transportation is vital to the economic development of a region—effectively all economic endeavours are connected by trucks. However, sometimes these vehicles are not properly accommodated in road planning, design, operations, and management due to insufficient understanding that exists about their accessibility requirements, operational performance characteristics, interactions with other road users, and their general importance for the prosperity of a jurisdiction and its residents. In urban areas, lack of appropriate truck accommodation, coupled with an increase in the demand for freight movement by trucks, gives rise to productivity losses for the trucking industry, and to negative social effects due to congestion, delay, safety concerns, and emissions.

The accommodation of trucks in urban areas requires a balanced approach for giving trucks appropriate priority throughout the infrastructure planning, design, operation, and management phases, while recognizing the multimodal nature of urban transportation systems.

. . . often trucks are improperly accommodated in road planning, design, operations, and management due to insufficient understanding about their needs, benefits, and performance characteristics.

Truck lanes can be used as a treatment—or series of treatments—that can help improve truck travel time, reliability, safety, and reduce emissions. However, these types of lanes should be viewed as one component of a much broader group of treatments and policies that can be used to achieve these performance outcomes. As depicted in Figure 1, general approaches for accommodating trucks in urban areas fall along a continuum ranging from those that are "truck-preferential," to those that are "truck-friendly," to those that are "truck-ignorant." The planning, design, operation, and management phases may each be categorized as using one of these approaches. Within this framework, truck lanes occur primarily within the "truck-preferential" domain.

The following sections further explain the range of "truck-friendly" options in terms of planning, design, operations, and management. The purpose is to emphasize that truck-friendly treatments have the potential to adequately improve truck travel time, reliability, safety, and emissions and should be considered prior to implementing truck lanes.

1.3.1 Planning Phase

Truck accommodation in urban areas begins with land use and transportation planning activities that account for current and future demand for goods movement and help locate truck-intensive developments in areas that are appropriate within the context of community objectives. For example, the development of major truck generators or attractors—such as intermodal facilities or commercial and industrial zones—requires planning for and protection of corridors and routes that efficiently accommodate truck traffic in ways that are compatible with the needs of transit, pedestrians, passenger vehicles, and railroads. Importantly, many of these types of developments do not occur exclusively within the control of an urban area government, but are rather influenced or completely controlled by external stakeholders. In these situations, close stakeholder collaboration at the planning stages helps promote appropriate accommodation of truck traffic.

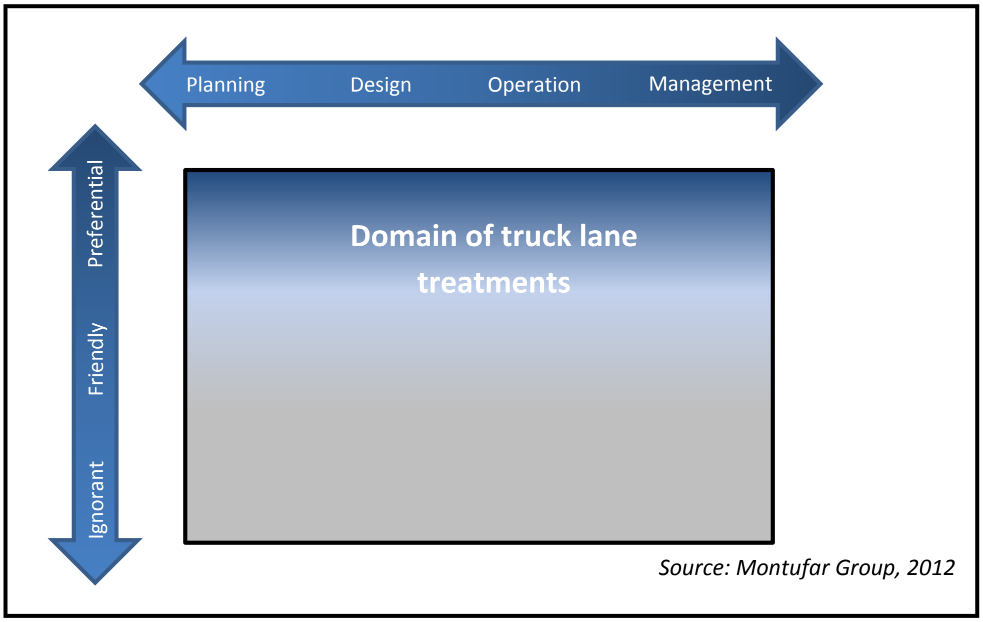

Figure 1: A framework for accommodating trucks in urban areas

1.3.2 Design Phase

Truck-friendly infrastructure design involves the specific elements of the roadway and right-of-way, and the design of sites to which trucks require access. The operational characteristics of trucks are fundamentally different from those of passenger vehicles, and necessitate explicit accommodation in the design phase. Prominent examples of these include accommodation of acceleration and deceleration capabilities through the design of longer merge and deceleration lanes, accommodation of vehicle off-tracking through wider curb radii, provision of vertical grades and clearances which can be safely navigated by trucks, and implementation of pavements and bridges with appropriate structural capacity. Site access for trucks is particularly important for rail intermodal terminals, cross-docking and transload facilities, marine and air terminals, and major commercial retail zones and industrial parks.

1.3.3 Operations Phase

Operational treatments may include the coordination of traffic signal timing with the acceleration and deceleration capabilities of heavy trucks, provision of adequate way-finding signage for trucks navigating a truck route network, or implementation of truck-specific intelligent transportation systems (ITS) solutions such as automated over-height vehicle warning systems.

Off-tracking on left turn

1.3.4 Management Phase

Truck-friendly management of transportation infrastructure develops policies and regulations that recognize the fundamental role of trucking in urban areas, including its potential benefits and costs.

For example, policies and regulations that govern truck route identification and management, allowable truck weights and dimensions, and temporal restrictions on truck operations are potential levers that can improve the accommodation of trucks in urban areas.

Truck lanes are potential treatments beyond the truck-friendly domain. However, truck-friendly treatments may be able to address most or all of the issues that truck lanes can address because they form part of a series of options that are intended to specifically accommodate trucks in road engineering. Accordingly, truck lanes should be considered only after all truck-friendly treatments have been explored and implemented.

1.4 UNIQUE FEATURES OF CANADA'S URBAN CONTEXT

Canada is a large country with a relatively small population, mainly spread along the border with the U.S. Its commodity flows, trucking population, and truck traffic movements operate principally under uncongested circumstances. The country has few large urban centres and many medium and smaller centres spread throughout its territory, and each of these centres has different priorities and constraints with respect to provision of urban infrastructure.

Generally, Canadian urban roads have between two and four lanes per direction although some exceptions exist. In addition, basic truck size and weight regulations in Canada allow for larger, heavier trucks than those in its largest trading partner, the U.S., and many Canadian urban jurisdictions routinely allow longer combination vehicles (LCVs) on specified road networks.

Most of the road system and most trucks operating in Canada are under the regulatory control and influence of provinces and some of the larger urban areas. Federal authority is limited and there is no highway network similar to the U.S. Interstate Highway System (rurally or in urban areas), nor are there infrastructure funding mechanisms such as those used in the U.S. for state or federal roads. Although there are exceptions to these generalizations, the scale of issues that truck lanes are addressing in the U.S. are different than the scale in Canada.

1.5 CONTENT OF THE RESOURCE DOCUMENT

The Resource Document is divided into five chapters:

Chapter 2 – *Truck Lanes in Urban Areas* provides an overview of truck lanes in urban areas. The chapter addresses the following topics related to urban truck lanes: (1) function and types of urban truck lanes; (2) benefits and costs; (3) challenges; and (4) current practice. The purpose of this chapter is to provide background information about truck lanes, explain why they should be understood and considered, and introduce a new perspective on truck lanes specifically for Canadian urban areas to set the context for the rest of the Document. The content of this chapter is primarily derived from the Technical Report.

Chapter 3 – *Case Studies* summarizes in-depth urban truck lane analyses conducted for six urban areas in Canada. This chapter characterizes the transportation system for each case study, including transportation supply, demand, and performance and reveals specific urban truck lane considerations for each situation. The purpose of this chapter is to identify considerations that are not available in the literature and which apply to small to large cities across Canada. Appendices A to F contain full details for each Case study. The content of this chapter is based on the case studies conducted specifically for this document.

Chapter 4 – *Considerations for Implementing Urban Truck Lanes* discusses important issues to consider prior to considering truck lanes as an option, during the planning, design, and operational phases, and for analyzing and evaluating their performance. This chapter integrates the findings from the Technical Report and the case studies in the appendices.

Chapter 5 – *Summary and Conclusions* synthesizes major planning, design, operation, and evaluation considerations for urban truck lanes in Canada based on the Technical Report and case studies. It identifies future research areas to address key knowledge gaps and provides practical next steps to continue advancing the concept of truck lanes in Canada.

The *Truck Lanes in Canadian Urban Areas Resource Document* is accompanied by the *Investigating the Potential for Truck Lanes in Canadian Urban Areas Technical Report* (provided as an attachment to this document) and by case studies in the appendices to this document. The Technical Report provides professionals with extensive material which is used as background for the creation of the Resource Document (see Table 1 for content of the Technical Report). The case studies provide detailed analysis of truck lanes in Canadian urban areas. Reference to the Technical Report and case studies is strongly recommended.

Table 1: Topics included in the Technical Report

1.0	**INTRODUCTION**	
	1.1	Purpose
	1.2	Background and Scope
	1.3	Approach and Methodology
	1.4	Technical Terminology
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	2.1	Separation of Trucks and General Traffic
	2.2	Truck Lane Design
	2.3	Truck Lane Operations
3.0	**TRUCK LANE IMPLEMENTATION CONSIDERATIONS**	
	3.1	Decision Inputs and Thresholds
	3.2	Potential Challenges Associated with Truck Lanes
	3.3	Perceptions About Truck Lanes
	3.4	Alternative Treatments
	3.5	Stakeholder Interview Findings
4.0	**TRUCK LANE PERFORMANCE**	
	4.1	Travel Time
	4.2	Reliability
	4.3	Safety
	4.4	Emissions
	4.5	Stakeholder Interview Findings
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	5.1	Travel Time
	5.2	Reliability
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	5.4	Emissions
	5.5	Costs and Tolls
	5.6	Stakeholder Interview Findings
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8.0	**BIBLIOGRAPHY**	

CHAPTER 2 – TRUCK LANES IN URBAN AREAS

This chapter provides an overview of truck lanes in urban areas including background information about truck lanes, rationale for their consideration, and a new perspective on truck lanes specifically for Canadian urban areas. It addresses the function and types of urban truck lanes, their benefits and costs, operational challenges, and current practice around the world.

2.1 FUNCTION AND TYPES OF URBAN TRUCK LANES

The purpose of truck lanes is to reduce travel time, improve system reliability and safety, and reduce emissions in the movement of goods in urban areas. The Resource Document defines an urban truck lane as a lane for preferential truck use where trucks are separated from other traffic either through physical or operational treatments. The intent of this definition is to include treatments of various scales that are relevant to the Canadian urban context—from a lane-specific treatment extending for several blocks on an arterial street to a truck-only road. It also emphasizes that trucks have the option to use truck lanes while other vehicles are restricted from using them.

In many jurisdictions and most research, truck lanes are viewed as large-scale solutions where trucks are physically separated from general traffic, though not always for providing a preferential treatment for goods movement. Truck lanes can be separated using physical barriers (e.g., Jersey barriers, grade separation) or operational measures (e.g., rumble strips, signage, and paint striping). Physically-separated truck lanes are sometimes referred to as exclusive truck lanes or barrier-separated truck lanes and restrict other vehicles from using these lanes. Operationally-separated truck lanes are sometimes referred to as non-exclusive truck lanes or buffer-separated truck lanes and allow other vehicles to weave through truck lanes to enter or exit the roadway. Truck lanes can also be separated temporally. In these cases, general purpose lanes (GPLs) are available to all vehicles during specified hours of the day (usually peak periods) and during other hours, one of the GPLs is restricted for truck use only.

Table 2 describes the options within the spectrum of truck lanes, beginning with those that are most "truck-preferential." The table indicates whether the treatment option is physically or operationally-separated and provides some Canadian examples of situations in which the treatment option has been implemented or considered through planning and analysis.

Table 2: The spectrum of truck lane treatment options

Treatment description	Type of separation	Example application in Canada
Physically-separated truck lanes on freeways: Lanes that physically separate truck lanes from general purpose lanes by constructing barriers or grade-separated structures.	Physical	None in Canada
Truckway to a major freight generator: An exclusive road for trucks to access a major freight origin or destination, e.g., rail intermodal terminals, marine terminals, truck staging areas, or a large industrial park. Though the intent of the truckway is to be truck-exclusive, in practice it may also be used by employees of the freight facility being accessed.	Physical	Halifax, NS (planning study)
Truck bypass: A facility that removes trucks from potential traffic bottlenecks such as merge areas at interchanges, access/egress ramps, or congested urban street systems.	Operational or physical	Waller St, Ottawa, ON (implemented)
Operationally-separated truck lanes on freeways: These are mainline lanes that are not physically-separated. These lanes are operationally separated using traffic control treatments (e.g., rumble strips, paint striping, signage) or special policies. Operational separation may only be in effect for certain periods.	Operational	Highway 401, Toronto, ON (research study)
Truck lanes on major arterials: Lanes that provide operational separation for trucks and general traffic on urban arterials that service large truck volumes. They may permit transit operations (ideally with bus pullouts) or use a lane which is designated as a parking lane during certain times of the day.	Operational	Waller St, Ottawa, ON (implemented)
Truck climbing lanes*: Lanes that separate slow-moving trucks from mainline traffic by providing an extra outside lane along sustained upgrades. This treatment typically occurs in rural areas but may be applicable in certain urban areas.	Operational	Highway 405 at Queenston-Lewiston Ontario border crossing (implemented)
Truck lanes at border crossings*: Lanes approaching ports-of-entry to separate trucks and cars to facilitate the different types of security and screening activities.	Operational or physical	Fort Frances, ON / International Falls, MN (implemented)
Truck routes for specially-permitted vehicles: Some routes in Canadian cities permit access for specially-permitted higher productivity vehicles, such as longer combination vehicles. These vehicles require special consideration in the urban context. As such, they are typically permitted only on certain routes during certain temporal periods. This approach is a form of operationally-separating larger vehicles from general traffic, particularly at times and places where their interaction is perceived to be potentially detrimental.	Operational	LCV routes in Winnipeg, MB (implemented)

* Truck climbing lanes and truck lanes at border crossings are not included in this document. Current design and operation of truck climbing lanes represent a truck-friendly treatment; however, innovations could lead to these lanes operating as preferential treatment for trucks. Truck lanes at border crossings apply to only a few situations in Canada - they require special attention for these locations are not suitable for inclusion in a national document.

2.2 BENEFITS AND COSTS OF URBAN TRUCK LANES

The literature and stakeholders generally agree that the primary and direct benefits of truck lanes are travel time savings, reliability improvements, safety improvements, and emission reductions. Increased truck productivity by improving longer and heavier truck access into a city is also sometimes included as a benefit. Some research finds that secondary and indirect benefits of truck lanes can be experienced by other road users. For example, separating trucks and cars can potentially increase capacity for general purpose lanes (GPLs) and reduce the probability of collisions between cars and trucks.

Benefits of truck lanes are travel time savings, reliability improvements, safety improvements, and emission reductions.

Costs are infrastructure-related.

Current methods and data for estimating truck lane benefits are inadequate. Consequently, the value of these benefits is highly variable and in many cases unknown. These benefits are primarily attributed to road users and must be converted into monetary terms in order to conduct a benefit-cost analysis. For this, it is necessary to know the value of time associated with the freight movement task, changes in collision frequency and severity resulting from truck lanes, changes in travel speed and the impact on emissions, and changes in truck productivity.

The value of time for trucks varies by truck type (single unit, articulated), commodity, truck operation (truckload, less-than-truckload, owner-operator, for-hire, private), trip type (long-distance/rural, drayage/urban), late delivery penalties, driver remuneration type (hourly, by trip, mileage), and others. The literature provides hourly value of time estimates for the following truck types and operations: for-hire, private, straight truck, articulated truck, drayage movements, and "average truck." These estimates range from $24.00 per hour to $45.50 per hour in the U.S. (2010 USD). In the Canadian context these figures would likely be different but not by much.

There is no conclusive evidence regarding the impact of truck lanes on collisions. Current information is either borrowed from truck restriction studies or derived from simulation modelling results. Truck restrictions are different from truck lanes since they still allow truck-car interaction and do not capture the safety effects of separating these vehicles. Modelling uses vehicle conflicts as a surrogate for estimating collision frequency and cannot determine collision severity or account for single-vehicle collisions.

Emissions are partly a function of engine type and travel speed. These variables are difficult to quantify in any emissions analysis and also apply when estimating the emission reduction benefits of truck lanes. Traffic simulation modelling can provide some information about travel speed changes resulting from implementing truck lanes, but data is unavailable to determine the distribution of engine types along specific corridors.

The costs of truck lanes are the associated capital, operational, and maintenance costs. These costs are typically distributed among infrastructure providers (i.e., government agencies). They vary by jurisdiction and are often specific to individual projects. Although each jurisdiction routinely estimates these costs, developing nationally-representative costs for use in this document is neither feasible nor practical.

Referring to the literature to address urban truck lane performance in terms of their benefits and costs is problematic for several reasons. First, there have been few truck lane benefit-cost analyses performed. Second, the performance benefits of truck lanes vary between studies and are based on insufficient data. Third, assumptions for monetizing these varying benefits also differ widely between studies. Finally, the costs associated with implementing truck lanes are highly dependent on the jurisdiction and are specific to individual projects.

2.3 CHALLENGES ASSOCIATED WITH URBAN TRUCK LANE OPERATION

Underutilization of truck lanes is a major risk and potential limitation. Truck lane utilization is dependent on many factors, especially the trade-off between mobility and accessibility. The literature indicates that truck lanes perform best in terms of mobility (i.e., reducing truck travel time, improving reliability, and decreasing vehicle conflicts) when they are physically separated from other lanes and minimize accessibility (i.e., minimize entry and exit points to the lane). Conversely, mobility benefits of truck lanes decrease as accessibility increases. Minimal accessibility may be necessary to accommodate through truck movements; however, if truck lanes are designed to accommodate urban truck traffic (as is the case in this document), adequate accessibility is critical. Therefore a balance is required: adequate accessibility must be provided to accommodate the routing needs of urban trucks without degrading the mobility benefits to the point where the truck lane is no longer attractive for trucks. To achieve this balance and mitigate the risk of truck lane underutilization, operationally-separated truck lanes with appropriate temporal restrictions may be the preferred approach.

Truck-car interaction and weaving are concerns associated with urban truck lanes. Truck lanes provided in the inner lanes require trucks to perform additional lane changes to access them compared to outer truck lanes. However, outer truck lanes require cars to weave between trucks to enter or exit a facility (refer to Section 4.2.1 for more detail). Both truck lane configurations have the potential to increase truck-car interaction which can have negative safety and mobility consequences. Limiting access to the truck lane through physical separation can reduce these interactions but can also reduce truck lane utilization.

Truck lane sign

Right-of-way requirements for physically-separated truck lanes and truck traffic volumes required for their implementation are another limitation. The literature consistently recommends providing at least two truck lanes per direction for physically-separated truck lanes for passing and navigating around out-of-service trucks. Truck traffic volumes typically are not high enough to warrant four lanes dedicated to trucks. The literature argues that constructing an additional four general purpose lanes would significantly outperform the addition of four truck lanes. Furthermore, most Canadian urban areas do not have adequate right-of-way available to support the construction of physically-separated truck lanes, particularly at interchanges.

Allowing trucks to use bus lanes (i.e., no-car lanes) or high-occupancy vehicle (HOV) lanes during off-peak hours has limitations to consider. According to the literature and stakeholder interviews, no-car lanes may only be feasible on corridors with low bus volumes, but corridors with low volumes are unlikely to have bus lanes. There is also hesitation from industry about sharing a lane with frequently stopping buses. Allowing trucks to use HOV lanes during off-peak hours may not benefit trucks since roads are typically uncongested during off-peak periods.

2.4 CURRENT PRACTICE INVOLVING URBAN TRUCK LANES

Truck lanes are a relatively new concept—the environmental scan identified six research studies conducted, eleven planning studies completed, and seven truck lanes implemented worldwide in both urban and rural environments. Valuable lessons can be learned from these efforts, particularly from operational truck lanes or truck lane planning studies. Table 3 provides an inventory of the state of truck lanes by truck lane type. Of the 24 truck lanes that have been researched, studied, or implemented, 14 are applicable to Canadian urban areas. The applicability is largely based on the scale of the truck lane (in terms of road infrastructure and traffic volumes) and whether it operates in an urban or rural environment. A summary of each truck lane applicable to Canada is provided in the Technical Report.

Table 3: State of truck lanes

Description	Physically-separated truck lane on freeway	Truckway	Truck bypass	Operationally-separated truck lane on freeway	Truck lane on arterial	Truck route for specially-permitted trucks	Rural environment	Urban environment	Applicable to Canadian urban areas
Truck lanes that have been implemented									
Waller Street in Ottawa			✓		✓			✓	✓
South Boston Bypass[1]		✓						✓	✓
New Orleans Clarence Henry Truckway[1]		✓						✓	✓
Tampa Bay Crosstown Connector[2]	✓							✓	✓
Newcastle no-car lanes[3]					✓			✓	✓
Rotterdam A16 and A20 motorways[4,5]				✓				✓	✓
Los Angeles I-5 truck bypass lanes			✓				✓		
Truck lane planning studies									
Halifax truck lanes[6,7,8]		✓						✓	✓
Los Angeles I-710 / SR-60[9,10]	✓							✓	✓
Chicago Mid-City Freightway[11,12]		✓						✓	✓
I-70 corridor[13,14]	✓						✓		
California I-15 corridor[15]	✓						✓		
Atlanta truck-only toll lanes[16]	✓			✓			✓		
Trans-Texas corridor	✓						✓		
Virginia I-81 corridor[17]	✓						✓		
I-10 corridor[18]	✓						✓		
I-35 corridor	✓						✓		
France A86 tunnel	✓						✓		
Truck lane research									
Highway 401 truck lanes in Toronto[19,20,21,22]	✓			✓				✓	✓
Florida truck facilities[23]	✓			✓			✓	✓	✓
NCFRP Report 3[24]	✓						✓	✓	✓
Winchester no-car lanes[25]					✓			✓	✓
Battelle truck lane research[26,27]	✓			✓			✓	✓	✓
Reason Foundation truck lanes[28]	✓						✓		

Please refer to Endnotes on page 105 for sources of information. The Technical Report contains detailed descriptions for each truck lane example that is applicable to Canadian urban areas.

Table 4 rates the performance of truck lanes that have been implemented or studied and that are relevant to Canadian urban areas. For each example, performance is assessed based on findings from technical reports or discussions with agencies responsible for their operation.

Table 4: Influencing factors for truck lane performance in planning studies or in operation, relevant to Canadian urban areas

Description	Truck lane type	Performance rating	Influencing factors for performance rating
Waller St, Ottawa	Truck bypass/ Truck lane on arterial	★★★	• Objective of lane is queue reduction at intersection to help buses • Separating trucks from other vehicles ensures that accelerating characteristics of trucks are constrained to a single lane • Improved highway access for trucks originating in the urban area
South Boston Bypass	Truckway	★★★	• Constructed within abandoned rail ROW • Mostly grade-separated intersections • Length of truck lane is 2.5 km connecting a major highway to a port, airport, and industrial area • Portion of truckway through residential area is depressed below grade
Clarence Henry Truckway, New Orleans	Truckway	★★★	• Relatively long (9 km) connector from a major highway to a port • Diverts trucks away from sensitive areas • Truckway pavement structure is designed for heavy trucks
Tampa Bay Crosstown Connector	Physically-separated truck lane on a freeway	N/A	• Scheduled for completion by the time this study is published in 2013, but information is unavailable at the time of this writing
A16 and A20 motorways, Rotterdam	Operationally-separated truck lane on a freeway	N/A	• Insufficient data and analysis to assess performance
Halifax truck lanes	Truckway	★	• Cost of implementing a unidirectional truck lane within rail corridor is relatively low but benefits are lower than this cost • Benefits of implementing a bidirectional truck lane within rail corridor are high but the cost is higher
I-710/SR-60, Los Angeles	Physically-separated truck lane on a freeway	★	• Insufficient ROW along I-710 corridor requires truck lanes to be elevated and therefore cost prohibitive • Trucks travel short distances along SR-60 and require access to truck lanes at each interchange which is cost prohibitive • Despite the potential for significant travel time and reliability improvements, the high cost of truck lane construction and operation cannot be adequately recovered by tolls
Chicago Mid-City Freightway	Truckway	★	• Public opposition to additional traffic through their neighbourhood (truck or car) prevented this idea from moving beyond the conceptual phase
No-car lanes, Newcastle, U.K.	Truck lane on arterial	★★	• No new construction required • Low bus volumes (bus headways greater than 3 minutes) • No-car lanes are too short (e.g., less than a city block) • Increased vehicle interactions at intersections due to cars merging into no-car lanes to perform turning movements • Various managed lanes with different operating rules/restrictions

★★★ Highly successful ★★ Moderately successful ★ Unsuccessful N/A Unknown performance

Overall, the experience with truck lanes in the literature reveals the following:

- There is limited information available for truck lanes.
- Most research and planning studies pertain to physically-separated truck lanes on freeways.
- Information about truck lanes other than physically-separated lanes on freeways is lacking.
- The cost of constructing new truck lanes generally exceeds benefits derived from these lanes.
- Truck lanes other than physically-separated lanes on freeways appear most feasible.

CHAPTER 3 – CASE STUDIES

The *Investigating the Potential for Truck Lanes in Urban Areas Technical Report* reveals truck lane issues primarily concerning U.S. experience outside of urban areas. Because of insufficient knowledge regarding truck lanes in Canadian urban areas, six case studies were conducted for the Resource Document. These case studies are not intended to recommend these treatments at the selected locations, but rather, they were conducted as examples to reveal issues that should be considered in the possible implementation of truck lanes in Canadian urban areas. The six case studies were selected to include: (1) the various geographic areas of the country; (2) small, medium and large urban areas; and (3) different truck lane treatment options. Table 5 shows the selected locations for the six case studies.

Because there is only one existing example of a truck lane in Canada, it was determined that these case studies be presented using the transportation systems analysis approach. This approach characterizes the existing transportation supply and demand at each of the selected sites, and concludes by bringing forward issues that need to be considered by transportation professionals in the implementation of urban truck lanes given the existing combination of supply and demand and traffic flow.

Table 5: Case study locations

Case Study	Truck Lane Type	Location/ Selected Site	Geographic Area	Jurisdiction Size
1	Physically-separated truck lanes on freeways	Greater Toronto Area Highway 427	Central	Large
2	Truckways to major freight generator	Regina Global Transportation Hub	West	Small
3	Truck bypass	Ottawa Waller St	Central	Medium
4	Operationally-separated truck lanes on freeways	Calgary Glenmore Tr	West	Medium
5	Truck lanes on major arterials	Vancouver Knight St/Clark Dr	West	Large
6	Truck route for specially-permitted vehicles	Moncton Various roads	East	Small

Figure 2 shows the approach followed for the completion of the case studies. This figure illustrates a dynamic interrelationship between the supply, demand, and resulting flows in an area. Over time, and with changes in supply and/or demand, a new system is created, with a new interrelationship between these elements.

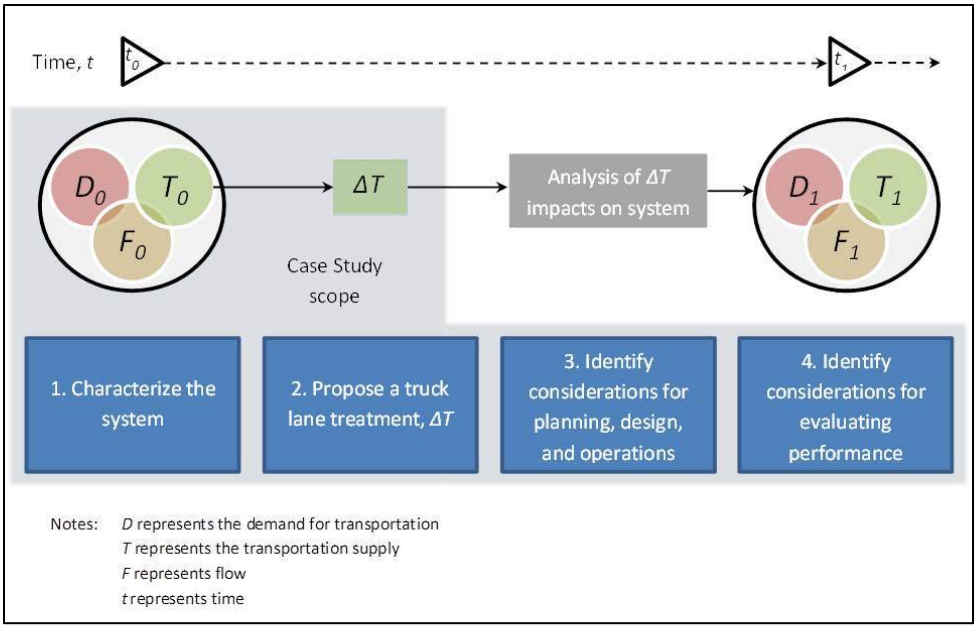


Figure 2: Transportation systems analysis approach and case study scope
Source: Adapted from Manheim (1979)

The transportation system (T) represents the supply and is characterized by the types of vehicles using a facility, technologies, network types, links, system operating policies, and organizational policies. The demand system (D) represents all the social, economic, political, and other transactions occurring over space and time in a particular region. Specific aspects of the demand system for the case studies include: types of commodities moved, origin-destination patterns, industries and shippers, and land use. The flow system (F) is a function of both the transportation system and the demand system and measures the quantity of freight and vehicular movements, temporal and directional distributions of freight movement, the resources they consume, and the level of service experienced by these movements. Demand and flow characteristics overlap occasionally and the distinction between these two elements is sometimes difficult to discern. In the case studies, examples of flow system elements include: truck volumes by type, temporal and directional distribution of truck flows, and travel times along a corridor.

Normally the four steps of the transportation systems analysis in Figure 2 are executed sequentially. However, the order of the steps for the case studies in this document are modified and in some instances conducted iteratively. This reflects the purpose of the case studies which is to reveal issues that should be considered in the possible implementation of truck lanes rather than conclude with a recommendation for implementing a truck lane.

Figure 2 also illustrates the scope of the case studies in this document (shown in the shaded grey area of the figure). Steps 1 and 2 are performed in their entirety and only parts of Steps 3 and 4 are completed. In this document, a truck lane treatment is proposed for a specific location (Step 2) followed by the characterization of the transportation system of this location (Step 1). In Step 3, truck lane impacts should be analyzed with the aid of microsimulation tools. The results of this analysis are then used in Step 4 to evaluate T, D, and F at a specified time in the future, t_1.

Developing microsimulation models to characterize the transportation system after implementing truck lanes is beyond the scope of the Resource Document. Rather, the case studies use Steps 3 and 4 to reveal issues and challenges associated with truck lanes and identify appropriate considerations to evaluate their performance. The results of Steps 3 and 4 in this document provide valuable information and insight for transportation planners and engineers when considering truck lanes as an option, analyzing truck lane operations, and evaluating truck lane performance.

The following sections describe the location, site, and the type of truck lane analyzed for the six case studies. Important characteristics of the transportation system as they pertain to truck lanes are highlighted and principal considerations for the potential of trucks lanes in urban areas are revealed. The users of the Resource Document can extract knowledge and lessons learned from each of these case studies and apply them in their own jurisdiction as appropriate. Detailed transportation systems analyses for each case study are provided in Appendices A to F.

3.1 PHYSICALLY-SEPARATED TRUCK LANE ON A FREEWAY

Physically-separated truck lanes on freeways are lanes that are physically separated from general purpose lanes using barriers or grade-separated structures. Highway 427 between Highway 401 and Major Mackenzie Dr in the Greater Toronto Area (GTA) was selected as the location to analyze this type of truck lane. Part of this segment (between Zenway Blvd and Major Mackenzie Dr) is still in the planning stage.

SITE DESCRIPTION

Highway 427 is a provincial freeway that has freeway interchange connections with Queen Elizabeth Way (QEW), Highways 401, 409, and 407 Express Toll Route (ETR). This highway facilitates large truck traffic volumes by providing direct access to Pearson International Airport, and feeding the largest intermodal facilities in Canada – CN Brampton and CP Vaughan.

The segment in this example is proximate to the regions of Peel and York and the cities of Mississauga, Brampton, Toronto, and Vaughan. About one-third of the GTA's manufacturing and industrial activity occurs in this area. There are plans to extend Highway 427 from Zenway Blvd to CP Vaughan. This extension will run through the proposed Vaughan Enterprise Zone which is planned to contain major manufacturing and distribution centres.

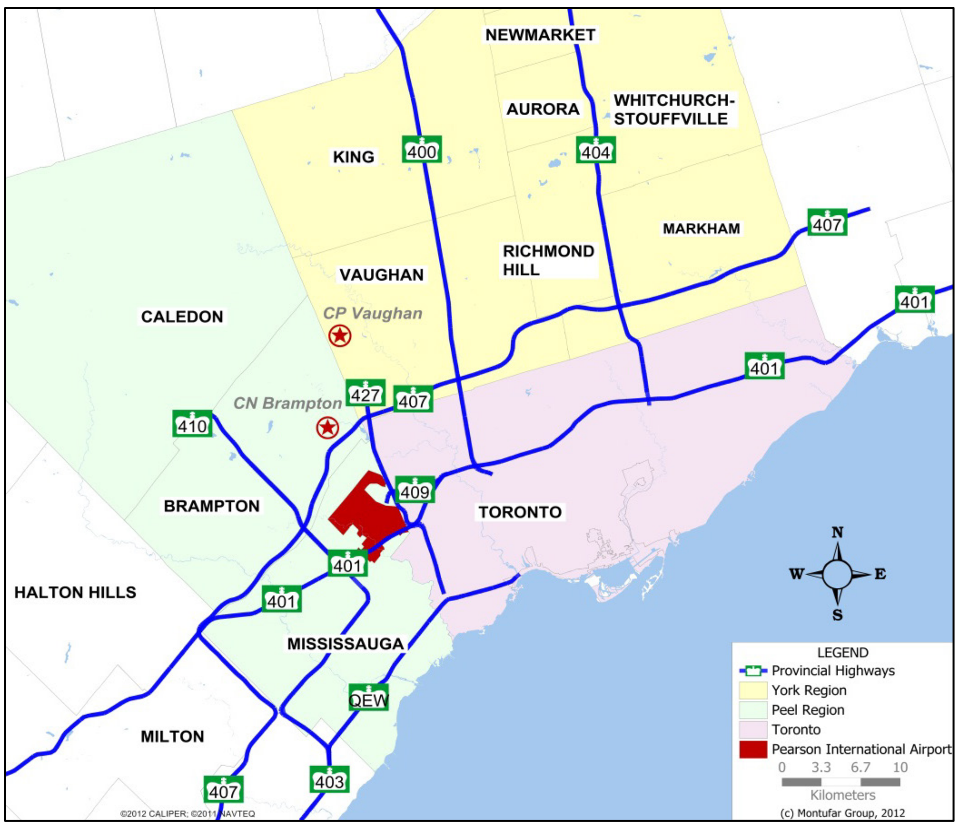


Figure 3: Regional area surrounding Highway 427

Highway 427 is approximately 12.5 km from Highway 401 to Zenway Blvd. The planned extension will be 5.5 km from Zenway Blvd to Major Mackenzie Dr; it includes widening Highway 427 from 3 to 4 lanes between Highway 409 and Highway 407 ETR and adding one HOV lane per direction. There are many grade-separated facilities along Highway 427 where additional structures would need to be constructed for physically-separated truck lanes. The posted speed limit is 100 km/h and most sections are divided with Jersey barriers or medians.

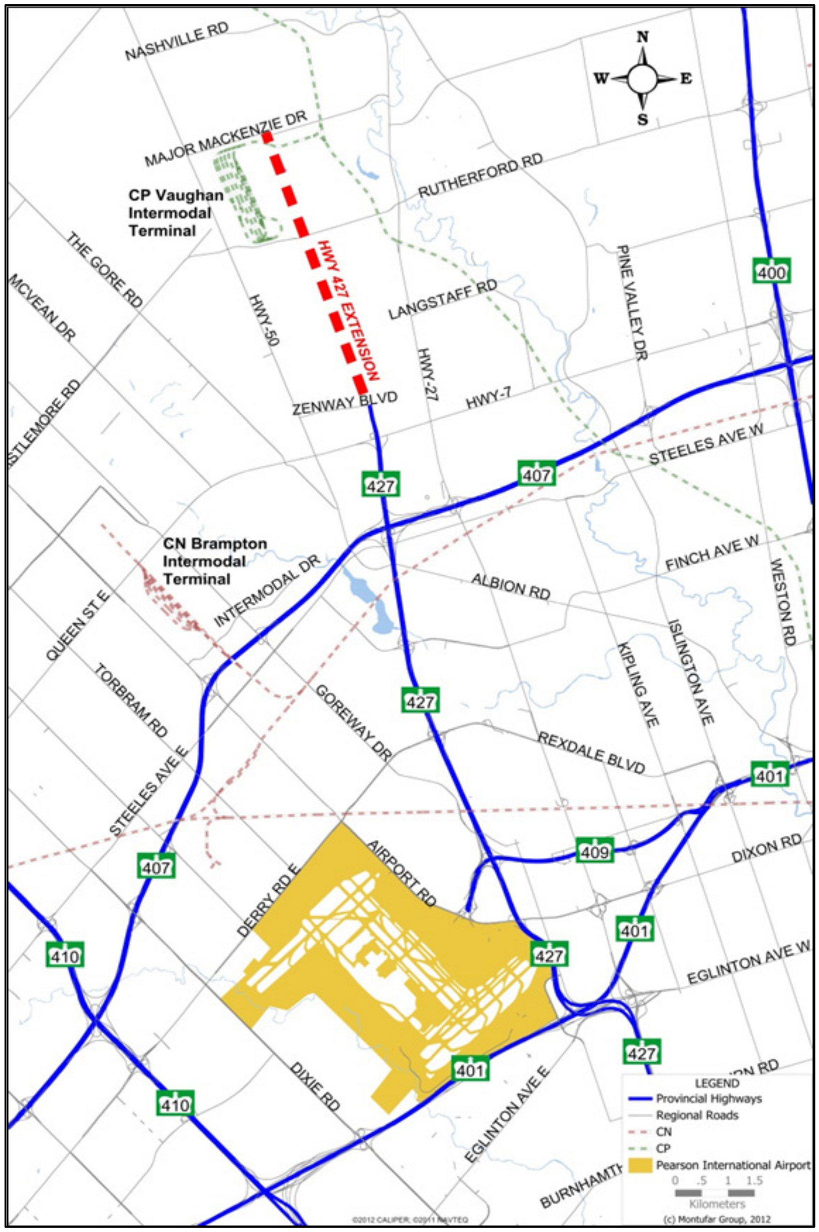


Figure 4: Highway 427 study area

In 2008, annual average daily truck traffic volumes on Highway 427 ranged from 22,500 near Highway 409 to 6,500 near Zenway Blvd. Annual average daily traffic volumes ranged from 183,000 near Highway 401 to 60,400 near Zenway Blvd. Truck traffic volume distributions at intermodal terminals, shown in Figure 5, indicate that truck volumes are relatively constant throughout the day and that these trucks do not necessarily operate during off-peak periods.

CN Brampton Intermodal Terminal uses a truck appointment system where truckers are given a time window during the day to pick up or deliver containers. The morning window is one hour and the afternoon is two hours. The larger afternoon window is reflective of traffic congestion and associated delays. CN uses this system to spread demand at the terminal throughout the day and reduce terminal processing time. CP Vaughan Intermodal Terminal does not use an appointment system for trucks. Truckers are allowed to pick up and deliver containers anytime. This has resulted in peak truck activity at the terminal on Monday and Tuesday mornings and Friday afternoons.

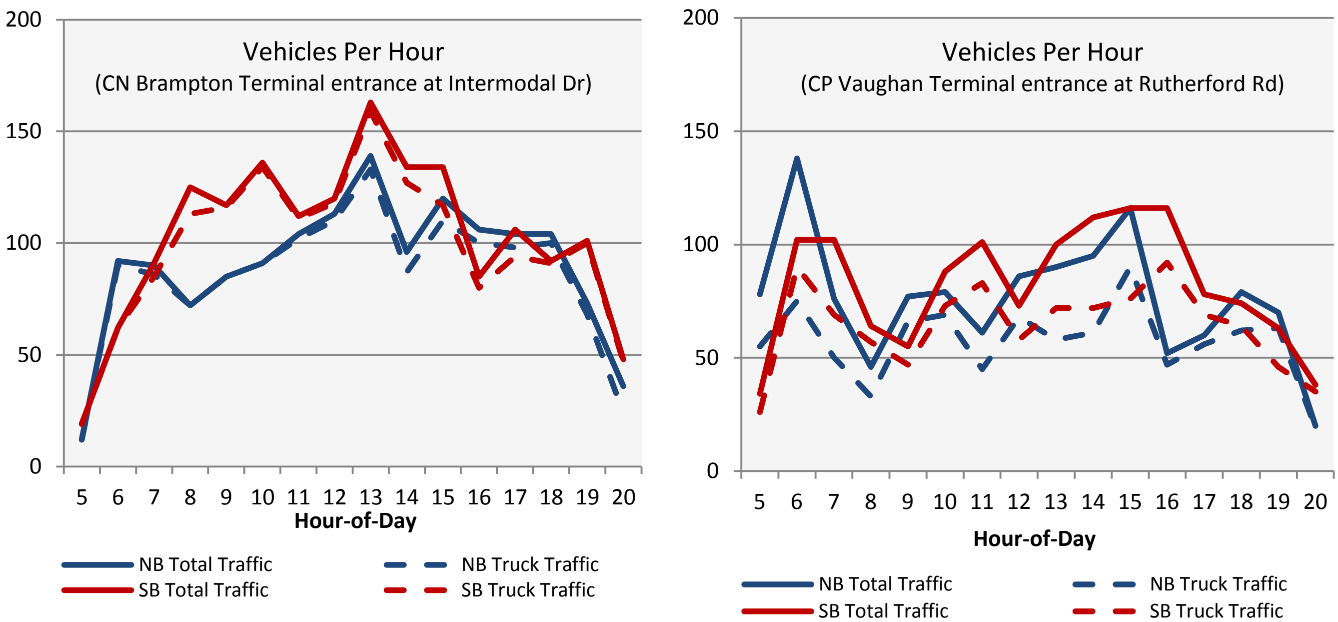


Figure 5: CN and CP Terminal truck traffic volume hourly distribution

Source: GTA Cordon Count Program

The 2006 truck traffic volumes on Highway 427 north of Steeles Ave are about 500 per hour per direction between 06:00 and 12:00 and decrease steadily to 200 per hour per direction by 19:00. Southbound volumes are higher than northbound volumes in the morning and lower in the afternoon. CN Brampton Intermodal Terminal generates about 3,000 trucks per day while the CP Vaughan Intermodal Terminal generates about 2,000 trucks per day.

The 2006 total traffic volumes on Highway 427 north of Steeles Ave follow a common commuter distribution with a.m. and p.m. peak periods. During the a.m. peak, hourly traffic volumes in the SB and NB directions are about 5,250 and 2,500, respectively. During the p.m. peak, hourly traffic volumes in the SB and NB directions are about 2,000 and 4,000, respectively.

The buffer time index (BTI) for trucks on Highway 427 is mostly 1.50 or higher during weekday morning peak periods between 06:00 and 09:00 (BTI represents the extra time that most travellers add to their average travel time when planning trips to ensure on-time arrival; computed as 95th percentile travel time divided by mean travel time – a BTI of 1.50 on a highway with a 1-hour average travel time means that travellers need to add 1.5 hours to their average travel time to arrive at their destination on time for 19 trips out of 20). Truck delays on Highway 427 during the morning peak are the worst north of Finch Ave. The segments of Highways 27 and 50 are currently used to access CP Vaughan Intermodal Terminal have BTI ratings of 2.00 and above. The BTI ratings for trucks during the afternoon peak period (15:00 to 18:00) are between 1.50 and 2.00 on Highways 27 and 50 (lower than during the morning peak). More segments of Highway 427 have truck BTI ratings higher than 2.00 during the afternoon peak period than the morning peak period.

In 2008, there were 291 crashes on Highway 427 between Highway 401 and 407; 65 of these (22%) involved a truck. The 2008 crash rate for trucks on this highway was 115 crashes per 100 million truck vehicle-kilometers traveled (VKT) and for all traffic it was 61 crashes per 100 million VKT. The truck crash rate exceeds the criteria developed in the U.S. literature for considering a physically-separated truck lane on a freeway (101 truck crashes per 100 million VKT). According to the Ontario Road Safety Annual Report, there were 229,196 collisions in Ontario in 2008; 16,708 trucks and 422,190 total vehicles were involved in these collisions. If none of these collisions were between trucks, trucks were involved in about 7 percent of all collisions (it is possible that some collisions involve only trucks which will lower this percentage). Compared to the Ontario truck collision frequency and percent of total collisions, Highway 427 poses a significant truck safety issue.

CONSIDERATIONS FOR TRUCK LANES BASED ON CASE STUDY

The following are considerations for physically-separated truck lanes on freeways based on the Highway 427 case study. The traffic volumes and road infrastructure on this highway are comparable to some U.S. urban interstate highways. Since the literature provides criteria for physically-separated truck lanes on highways with similar characteristics as Highway 427, these criteria are referenced for this section. However, more detailed analysis is necessary to properly assess the appropriateness of a truck lane in this situation.

- **High truck traffic volumes are required to justify two truck lanes per direction.**

  Although truck traffic volumes on Highway 427 are high (up to 20,000 trucks per day along certain segments), they are not enough to warrant the construction of two lanes per direction and physically separated from general purpose lanes (GPLs). Literature from the U.S. strongly recommends two truck lanes per direction for physically-separated configurations. It also indicates that more than 60,000 trucks per day are necessary to consider physically-separated truck lanes on freeways and the truck percentage should be greater than 14 percent (it is about 10 percent on Highway 427). However, this literature also states that this type of truck lane should be considered on freeways with more than 80,000 vehicles per day (Highway 427 has up to 183,000 vpd), located within 3 km of an intermodal terminal (CN Brampton is about 4 km from Highway 427 and CP Vaughan will be less than 2 km from the planned extension), and with a truck crash rate greater than 101 per 100 million VKT (on Highway 427 the truck crash rate is 115 per 100 million VKT). Based on U.S. literature, some conditions on Highway 427 support truck lanes and others do not. More detailed analysis is necessary to determine the feasibility of truck lanes.

- **Adequate right-of-way must be available to construct new lanes for trucks.**

  There is limited ROW along Highway 427 between Highway 401 and Highway 7. This is especially the case between Rexdale Blvd and Finch Ave where Highway 427 runs through a residential area. Physically-separated truck lanes require two lanes per direction to accommodate truck breakdowns, facilitate passing, and allow emergency vehicle access.

- **Entering and exiting truck lanes can increase vehicle interaction and raise the potential for collisions between trucks and cars.**

  Weaving at interchange points creates a safety concern. Different approaches for addressing weaving include infrastructure design to physically guide vehicles and restrict lane changes, signage and pavement markings to warn and inform drivers about upcoming merging, and combinations of these.

- **Truck lanes should be developed as part of a larger truck lane network.**

  Providing short, isolated truck lane segments can address local mobility issues; however, trucks operate across a network and creating a truck lane network will provide larger benefits to more trucks. Short truck lane segments on freeways may only be capable of providing marginal travel time savings and reliability improvements. Highway 427 is part of a much larger freeway network in the GTA. In this context, providing a truck lane along a segment of this highway is more of a spot treatment than a network solution and benefits only a portion of the truck population. Further these benefits apply to only a part of the route travelled by most trucks.

- **Peak period truck traffic volumes at intermodal terminals coincide with peak commuter traffic volumes.**

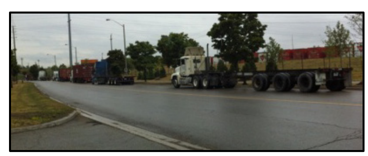
  Truck traffic at one of the intermodal terminals is the highest on Monday and Tuesday mornings and Friday afternoons. These truck traffic peak periods coincide with commuter traffic peak periods. This correlation may justify the provision of a truck lane. For CN Brampton and CP Vaughan, commuter traffic a.m. peak periods are in the southbound direction and trucks accessing the terminals are traveling north. During this time period, truck lanes may be underutilized. During the p.m. peak period, both cars and trucks are traveling north and truck lanes could provide mobility benefits for both road users. Temporally-restricted truck lanes might be a preferred solution.

- **Mobility benefits of truck lanes connecting to rail intermodal terminals can be negated by processing delays at the terminal.**

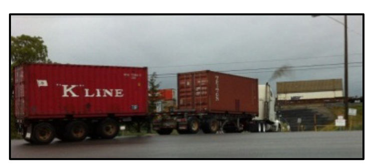
  Mobility benefits provided by truck lanes can be constrained by intermodal terminal processing times and delays. Travel time reductions on truck lanes connecting to intermodal terminals may be helping trucks arrive at a bottleneck faster than without a truck lane.

- **Intermodal terminal truck appointment systems can increase the benefits of truck lanes connecting to these facilities.**

  CN requires trucks to reserve a time to pick-up and drop-off containers; in the morning they have a 1-hour window, in the afternoon they have a 2-hour window (CN would like these windows to be as small as possible but recognize the realities of traffic congestion). Truck lanes on Highway 427 could help meet this pick-up and delivery window and may allow railroads to decrease its size since this highway is used by some trucks to access the terminal.



Trucks queuing at CN Brampton intermodal terminal entrance



Double trailer container truck entering CP Vaughan intermodal terminal

CP does not use an appointment system and does not control hourly truck traffic demand; consequently they experience peaking on Monday and Tuesday mornings and Friday afternoons. In this type of operation, truck lanes can help meet the demand during these peak periods.

- **Providing truck lane exemptions for specific road users may provide the necessary volumes and performance level to justify two separated lanes per direction.**

  Truck lanes represent a preferential treatment for a specific component of the traffic stream, namely trucks. If corridor capacity is insufficient and truck volumes are too low to justify dedicating a lane for trucks, other road users could share preferential treatment benefits with trucks. HOVs are one type of vehicle where preferential treatment may be desired but volumes are too low to provide a dedicated HOV lane. The planned HOV lanes on Highway 427 provide an opportunity to explore this option if HOV volumes are insufficient to dedicate a separate lane for their use.

  Policy and regulation can be used to control traffic volumes on truck-HOV lanes to maintain a desired level of service, such as changing the truck and HOV definition (e.g., prohibiting medium-duty trucks, or defining HOV as 3+ passengers per vehicle instead of 2+). However, enforcing truck lane usage by truck type could be difficult. These types of lanes were considered in Houston, Texas; however, concern that truck driver unfamiliarity with HOV lanes would result in low utilization lead to the rejection of this idea.

3.2 TRUCKWAY

Truckway is an exclusive road for trucks to access a major freight origin or destination (e.g., rail intermodal terminals, marine terminals, truck staging areas, or a large industrial park). Though the intent of the truckway is to be truck-exclusive, in practice the truckway may also be used by employees of the freight facility being accessed. The highway system being developed to access the Global Transportation Hub near Regina, Saskatchewan was selected as the case for which an exclusive truckway may apply.

SITE DESCRIPTION

The Global Transportation Hub (GTH), a 2000-acre (over 800-hectare) parcel of land located on the west end of Regina, Saskatchewan, is a major origin and destination of freight. The GTH is situated on the CP mainline and is the future site for the CP Regina intermodal terminal, which is being relocated from downtown Regina. Currently, highway access to the GTH is provided via Dewdney Ave, which connects east to Regina, and via Pinkie Rd, which links Dewdney Ave with the Trans-Canada Highway to the south (Figure 6 and 7).

Figure 6: The Global Transportation Hub and its highway connections

Future plans to upgrade these connections include: (1) developing a full interchange at the intersection of the Trans-Canada Highway and Pinkie Rd (underway), and (2) developing the West Bypass, which includes a portion of existing Pinkie Rd and a new highway that connects north to Highway 11 (the main connection between Regina and Saskatoon, Saskatchewan). Long range plans call for twinning of the West Bypass and interchanges at Highway 11 and Dewdney Ave.

The GTH is a greenfield development that will function as an inland port. It will offer space for major distribution centres to co-locate with a rail intermodal facility, related vendors and service providers, and companies that manufacture value-added agricultural products. The anchor tenant is Loblaw, a major grocery distributor. They have established their western Canadian distribution centre at the GTH which occupies over 1 million square feet. The centre will attract freight via rail (through the co-located intermodal facility) and truck from across North America. Freight distribution will occur primarily by truck to Canadian destinations between eastern British Columbia and northwest Ontario and the Northwest Territories. Two major for-hire trucking companies have also established a presence at the GTH; these companies currently provide inbound and outbound freight transportation services for Loblaw. In addition, Loblaw operates its own private truck fleet. The vision is that companies which produce goods for Loblaw may be interested in co-locating in the GTH. Further, agriculture-related companies that ship products outbound via container (on rail) may also establish a presence in the GTH.

Transportation productivity is a major objective of the GTH development. Direct, unimpeded access to mainline rail and the National Highway System is integral. In addition, the GTH is aggressively pursuing the use of longer combination vehicles (LCVs), including Turnpike doubles, and on a pilot basis, a "Turnpike triple" configuration, which consists of three 53-ft trailers. Highway connections to the GTH and roadways within the GTH site are being designed to accommodate these vehicles. Provision of full access control (i.e., no at-grade signalized intersections) is therefore a high priority.

A major limitation on trucking productivity currently occurs for vehicles travelling to/from the GTH via Highway 11. From the GTH, these vehicles currently travel south on Pinkie Rd to access Highway 1, and then travel east toward Ring Rd (Regina's east bypass) to access Highway 11 and continue north to Saskatoon (Figure 7). This adds an estimated 30 minutes to each one-way trip between the GTH and Saskatoon. Construction of the planned West Bypass will alleviate this problem; however, there is currently no timeline or dedicated budget for its completion.

The option of the exclusive truckway represents a potential interim and less costly solution to this issue. The concept is to construct a 2-lane undivided highway with a grade-separated access to Highway 11 on which all trucks (including various LCV configurations) would be permitted. This necessitates a relaxation of the general rule restricting LCV travel to divided highways. The truckway would be exclusively for trucks. The connection to Highway 11 could consist of merge lanes to

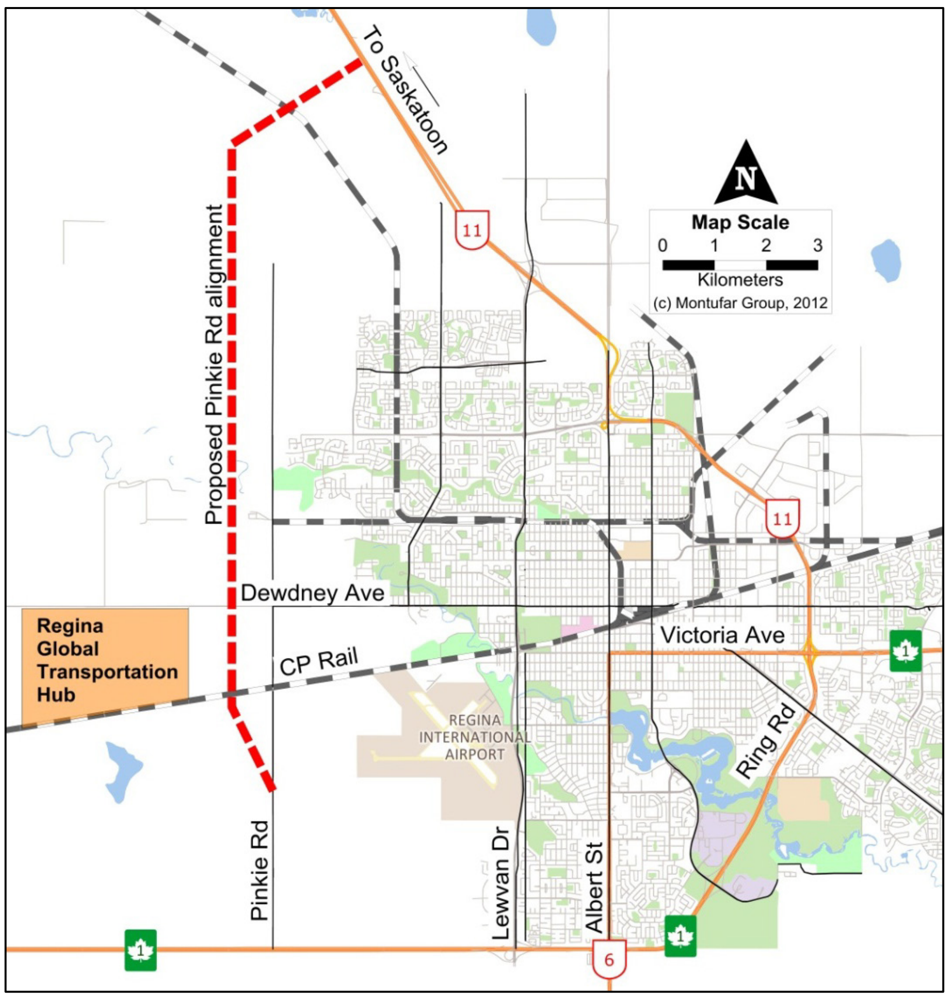


Figure 7: Current and future truck routing between the GTH and Highway 11

accommodate right turn movements and a single lane fly-over for the left turn movements. This facility—including the fly-over—could be developed with the view to complete the fully-divided facility in the future. However, it would provide an interim solution that could improve travel time, reliability, safety, and reduce emissions for trucks going to/from the GTH. Instead of trucks traveling at least 30 minutes around Ring Rd (depending on traffic conditions and time-of-day), this truckway configuration could use the proposed Pinkie Rd alignment ROW and result in travel times consistently around 5 minutes.

Dewdney Ave, between Courtney St in Regina and the GTH, is currently an undivided two-lane highway with gravel shoulders and a posted speed limit of 80 km/h. Pinkie Rd is currently being upgraded to a divided facility between the Trans-Canada Highway and the GTH. The alignment of the southernmost portion of Pinkie Rd is being retained as part of the West Bypass, but will be realigned south of its intersection with Dewdney Ave. A future interchange is planned for the intersection of the West Bypass and Dewdney Ave. North of Dewdney Ave, plans include continuing the West Bypass and interchanging with Highway 11 north of Regina.

All internal GTH site roads are designed to accommodate the performance characteristics of Turnpike triples (shown in Figure 8). Rights-of-way are 60 m wide, and include ditch drainage, full-width paved shoulders, and a four-lane undivided paved road surface.

Figure 8: Turnpike triple operated by Loblaw in Saskatchewan

Truck types operating to/from the GTH principally include five-axle tractor semitrailers (van or container body types), Turnpike doubles (van body types), and Turnpike triples (van body types). Other truck body types (e.g., dump) are being used for construction purposes. All trucks (including the LCVs) are governed by the Roads and Transportation Association of Canada (RTAC) weight regulations on axle groups and gross weight. Length limits on the LCVs are specified by the special permit. Turnpike doubles (two 16.2-m trailers) are limited to 42.0 m in overall length and Turnpike triples are limited to 58.0 m. Turnpike triples must operate with B-connections (tridem axle groups) between the trailers. Both the Turnpike doubles and triples operate under special permit and are subject to unique operating requirements (refer to Section 3.6 for more details).

The GTH currently generates over 3,600 truck movements per day; primarily due to Loblaw-related trucking and the construction of the CP intermodal facility. Passenger vehicle traffic consists mainly of employees accessing the site. Currently, approximately 1,500 people work at the Loblaw facility. There are three shifts per day. This facility operates 24 hours a day, seven days per week, except for Christmas Day and New Year's Day.

CONSIDERATIONS FOR TRUCK LANES BASED ON CASE STUDY

The following are considerations for truckways based on the Regina Global Transportation Hub case study.

- **Interim truck lanes may be appropriate to accommodate trucks during specific events (e.g., construction).**

  The GTH development is positioned to become a major generator and attractor of freight transportation. An intermodal facility and a major distribution centre have already chosen to co-locate within the GTH facility, potentially giving rise to further co-location developments. The GTH offers efficient access by rail and truck and promotes the use of high productivity vehicles. Long range plans, which rely on both provincial and municipal decision-making, include the development of Regina's West Bypass.

  However, the demand for efficient freight transportation is already present. As a result, there may be an opportunity to develop an interim, two-lane undivided truckway which provides exclusive access between the GTH and Highway 11. This truckway would reduce travel time and improve reliability, as well as reduce truck-car interactions on more congested routes within and around Regina. In time, this truckway may be replaced by a divided highway, which would then be accessible for all road users.

  Permitting LCVs (i.e., Turnpike doubles and triples) on a two-lane undivided roadway is not normally allowed within the context of provincial LCV permits. Many municipalities, however, do permit LCV access on certain undivided roads. Where an undivided road is used exclusively by trucks, there are opportunities to relax the divided road requirement because the interaction between large trucks and passenger vehicles would be avoided, and because all users (i.e., truck drivers) would be familiar with the operating characteristics of an LCV.

  Interim truck lanes could also be used to accommodate trucks during major construction projects. Road safety, particularly potential collisions between trucks and cars during the construction of the GTH, was the main reason for installing temporary traffic signals at the intersection of Pinkie Rd and the Trans-Canada Highway. Providing a temporary truck lane during this construction provides another opportunity to improve road safety.

- **Land use planning and zoning can be used to create natural truck lanes.**

  Important to developing the GTH is acquiring and protecting surrounding lands so that the roads serving this area can be primarily used by trucks. This will help the GTH maintain efficient access for trucks. Without this type of planning, the possibility exists for residential land use to encroach on the GTH site, thus necessitating the use of roads by general traffic. Land use zoning in this area is defined to facilitate truck and employee traffic only. For example, traffic calming measures and pedestrian accommodation on these roads and allowing commercial businesses such as coffee shops in the area will not be considered if they negatively impact truck traffic (and associated employee traffic). Truck-friendly road and land use design are used to create conditions where only trucks will logically travel, and thereby create truck lanes without officially designating these roads as such.

- **Waiting times at freight facilities (e.g., loading docks, intermodal terminals) are often the source of greatest delay in an overall freight trip.**

  Shippers at the GTH noted that the largest delays for trucks usually occur at freight facilities. The benefits of truck lanes primarily serving trucks accessing a major freight facility can be negated if the delays at the freight facility are excessive (i.e., orders of magnitude greater than the truck lane travel time savings). In these situations, truck lanes are helping trucks reach a bottleneck faster and not actually improving the overall freight movement. Transportation engineers and planners should recognize these types of situations and determine if truck lanes are still an attractive option to improve on-road performance for trucks using the truck lane.

- **Truck lanes have the potential to provide sufficient travel time savings and reliability improvements to allow round-trips between major regional origin-destination pairs within hours-of-service regulations.**

  Travel time reliability is a key consideration for the trucking industry, especially as governments consider changes to hours-of-service regulations and the means by which these are enforced (e.g., electronic on-board recorders). Much of Canada is characterized by long distances between major freight origin-destination pairs and sparse populations between these endpoints. For example, there are relatively few major centres that demand freight between Winnipeg and Regina. Round-trips between these cities, including pickup and delivery, is around 13 hours. Current hours-of-service regulations limit daily driving time to 13 hours; therefore it is possible to perform a round-trip during one driving cycle. However, there is little buffer time to allow for unexpected delays. To this end, improving travel time reliability at the trip endpoints (such as at the GTH) through the use of an exclusive truckway or other truck-preferential facility is beneficial.

3.3 TRUCK BYPASS

A truck bypass provides special facilities/operational controls for trucks to move them away from potential traffic bottlenecks such as merge areas at interchanges, access/egress ramps, or congested urban street systems. Ottawa's Waller St (the only existing truck lane in a Canadian urban area), was selected as the location to analyze this type of truck lane.

SITE DESCRIPTION

Waller St is a 400 m long local arterial road located in the Ottawa downtown area. The waterway system and truck route network constrain truck movements. Within the study area, there are three truck routes crossing the Rideau Canal (Rideau St, Mackenzie King Bridge, and Laurier Ave), one truck route crossing the Ottawa River and connecting to Gatineau (MacDonald-Cartier Bridge), and one truck route crossing the Rideau River (Rideau St). Due to the limited crossing opportunities for trucks and the structure of the truck route network, trucks are often directed through downtown Ottawa.

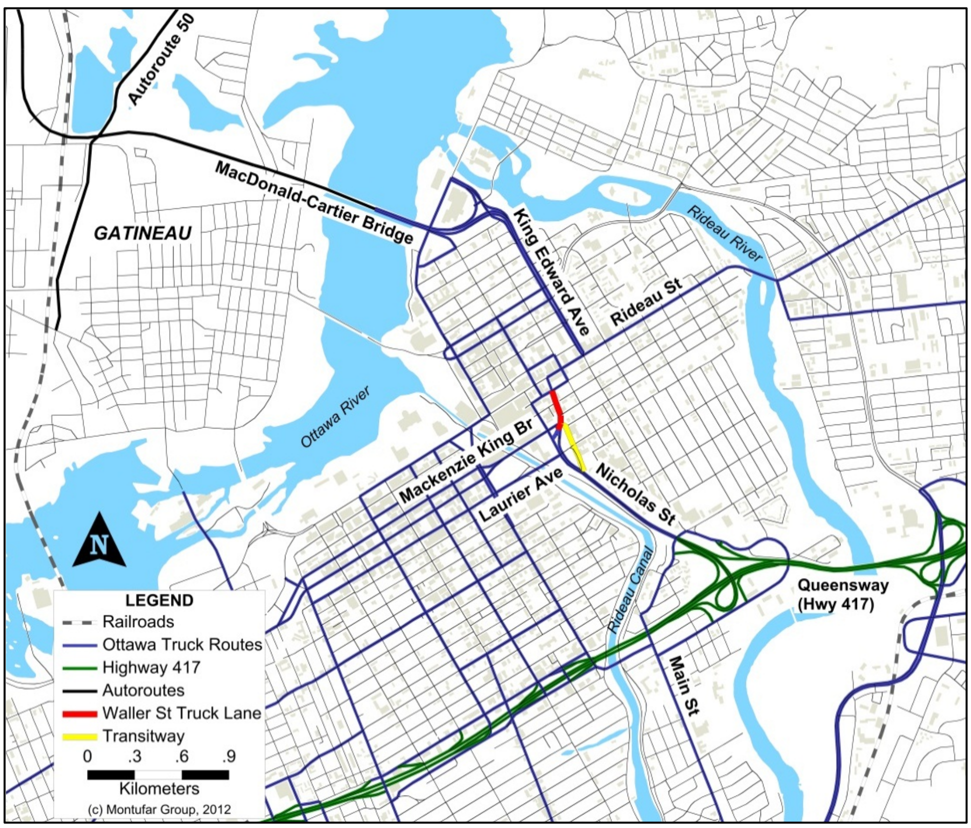


Figure 9: Waller St study area

The corridor comprising the MacDonald-Cartier Bridge, King Edward Ave, Rideau St, Waller St, and Nicholas St provides the only truck route connection between Autoroute 50 (the major east-west freeway in Quebec that connects Gatineau to Montreal) and the Queensway (the major freeway in Ontario which forms part of the TransCanada Highway). Waller St is the only practical option for southbound (SB) trucks to access Nicholas St.

The Waller St truck lane was implemented in the 1980's within the context of a limited downtown truck route network. It operates in the southbound direction only and is designed to reduce intersection queues for buses and improve bus access to the transitway at Mackenzie King Bridge. The truck lane is about 300 m long, beginning at the intersection of Besserer St and ending at the Mackenzie King Bridge ramp. It is designated with signs but not pavement markings whereas bus lanes on Waller St are designated with both.

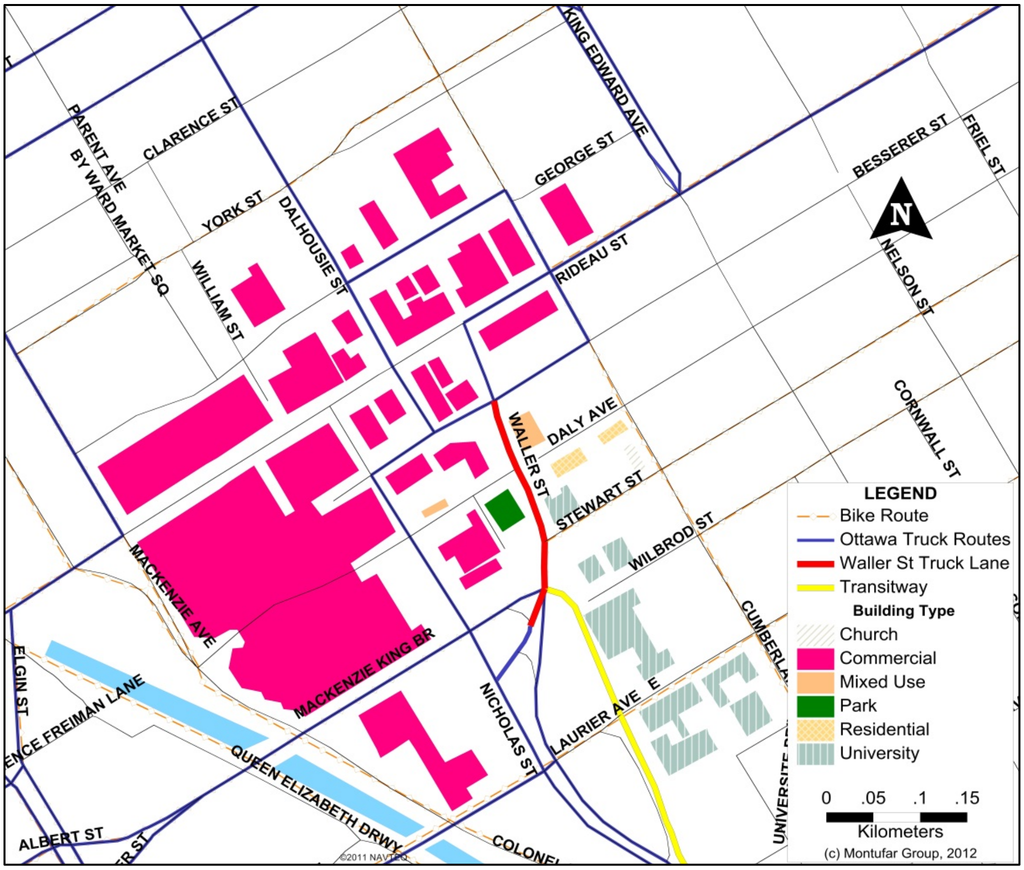


Figure 10: Waller St and surrounding land uses

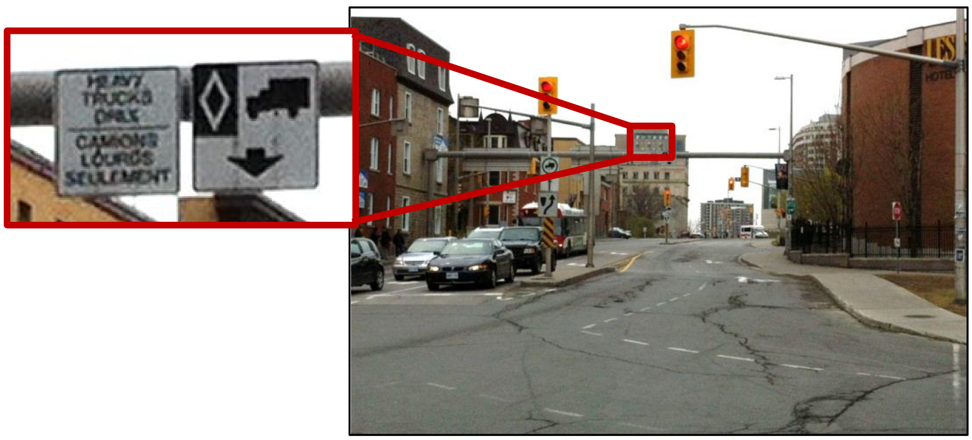
There are two through lanes per direction for almost the entire length of Waller St. The street is divided by a narrow median (less than 1.5 m) for most of the length. A painted median is provided where a raised curb median is absent. Most intersections have right- and left-turn auxiliary lanes. There are five signalized intersections between Rideau St and Nicholas St, inclusive. There is a bike lane on Waller St that begins north of Mackenzie King Bridge; it is part of the bike route network and intersects Waller St at Stewart St. A transitway intersects Waller St at Mackenzie King Bridge. The speed limit along the entire length of Waller St is 50 km/h. Parking is prohibited along Waller St.

Two-way average daily traffic volumes are about 17,150; however the SB direction (the direction with the truck lane) accounts for only 15 percent (2,285 vpd). Northbound (NB) traffic volumes peak at 16:00 (1,500 vehicles per hour); SB traffic volumes peak at 07:00 (250 vph). The NB hourly traffic volume distribution has a morning peak between 07:30 and 09:30 and a larger peak between 15:30 and 17:30. The opposite applies to the SB direction where traffic peaks between 07:30 and 09:30 and steadily declines throughout the day. Hourly truck volumes range between 30 and 150. SB truck volumes on the truck lane are often half to two-thirds of the NB truck volume. Daily pedestrian and cyclist volumes at the intersection of Waller St and Daly Ave are about 1,750 and 200, respectively.

Along Waller St there are few significant freight generators. Most SB trucks on the truck lane are traveling from Rideau St to Nicholas St and beyond. The Byward Market Square, Rideau Centre, and

University of Ottawa are nearby and each generates high pedestrian and transit volumes. The Ottawa Macdonald-Cartier International Airport, located about 13 km south of Ottawa's central business district is a major regional freight generator. It operates 24/7, has 23 air cargo companies on site, and generated 20,000 tonnes of cargo in 2007 with estimates that this could double in the next 20 years.

Generally, traffic congestion is not a problem along Waller St. Traffic queuing at intersections is not an issue (during peak and off-peak periods). There are few instances where a traffic queue is unable to pass through the intersection during a single signal cycle (at least for vehicles on the general purpose lanes; some buses on the transitway require two signal cycles during peak periods). The posted speed limit is 50 km/h and vehicles tend to operate at or below this speed. At times, the truck lane does not appear to be very effective at reducing queues for buses on Waller St. A single B-train truck or the combination of a 5-axle tractor semitrailer and straight truck prevents SB Waller St buses approaching Mackenzie King Bridge from accessing the bus lane.



Source: Montufar Group, 2012

Figure 11: Waller St truck lane

Some passenger vehicle drivers exhibit confusion about the lane designations at the intersection of Waller St and Mackenzie King Bridge and perform erratic manoeuvres and lane changes. Due to the low traffic volumes and travel speed, these movements do not pose a serious safety risk between vehicles.

CONSIDERATIONS FOR TRUCK LANES BASED ON CASE STUDY

The following are considerations for truck bypasses based on the Waller St case study.

- **Truck lanes on arterial roads can be appropriate on short, low volume downtown streets.**

  One of the most important findings from this analysis is that there is potential for arterial truck lanes to be successfully implemented on short routes with low traffic and truck traffic volumes and less than three lanes per direction. This appears to be successful for the following reasons:

  Trucks on Waller St truck lane at the Mackenzie King Bridge intersection

  1) Total traffic volumes are low and can be accommodated with a single lane; therefore the truck lane is not removing necessary capacity for other vehicles.
  2) The truck lane is short (300 m) and attracts trucks away from other streets and intersections. This has the potential to improve traffic conditions for passenger vehicles and buses on other nearby routes.
  3) There are few alternative routes for trucks due to the defined truck route network. Consequently, trucks are funnelled through the downtown area. The truck lane provides a dedicated corridor that channels trucks to a specified route, gives preferential treatment to trucks, and does not restrict their ability to serve local freight generators.

  This demonstrates that truck lanes could be applicable in many Canadian urban areas and not limited to large cities with high traffic volumes (both truck and total). It also challenges the traffic volume criteria for considering truck lanes identified in the literature (which is primarily U.S.-based). This case study helps support the argument that a new approach to truck lanes is necessary for Canada and that applying U.S.-based criteria and experience may not be appropriate.

- **Truck lanes can be implemented to address non-truck specific issues.**

  The Waller St truck lane also demonstrates that truck lanes can be implemented to address a non-truck specific issue. In this case, the truck lane is implemented primarily to improve transit operations, particularly traffic queues at an intersection. This shows that truck lanes may be an appropriate option designed principally to improve conditions for other road users while providing significant benefits for trucks. In this case, extended queue lengths produced by trucks are contained to a single lane thereby reducing queue lengths in other lanes. Furthermore, traffic progression is improved since vehicles with similar acceleration and vehicle lengths operate in the same lane. A lesson learned from the Waller St truck lane is that trucks that have few routing options but are provided with a dedicated lane that significantly improves access to an expressway within a downtown area will voluntarily use the truck lane despite the risk of queue build-up in this lane. This is the case under relatively low volume and uncongested conditions; it is unknown if this would apply to other situations with higher volumes or congestion.

- **Truck lanes do not necessarily need to be bi-directional.**

  The Waller St truck lane is only in the southbound direction. This is surprising since the northbound direction has considerably higher total and truck traffic volumes. However, upon closer inspection and understanding the purpose of the truck lane, a uni-directional truck lane is appropriate for this situation. The purpose of the lane is to reduce queuing for southbound buses turning left onto the transitway. Buses in the northbound direction access the transitway with a right-turn and can perform this movement relatively unimpeded and without experiencing long queues.

Trucks queuing on Waller St truck lane and blocking access to bus lane

- **Truck lanes in urban areas can be difficult to toll.**

  Electronic toll collection using transponders installed on trucks has reduced the need for extensive physical systems on toll roads. In urban areas and in situations where there are limited truck route options, tolling is likely technically feasible but discouraged. Given experiences by other jurisdictions and the trucking industry's position on tolling, tolls on the Waller St truck lane would be opposed due to insufficient alternative routes. In general, the literature review and stakeholder interviews contained in the Technical Report consistently recommend avoiding truck lane tolling.

- **There is potential for high violations by passenger vehicles.**

  During the field investigation many passenger vehicles were observed in violation of the truck lane designation. During peak and off-peak periods, about 30 percent of the vehicles using the truck lane were passenger vehicles. This occurred despite a significant police presence in the area.

3.4 OPERATIONALLY-SEPARATED TRUCK LANE ON A FREEWAY

Operationally-separated truck lanes on freeways are mainline lanes that are not barrier separated; rather, these lanes are operationally-separated using traffic control treatments (e.g., rumble strips, paint striping, signage, speed limits) or special policies. Operational separation may only be in effect for certain time periods of the day. Calgary's Glenmore Tr was selected as the location to analyze this type of truck lane.

SITE DESCRIPTION

Glenmore Tr, between Deerfoot Tr and 84 St, is located in the southeast quadrant of Calgary and is planned as a future freeway. Currently this section has four at-grade intersections and two interchanges; these are spaced less than one km apart. Upgrading this route to a freeway will include constructing 3 to 4 lanes per direction between Deerfoot Tr and 84 St, a barrier median, 3 m wide paved shoulders, an interchange at each intersection, grade-separating the rail crossing, and closing access at 30 St. The study area includes the Southeast Industrial Area and the Stoney Tr right-of-way. Stoney Tr, Calgary's ring road, will be extended south from 17 Ave and intersect with Glenmore Tr in 2013. This development is expected to alter truck travel patterns in the area and around Calgary.

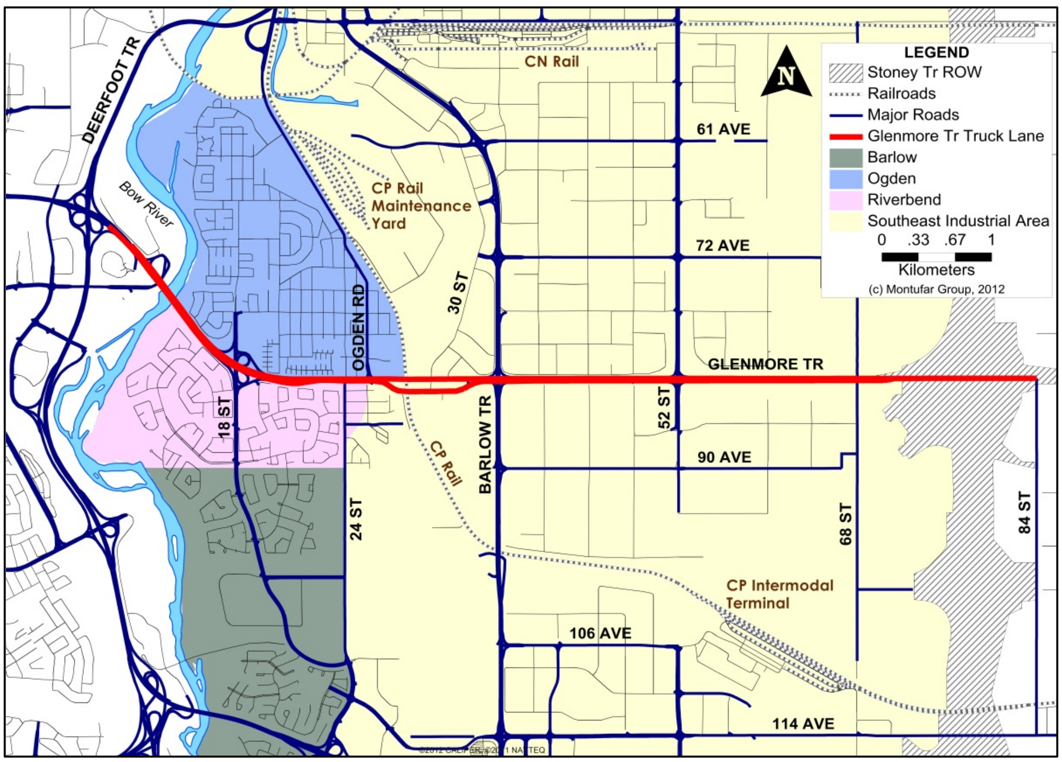


Figure 12: Glenmore Tr truck lane study area

Glenmore Tr is a Skeletal Road and is about 8.5 km long from Deerfoot Tr to 84 St. Skeletal Roads promote the movement of vehicular traffic over long distances, operate at high speeds, and have little access with adjacent land uses. The speed limit along Glenmore Tr upon completion of the freeway upgrade will be 100 km/h. The CP mainline crosses Glenmore Tr, their intermodal terminal is located about 750 m south of Glenmore Tr, and their rail maintenance yard is just north of Glenmore Tr. CN is in the process of re-locating their intermodal terminal along 50 Ave to about 15 km east of the Calgary International Airport.

Calgary's southeast quadrant is heavily industrialized and the City expects industrial growth to continue, especially in the Southeast Industrial Area. Land being developed between Glenmore Tr and 114 Ave is approximately 1,000 acres (400 hectares) and already contains several large facilities. Truck trip generation and truck travel patterns (e.g., origin-destination pairs, routing, hourly distribution) for this area are currently unknown as is the effect of the Stoney Tr extension. Consequently, truck trip distance along Glenmore Tr and whether most trucks will access this area from the west or east is also unknown.

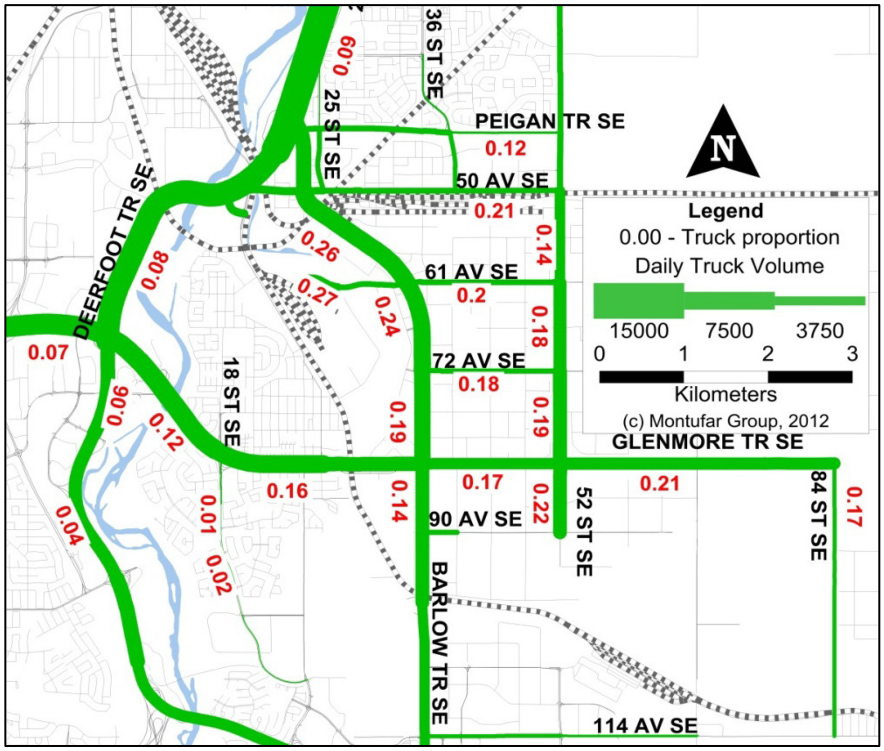


Figure 13: Truck traffic volumes and proportion of truck traffic to total traffic on Glenmore Tr

Source: City of Calgary

Glenmore Tr has experienced traffic peak spreading; traffic is growing faster between the 06:00 and 07:00 period compared to the 07:00 and 08:00 period. Between Deerfoot Tr and 18 St, the 2010 Average Annual Weekday Traffic (AAWT) volume was 66,000; between 18 St and Ogden Rd it was 46,000; between Ogden Rd and Barlow Tr it was 37,000; between Barlow Tr and 52 St it was 28,000; and between 52 St and 84 St it was 25,000. Figure 13 shows truck traffic volumes, the proportion of truck traffic to total traffic, and demonstrates that routes with high truck traffic volumes do not necessarily have high truck ratios, and vice versa.

Glenmore Tr operates as a major commuter route with commuters traveling into Calgary (WB) in the morning and leaving Calgary (EB) in the afternoon. Permanent truck traffic data is unavailable and short-term counts reveal different hourly distributions. However, data from 2009 and 2011 (shown in Appendix D) indicates that truck traffic does not exhibit a.m. and p.m. peaking characteristics. The highest truck traffic volume occurs between 11:00 and 12:00 in the WB direction near Deerfoot Tr. During this hour, the truck traffic volume is 350 and the total traffic volume is 3,000. Glenmore Tr at Deerfoot Tr has the highest total traffic and truck traffic volumes along the segment under analysis. The highest hourly traffic volume is in the WB direction beginning at 16:00. During this hour, the total traffic volume is 4,500 and the truck volume is 200.

Figure 14 illustrates that truck percentages by direction and by hour can be misleading in terms of describing truck traffic volumes. In the EB direction, the lowest truck percentage (15%) corresponds with the highest truck traffic volume (100 per hour). In the WB direction, the highest truck percentage (40%) corresponds with the lowest truck traffic volume (less than 10 per hour). This figure shows that truck traffic does not decrease during peak commuter periods and implies that trucks may not be able to adjust their travel time to avoid congestion.

The free flow travel time on Glenmore Tr is 9.5 min, the average travel time varies between 15 and 20 min, and the 95% travel time (i.e., travel time required to arrive on time for 19 trips out of 20) varies between 20 and 34 min. To achieve 95% on-time performance, trucks must increase their average travel time by 42 to 74%. Truck lanes could offer travel times near free flow conditions, especially since current truck volumes are less than the capacity of a lane. Therefore travel time savings could be significant; over 20 minutes during peak periods for trucks travelling the entire length in the WB direction.

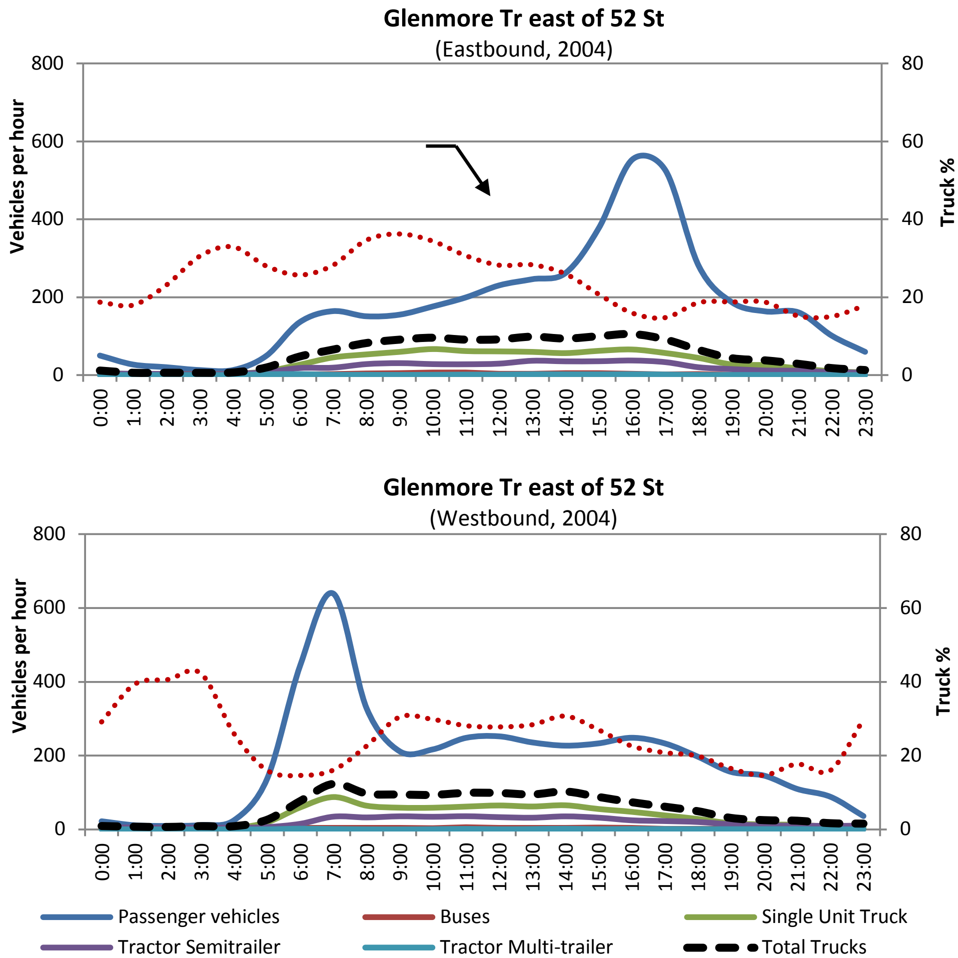


Figure 14: Glenmore Tr hourly traffic volume distribution
Source: City of Calgary

CONSIDERATIONS FOR TRUCK LANES BASED ON CASE STUDY

The following are considerations for operationally-separated truck lanes based on the Glenmore Tr case study.

- **Truck percentages can be an inappropriate metric for truck lane analysis.**

  Truck percentages can give the illusion that a road carries high truck volumes or that truck volumes exhibit peaks; however, increasing truck percentages may actually indicate a decrease in total traffic, not an increase in truck traffic. Truck lanes may be feasible during times when truck percentage is lowest, but truck traffic volumes are highest, such as a.m. peak periods. Traffic data collected on Glenmore Tr at 52 St illustrates this issue. According to this data, truck percentage is highest (around 35 percent) during hours with the lowest truck traffic volume. Truck percentage is lowest (around 15 percent) during the hours with the highest truck volume. Using truck percentage to determine if a truck lane is feasible or to determine which hours a truck lane should be operated can be misleading. For Glenmore Tr, relying on truck percentage alone for these decisions would result in a truck lane being operated during times when truck volumes are lowest.

- **Hourly traffic distribution by vehicle class and direction is important.**

  Roads that exhibit commuter traffic patterns (i.e., morning peaks in one direction and afternoon peaks in the opposite direction) may not require truck lanes, especially if trucks are operating counter to the direction of commuter peaks. In this case, calculating the combined two-way total hourly truck traffic volume and traffic volume may be inadequate, and directionality should be also considered.

- **Ingress and egress points of truck lanes can create safety issues.**

  Weaving at interchanges creates a safety concern as lane changes, speed differentials, and general vehicle interaction increase the probability of a collision. Glenmore Tr is scheduled to have seven interchanges between Deerfoot Tr and Stoney Tr, inclusive, upon completion of the freeway upgrade. This is nearly one interchange every kilometre. Currently 52 St, Barlow Tr, and Deerfoot Tr have high truck traffic volumes (around 6,000 trucks per day) and Stoney Tr is expected to generate similar truck volumes in the near future. If current truck traffic patterns continue and expected truck traffic volumes materialize, large volumes of trucks will require access to four of the seven interchanges. Given the short spacing between interchanges, this could generate significant weaving.

- **Truck lanes should be developed as part of a larger truck lane network.**

  Providing short, isolated truck lane segments can address local mobility issues; however, trucks operate across a network and creating a truck lane network will provide larger benefits to more trucks. Travel time is currently unreliable on Glenmore Tr, with Buffer Time Indices up to 75% and the 95% travel time being 3 times higher than free flow travel time during certain periods. Since truck volumes on Glenmore Tr are less than the capacity of a single lane, a truck lane for through truck movements could reduce travel time to near free flow conditions, particularly after the corridor is upgraded to a freeway. During the most congested periods, this could save trucks up to 20 minutes in travel time which is significant. However, if travel time delays on connecting truck routes, such as Deerfoot Tr, Barlow Tr, and Stoney Tr, continue to increase, the travel time savings on Glenmore Tr could become insignificant compared to their total trip time.

- **Understanding the cause of travel time delays can help determine if truck lanes are appropriate.**

  Delays that are caused by at-grade rail crossings at the CP rail crossing on Glenmore Tr, for example, are unlikely to be addressed for trucks (or other vehicles) by constructing an at-grade truck lane. Similarly, truck lanes are unlikely to overcome travel time delays caused by operational inefficiencies such as inadequate traffic signal timings.

  Prior to implementing a truck lane, truck-friendly design and operational treatments should be considered and followed up with a data-driven analysis to evaluate any improvements in performance. If travel time, reliability, safety, and emissions (or other performance criteria) are still inadequate following a truck friendly approach, then truck preferential treatments such as truck lanes may warrant consideration.

- **How will traffic patterns change after implementing a truck lane?**

  The inability of adding road capacity to sustainably address congestion and increasing traffic volumes is due in part to latent passenger travel demand and the flexibility of driver decisions regarding when, where, and how to travel. When new lanes are provided on congested routes, temporary performance improvements are evident – but these improvements attract more vehicles and eventually performance degrades to original conditions. However, truck traffic may not exhibit the same latent travel demand characteristics as cars nor do they have the same freedom to alter when, where, and how they travel. Therefore, in the case of trucks, adding road capacity may actually sustainably address congestion, at least more than for general traffic. Important questions arise from this possibility, such as:

  - Will truck traffic patterns change as a result of a truck lane?
  - How will traffic patterns on Glenmore Tr change due to the upgrade from expressway to freeway?
  - If current truck traffic volumes and projections are insufficient to warrant a truck lane, is there enough, or any, latent demand that will generate sufficient truck traffic volumes?
  - Is the provision of truck lanes a case of “build truck lanes and they will come” or are trucks unable to adjust their routing to take advantage of a truck lane?

  Glenmore Tr data indicates that truck traffic volumes are high (and sometimes peak) during commuter peak periods. This concurs with industry that trucks may not have much control when they travel and that the provision of a truck lane, at least during peak commuter periods, could be beneficial.

- **Truck lanes do not necessarily need to be directionally symmetrical.**

  The major truck traffic generator along Glenmore Tr will be the Southeast Industrial area situated south of Glenmore Tr. Currently it is unknown how many trucks this area will generate or the routing that trucks will use to access this area. Although Glenmore Tr is scheduled to be upgraded to a freeway with an interchange at 68 St, the truck lane issue described herein applies to the current configuration of Glenmore Tr with at-grade intersections at 68 St.

  It is possible that many trucks could access this area from the east using Stoney Tr, then Glenmore Tr, and turning left onto 68 St. Trucks from the west may use Deerfoot Tr, then Glenmore Tr, and turning right onto 68 St. If trucks use this routing, it may be sensible to provide an inner (i.e., median lane) truck lane on westbound Glenmore Tr to accommodate left-turning trucks and avoid trucks weaving from outer truck lanes to make a left turn. On eastbound Glenmore Tr, an outer (i.e., adjacent to the shoulder) truck lane may be sensible to accommodate right-turning trucks.

  In this situation, truck lanes would not be symmetrical; i.e., westbound truck lanes would be inner lanes while eastbound truck lanes would be outer lanes. For trucks exiting the industrial area via 68 St, right-turning trucks going eastbound on Glenmore Tr would access the truck lane without requiring lane changes. Left-turning trucks going westbound on Glenmore Tr would access the truck lane without requiring lane changes to the outer lane. This would help maximize the use of truck lanes and could significantly reduce truck lane changes and interactions with other vehicles. However, if most trucks using Glenmore Tr are through movements between Deerfoot Tr and Stoney Tr, then inner truck lanes in both directions may be preferred.

  This issue underscores the importance of understanding how trucks are expected to use the truck lane. The decision to implement inner, outer, or one of each on Glenmore Tr is directly impacted by truck routing and truck traffic volumes in this area.

- **Truck trip distance along a truck lane is important for calculating truck lane benefits and performance.**

  Development plans for the Southeast Industrial Area include large industrial facilities that are expected to generate large truck traffic volumes. 68 St which is about half way between Deerfoot Tr and the future Stoney Tr ring road, will provide primary access to this area. Since the major truck generator along Glenmore Tr is at the midpoint, trucks generated by this industrial area may only travel half the distance of the Glenmore Tr truck lane (or less) to access Deerfoot Tr or Stoney Tr.

  Determining the origin and destination patterns and routing of trucks along Glenmore Tr is necessary to accurately calculate travel time saving and reliability benefits of the truck lane. Estimating total daily truck traffic volumes and applying corridor-level travel time savings and reliability improvements to this volume may overestimate truck lane benefits. If trucks only travel on a portion of the truck lane (e.g., between Stoney Tr and 68 St), the travel time savings along this segment may be relatively low compared to the nearly 20 minutes of potential travel time savings a truck lane might provide along the entire truck lane length.

- **Truck lanes may not be enforceable without provincial legislative changes.**

  Currently truck lanes and any associated enforcement provisions such as signage and lane markings are not included in Alberta legislation or City of Calgary by-laws. Without these provisions, truck lanes are unenforceable. Therefore, when considering implementing truck lanes, appropriate legal changes may be necessary, otherwise truck lane signs and lane markings will be considered advisory.

- **Truck lane compliance could be higher for newly constructed lanes compared to existing lane conversion.**

  The City of Calgary has experienced different levels of compliance regarding their bus lane network. For bus lanes that have been converted from existing lanes that previously allowed cars, they observed low levels of compliance. However, for bus lanes that were implemented using new or previously untraveled lanes (such as allowing buses to use shoulders during peak periods), they observed high levels of compliance. Similar types of compliance could be observed for truck lanes. In the Glenmore Tr case, new lanes are being constructed, and implementing truck lanes immediately could result in high compliance rates.

- **Truck lanes may be appropriate within the internal road network of an industrial area.**

  Large industrial parks, such as the Southeast Industrial Area, have internal road networks that primarily serve employees and trucks. These roads can experience congestion during the a.m. and p.m. peak periods which in some cases coincides with truck pick-up and delivery times. Access into the industrial park and out to the external road network could be improved by providing trucks with their own internal road network.

  With appropriate site design, trucks could have direct access to loading zones and the performance of the rest of the internal road network would improve by removing trucks from traffic. Further, roads could be designed and maintained with improved precision with pavements that could handle the heavier loads from trucks and geometry that could accommodate longer trucks.

3.5 TRUCK LANE ON A MAJOR ARTERIAL

Truck lanes on major arterials provide operational separation for trucks and general traffic on urban arterials that service large truck volumes. They may permit transit operations (ideally with bus pullouts) or use a lane which is designated as a parking lane during certain times of the day. Vancouver's Knight St/Clark Dr corridor was selected as the location to analyze this type of truck lane.

SITE DESCRIPTION

Knight St/Clark Dr is a major north-south facility, which extends from the Port of Vancouver on the Burrard Inlet to the Knight St Bridge at the Fraser River. This eight-kilometer arterial, which runs through residential and commercial areas for the majority of its length, carries about 100,000 vehicles per day at the Knight St Bridge, and is the most heavily used truck route in Vancouver due to its role as a key connector between the city and Richmond, Delta, Surrey and the United States. Figure 15 shows the location and extent of this arterial in Vancouver. The Knight St/Clark Dr corridor became a major truck route in the mid 1970s with the construction of the Knight St Bridge.

It is expected that this corridor will continue to play a key role in goods movement for years to come. As trade, population and employment continue to grow the demands placed on this corridor will also increase. The City of Vancouver estimates a population growth of 14% and total employment growth of 63% for this corridor by the year 2021 from a 1999 base year.

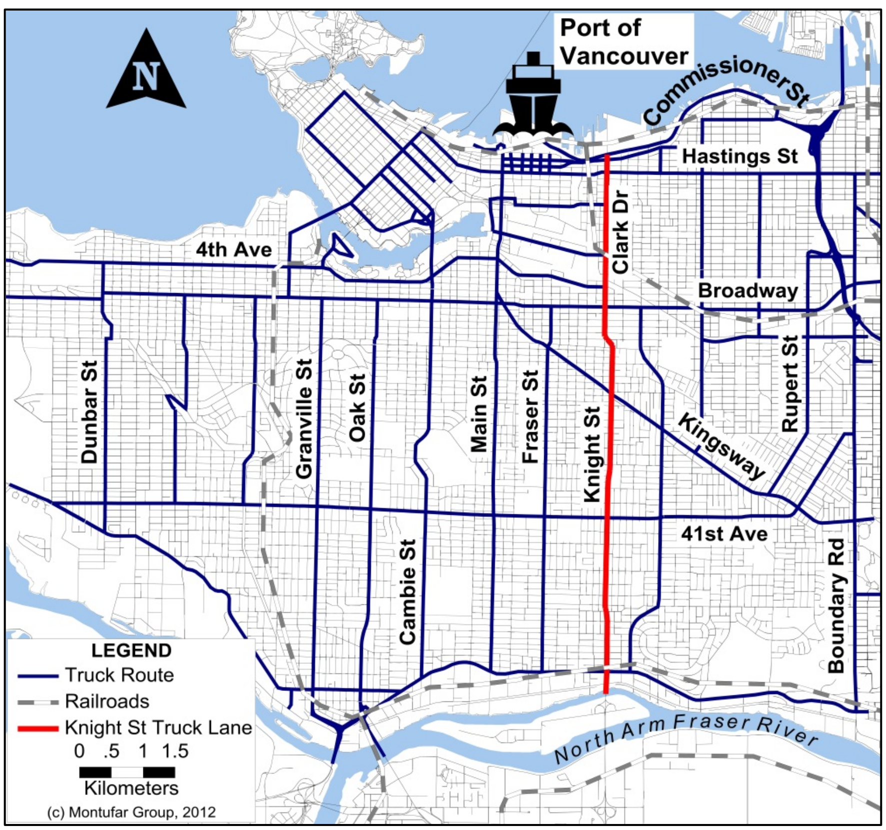


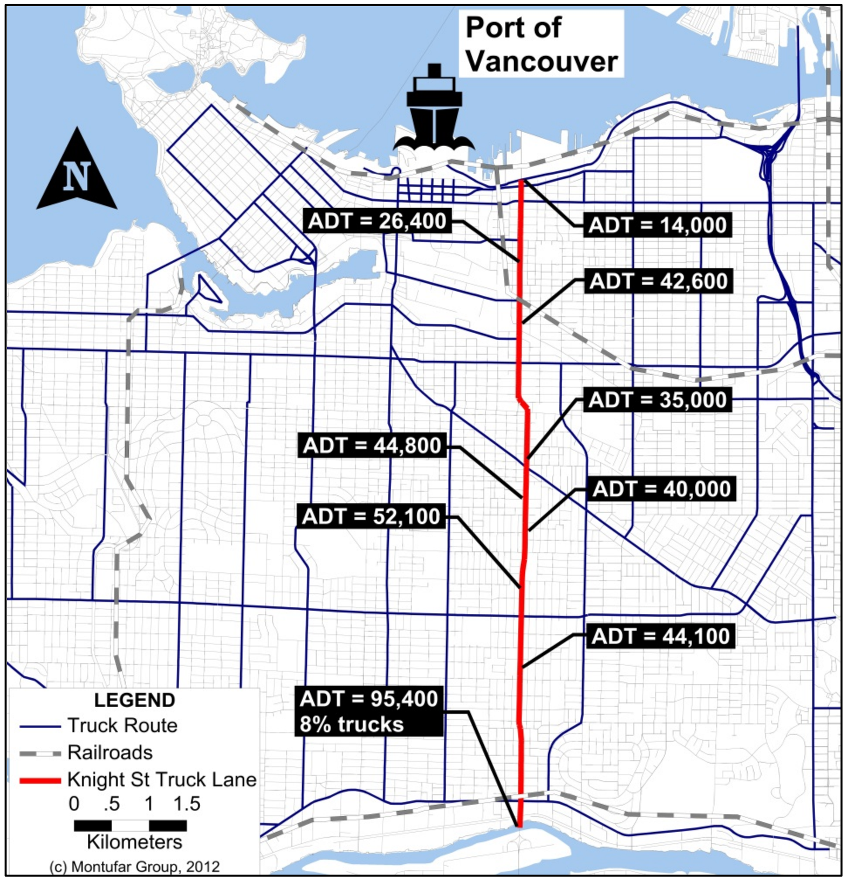
Figure 15: Knight St/Clark Dr corridor and area

This corridor has been designated as part of the Major Road Network for Greater Vancouver. The City receives funding contributions from TransLink for maintenance and major projects associated with the corridor.

The Knight St/Clark Dr corridor is, for the most part, a six-lane undivided road. There are 72 intersections along this corridor. Of these, 25 are signalized and use either fixed-time, semi-actuated, fully-actuated, or pedestrian-actuated cycles. Nearly one-half of the 25 signalized intersections (11 of 25) are pedestrian-actuated.

The speed limit along the entire length of the corridor is 50 km/hr. There is parking allowed throughout the corridor on both sides of the street. There are also NO STOPPING restrictions between 15:00 and 18:00 and/or between 07:00 and 09:30 from Monday to Friday, on various sections along the corridor.

This route has turning restrictions at various locations for port-destined trucks. For example, at the intersections with Broadway and 41st Ave, trucks going to the port are not allowed to turn east. The north end of the corridor is the entrance to Port Metro Vancouver and only vehicles entering the port are allowed on the ramp.



Source: City of Vancouver Automatic Count Program

Figure 16: 2011 two-way daily traffic volumes on Knight St/Clark Dr

The daily traffic volumes generally range from about 15,000 vehicles per day at the north end of the corridor, to 95,000 vehicles per day at the Knight St Bridge. Figure 16 illustrates 2011 two-way traffic volumes. Truck traffic along the corridor is between 8 and 9 percent of total traffic. However, unlike passenger vehicle traffic, which peaks twice in the day, truck traffic peaks only once in the day. This occurs between 10:00 and 11:00, when trucks account for 13 percent of total traffic. Port Metro Vancouver currently handles over 3,000 vessels per year, or about 1.4 million TEUs. Nearly 70 percent of import containers are loaded onto rail for shipment outside the Lower Mainland; the rest are trucked to local businesses. The Vancouver Port Authority estimates that container traffic will nearly quadruple by 2020.

The northern portion of the corridor is mainly industrial. South of 7th Ave the land use is mainly residential with some commercial land. The largest commercial concentration in the corridor is near Kingsway and Knight St.

General traffic congestion is a concern, particularly for goods movement. A travel time and delay study conducted along the corridor in May 2012 found an average travel delay of between 8 and 10 minutes, compared to free-flow conditions. The locations where most of the delay was observed are: Broadway, 7th Ave, 37th Ave, and 41st Ave.

Collisions on this corridor are a problem for the City of Vancouver. According to the Insurance Corporation of British Columbia, collisions on the corridor cost over $20 million per year. The most common contributing factors to collisions are increased lane changing, weaving, and erratic driving behaviour between intersections. Truck collisions account for only three percent of all collisions in this corridor. However, given the large truck volumes observed in this corridor, eight intersections along the corridor fall in the top 10 truck collision locations in Vancouver. Some of the intersections with significant collision problems along this corridor are: the Knight Street Bridge, Knight and 49th St, Knight and 33rd St, Knight and Kingsway, and Clark and 1st St.

CONSIDERATIONS FOR TRUCK LANES BASED ON CASE STUDY

The following are considerations for truck lanes on major arterials based on the Knight St/Clark Dr corridor case study.

- **Stakeholder engagement and involvement are essential for helping decide if truck lanes are appropriate.**

  Depending on the area of the city where a truck lane is intended to be implemented, it can be a controversial topic. Extensive stakeholder engagement and public consultation can help inform constituents about truck lanes and obtain input for their planning, design, implementation, and operation. The fact that the corridor runs through a series of residential areas presents challenges that would require extensive public consultation.

  The opportunities associated with the implementation of truck lanes in this corridor need to be weighed against the costs and presented to all stakeholders for their input.

  Important questions to consider during stakeholder consultation for this corridor include: What are the options regarding freight movement from the existing origins to destinations? Are there opportunities for temporal use of truck lanes (i.e., during certain times of the day)? Would a truck lane improve intermodal operations to and from the Port of Vancouver?

- **Truck-friendly designs and operational treatments should be considered prior to truck lanes.**

  Before considering truck lanes as an option, a thorough understanding of the problem being addressed is required. The reason for this is to explore the possibility of implementing truck-friendly treatments that could also result in the safe and efficient movement of goods but without needing to implement a truck lane. In the case of this corridor, there may be other options to consider prior to the implementation of a truck lane.

Some of the issues to investigate prior to the implementation of a truck lane include: traffic signal coordination performance, the extent of use of advanced technologies for improved reliability along the corridor, and temporal alternatives for the movement of trucks (e.g., night time deliveries or port access/egress). There are a few intersections that currently function as congestion points along the corridor. While the implementation of a truck lane through these intersections may assist truck movement, the net effect on the overall system may be a negative one.

- **Temporally-operated truck lanes may be appropriate.**

  There are situations where a truck lane may operate successfully if managed to service specific periods of demand. One example is where truck demand is not consistent and sustained throughout the day. In the case of this corridor, unlike the situation with general traffic which peaks twice per day, truck traffic peaks only once in the day. This occurs between 10:00 and 11:00 a.m. At this time, trucks account for 13 percent of total traffic. In this type of situation, a temporally-operated truck lane may be more appropriate than a full-time truck lane.

  Three issues to consider in determining the attractiveness of a temporally-operated truck lane are: on-street parking allowance, types of commodities carried in the corridor, and environmental costs due to congestion. In essence, when considering these issues, it is important to ask these questions: (1) is it possible to prohibit parking during certain times of the day to allow trucks to exclusively use those lanes during those periods?; (2) does the corridor carry high-value, time-sensitive commodities that would warrant expedited service along the corridor, even if only for a few hours of the day?; and (3) what are the environmental costs that can be attributed to existing congestion in this corridor for trucks and total traffic?

- **Curbside parking can preclude the ability to provide truck lanes.**

  In some cases curbside parking can preclude the ability to provide truck lanes and options should be explored to relocate or remove this parking supply.

  In the case of this corridor, there is parking allowed throughout the corridor on both sides of the street. There are also NO STOPPING restrictions between 3:00 and 6:00 p.m. and/or between 7:00 and 9:30 a.m. from Monday to Friday, on various sections along the corridor. These restrictions are associated with peak-hour traffic flows.

Curbside parking on Knight St

  Also, since residential dwellings have their own parking spaces on their properties, there is no need for residents to have full time access to on-street parking.

  In considering the implementation of truck lanes along this corridor it is important to consider the importance that on-street parking may have. This should be compared to the costs associated with delayed delivery of goods as a result of congestion due to decreased capacity. If parking is necessary, consider whether it can be moved to adjacent streets or behind businesses located along the corridor.

- **Land use planning and infrastructure design are essential for freight transportation.**

  Truck lanes can sometimes be a reactive response to poor land use planning and infrastructure design decisions. Taking a proactive approach to freight transportation is more beneficial than being reactive. In other words, it is necessary to consider the needs associated with the movement of goods every time there is an infrastructure project being undertaken, or a land use development plan. Are there any future land use changes or transport supply changes in the region that could impact truck traffic movement along this corridor?

S-Curve on Knight St/Clark Dr corridor

  The Knight St/Clark Dr corridor became a major truck route in the mid 1970s with the construction of the Knight St Bridge. While this may have not been the original intention of the bridge construction, the result was the creation of a major truck corridor through residential land. While implementation of a truck lane may be beneficial to improve the safety and efficiency of goods movement along this corridor, the fact that the corridor travels through residential areas introduces challenges that would not be there if this route were located in an industrial zone.

- **Taking a proactive approach to road safety is necessary when considering truck lanes.**

  The safety operation of a facility is essential at all times. Prior to implementing a truck lane it is important to do a thorough investigation of potential areas of concern from the safety perspective. For example, the geometric design of the road should be assessed to determine if improvements are required to accommodate trucks better. In the case of this corridor, just north of 15th Avenue there is a tight S-curve located on a slope. This poses a challenge for vehicles traveling south as the bottom of the slope represents the end of the curve, where a traffic signal is located. This type of geometry would not be conducive to implementing a truck lane.

  Another example is the interaction between different users of the transportation system. Poor control of interactions between trucks and other road users, especially vulnerable road users, can introduce a safety problem with truck lanes. While the corridor itself is not a bicycle route, it is intersected by the existing bicycle route network at three locations. Furthermore, there are potential pedestrian crossing opportunities at each of the 72 intersections (including the 25 signalized intersections) along the corridor. The presence of bicycle routes intersecting this corridor, combined with pedestrian activity in residential areas near schools and commercial areas can pose safety problems.

  While trucks collisions account for only three percent of all collisions in this corridor, it is likely that the outcome is severe given the difference in mass between objects. Therefore, the risk associated with the interactions between various road users is something to consider. Some questions to consider are: Are there locations that require special attention to improve interaction between various road users once truck lanes are implemented? Are appropriate and properly-operating crossing control devices present to safely accommodate pedestrians? Is the geometry of the corridor adequate to safely implement truck lanes?

3.6 TRUCK ROUTE FOR SPECIALLY-PERMITTED VEHICLES

Some routes in Canadian cities permit access for specially-permitted higher productivity vehicles, such as longer combination vehicles. These vehicles are larger and require special consideration in the urban context. As such, they are typically permitted only on certain routes during certain temporal periods. This approach is a form of operationally-separating larger vehicles from general traffic, particularly at times and places where their interaction is perceived to be potentially detrimental. Moncton was selected as the location to illustrate the case of truck routes for specially-permitted vehicles.


Dieppe Blvd at Adelard Savoie Blvd intersection


Macnaughton Ave at Urquhart Ave intersection


Edinburgh Dr south of Berry Mills Rd intersection

SITE DESCRIPTION

The Province of New Brunswick, like many other Canadian provinces, permits Long Combination Vehicles (LCVs) to operate on specified four-lane, divided provincial routes. Figure 17 shows a map of these routes within the regional context. The New Brunswick portion of this network connects via the Trans-Canada Highway (Route 2) into Nova Scotia to the east as far as Halifax. To the west, a short segment of the Trans-Canada Highway (Route 185 in Québec) remains undivided; however, planned dividing of this segment will connect the New Brunswick network to the Québec City-Windsor corridor. The New Brunswick LCV network comprises:

- Route 2 from the New Brunswick/Nova Scotia border to an approved staging area (proposed by the applicant) east of the end of the two-lane, two-way sections of Route 2 in advance of the New Brunswick/Québec border;
- Route 1 from the junction of Routes 1 and 2 at River Glade, New Brunswick to an approved staging area east of the existing terminus of the four-lane divided section of Route 1 near the Point Lepreau interchange; and
- Route 95 from the Route 95/Route 2 interchange at Woodstock, New Brunswick to a staging area near the Canada/U.S. border at Houlton, New Brunswick.

To enable accessibility and connectivity into carriers' terminals in urban areas, municipalities in New Brunswick may give permission for limited-distance travel on two-lane highways as requested by the carrier. This permission is subject to provincial approval. In Moncton, as specified by provincial requirements, LCV carriers wishing access on a two-lane undivided road must provide evidence that the LCV configurations can safely maneuver along the proposed routing. This evidence must clearly show the path that the LCV will travel relative to traffic lanes, pavement and shoulder edges, traffic sign posts, guide rail, lighting posts or masts, lane dividers or barriers, and any other potential obstacles. In addition, carriers must provide written permission if they intend to access private property. If no issues arise from this process, municipal representatives proceed with the permit. If issues arise, modifications to the routing or infrastructure improvements may be required. In certain cases, municipal representatives may ride on an LCV as it travels along the route to gain a better practical sense of how the vehicle operates.

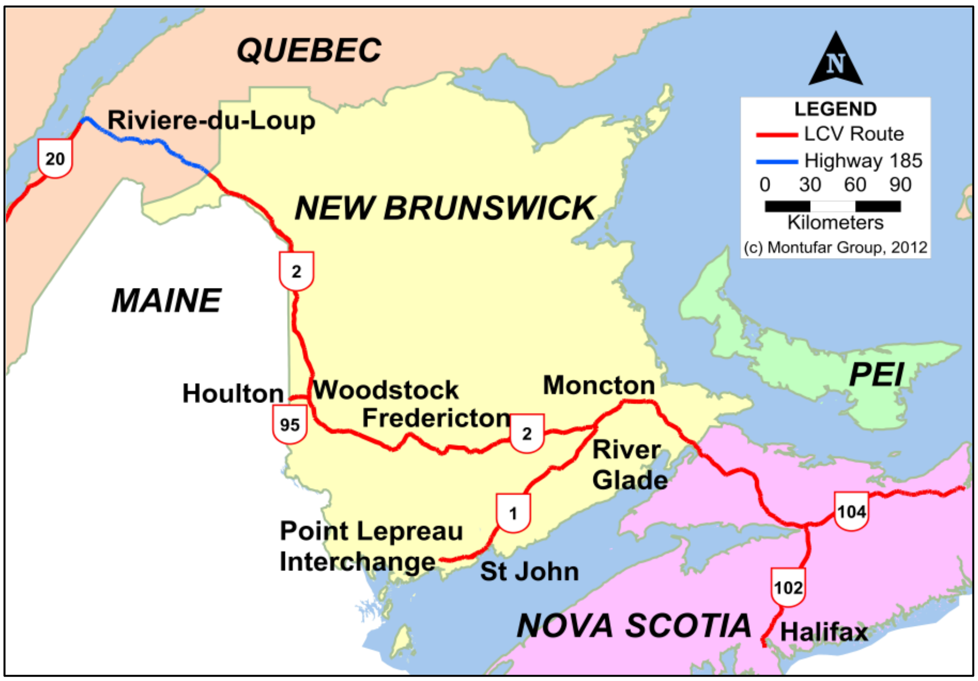


Figure 17: Regional LCV route network connected to Moncton

Figure 18 shows the three routes that currently enable LCV access into Moncton: (1) Dieppe Blvd; (2) Harrisville Blvd; and (3) Berry Mills Rd.

The Dieppe Blvd LCV access route is on the east side of Moncton and connects carriers' terminals with Route 2 via the Route 15 interchange near the Greater Moncton International Airport. LCVs are permitted access from Route 15 (2.9 km, divided) onto Dieppe Blvd (0.5 km, undivided) and then to Adelard Savoie Blvd (0.8 km, undivided). This access route permits LCV travel in both directions.

The Harrisville Blvd LCV access route is on the east side of Moncton and connects carriers' terminals to Route 2 via the interchange of Route 2 and Harrisville Blvd. LCVs are permitted access from Route 2 onto Harrisville Blvd (0.3 km, divided), to Macnaughton Ave (2.6 km, undivided), Caledonia Rd (0.8 km, undivided), and then back to Route 2 via the Elmwood Dr interchange. This access route permits LCV

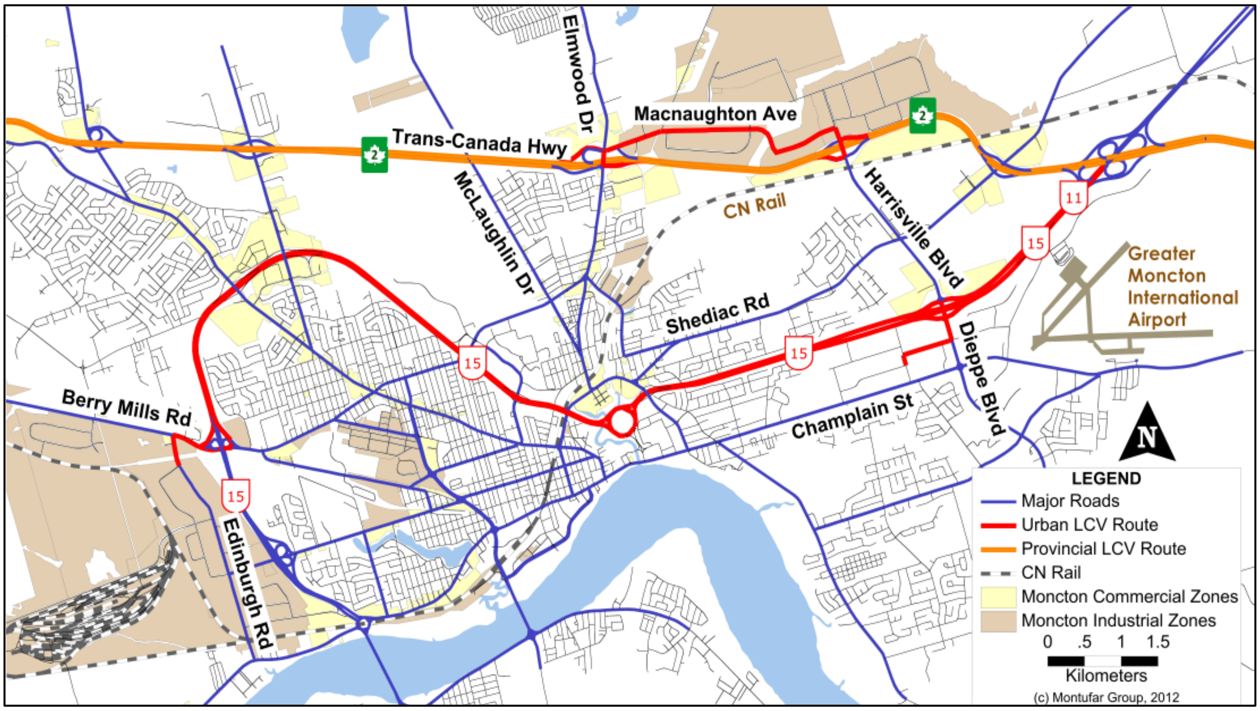


Figure 18: LCV routes in Moncton

traffic only in the westbound direction.

The Berry Mills Rd LCV access route is on the west side of Moncton and connects carriers' terminals to Route 2 via the Route 15 interchange near the Greater Moncton International Airport. LCVs are permitted access along Route 15 (16.0 km, divided), through the Wheeler Blvd roundabout, to the interchange of Route 15 and Berry Mills Rd (0.4 km, undivided), and finally onto Edinburgh Dr (0.6 km, undivided). This access route permits LCV traffic in both directions.

CONSIDERATIONS FOR TRUCK LANES BASED ON CASE STUDY

The following are considerations for truck routes for specially-permitted vehicles based on the Moncton case study.

- **Truck lanes provide connectivity and accessibility for higher productivity vehicles**

  The productivity benefits of LCVs that are gained on long-distance hauls are reduced if they cannot efficiently and reliably access certain urban areas. Typically, carriers assemble or disassemble an LCV at their terminal or a staging area. Urban pickups and deliveries are normally handled by conventional trucks. Thus, providing effective connectivity and accessibility for LCVs in urban areas may involve granting them access to a small number of relatively short undivided routes. In Moncton, the major LCV carriers are all served by the three access routes identified in this case study. The need for additional access routes is not currently expected.

Although not yet developed in most urban areas, the concept of strategically locating LCV staging areas—ideally used by multiple carriers—may provide benefits to both LCVs and the motoring public by reducing the need for LCVs to travel in urban areas. As LCV travel increases, this need may increase. Truck lanes offer a potential means to access these staging areas.

- **Road geometry must accommodate LCV performance characteristics**

  Permitting LCV operations on undivided urban roads requires careful consideration of vehicle performance characteristics—particularly turning radius and low-speed off-tracking—and the road geometry and locations of obstructions on the desired route. Collaborative efforts between LCV carriers and municipal officials during the permitting process are essential for establishing a safe and appropriate routing.

  Better understanding of the handling capabilities of LCVs provides insights into the types of physical changes that may be required. In certain cases, existing road geometry may be sufficient even though actual lane widths and curb radii may not provide adequate space for LCV manoeuvres. It may be reasonable to allow these vehicles to encroach into opposing traffic lanes or onto shoulders provided that LCV travel occurs during times of the day with low traffic volume, thereby lowering or eliminating the safety risk. In other situations, minor adjustments such as widening curb radii or relocating signs or traffic signals may be required.

- **Traffic volume, vehicle mix, and temporal variations are important considerations for accommodating LCVs**

  Although detailed traffic volume data (specifically, vehicle classification mix and temporal variations) are unavailable for the access routes considered in this case study, these features influence the appropriate accommodation of LCVs on undivided urban routes.

  The approval of urban LCV access may depend on the types of users present on the routes being considered. For example, industrial areas that serve primarily trucks and industry employees are more conducive for LCV travel because the users are generally more familiar with their operating characteristics. In contrast, residential or commercial areas attract a higher proportion of passenger vehicles and vulnerable road users. Interactions between LCVs and these users may be less desirable. Notably, one of the Moncton access routes (Harrisville Blvd Access) has successfully integrated LCV travel with a dedicated bicycle lane.

  Understanding temporal variations in traffic volumes is also important, since operational separation of LCVs from other traffic typically involves temporal restrictions. Many Canadian cities,

Truck on Caledonia Rd approaching Elmdale Dr including Moncton, restrict urban LCV travel to particular times of the day. To some extent, however, these restrictions simply formalize what LCV operators may prefer anyway (i.e., to avoid times when LCV travel may be operationally challenging). There has been some pressure from LCV carriers to relax these restrictions, thereby improving the flexibility with which they operate.

- **Stringent regulatory oversight helps ensure productivity benefits without incremental safety risks**

  LCV operations in all parts of Canada occur under stringent regulatory oversight, beyond those governing conventional trucking operations. Among others, these regulations define: LCV routing, speed, temporal operating conditions, incident reporting requirements, vehicle specifications, and driver and carrier credentials.

  Recent Canadian-based studies of LCV safety performance find that the collision rate for Turnpike doubles is lower than those for all other truck configurations, despite having physical performance characteristics that make their operation more challenging. Many of these studies cite the permitting conditions as part of the reason for this. As LCVs become more common in Canadian urban areas, the level of operational separation between them and other types of traffic may naturally degrade. Truck lanes, in the sense that they are discussed in this case study, may be an option to help limit interactions between LCVs and other traffic and ensure that productivity benefits can continue to be realized without incremental safety risks.

- **Neighbouring jurisdictions should act harmoniously to accommodate LCVs**

  Given the long-distance, multi-jurisdictional nature of LCV trips, it is important that neighbouring jurisdictions (including municipalities) work collaboratively to harmonize the conditions under which LCVs operate. Failure to do so potentially reduces the productivity and emissions benefits derived from LCV travel by increasing travel time.

  In Moncton, LCVs accessing terminals along Edinburgh Dr (via the Berry Mills Access) on the west side of the city are required to travel across Moncton rather than connecting to this area via a more direct route from the Trans-Canada Highway (see Figure 18). From a travel time perspective, the desired route is an undivided road (Berry Mills Road) which is under provincial jurisdiction. Currently, the provincial permit does not allow LCV travel on undivided roads, except in municipal jurisdictions where special access has been granted. Therefore, LCV trips to/from the west are lengthened and a higher proportion of the trip occurs in the urban area. Further harmonization of the LCV policies between the province and the municipality may be needed to address this issue.

3.7 OBSERVATIONS FOR IMPLEMENTING TRUCK LANES

The cases studies conducted for the development of the Resource Document provide the basis for identifying favourable and unfavourable conditions for implementing truck lanes in Canadian urban areas. Each case study addresses a different type of truck lane, in a different jurisdiction, for different freight movement situations. The following tables present a summary of favourable and unfavourable conditions, based on observations from each case study, for truck lane implementation in each of the studied situations. While it is understood that each jurisdiction has its own needs, priorities, available resources, demand, and other issues, the observations presented in these tables raise issues that should be considered by those involved in making decisions regarding truck lane implementation in their jurisdictions. Details about each case study are presented in Appendices A to F.

Physically-separated truck lane on a freeway – Highway 427, Ontario *(Appendix A)*

Favourable conditions for truck lane implementation	Unfavourable conditions for truck lane implementation
• Total traffic volumes (up to 183,000 vpd) exceed the range of criteria defined in the literature (i.e., between 80,000 and 120,000 vpd) • The Highway 427 extension will be within 3 km of an intermodal terminal (defined as a criteria in the literature) • 3 or more lanes of traffic per direction • Grade-separated intersections along corridor • Connects to a major freight generator • Supports time-sensitive and high-value goods movement • Potential to connect to a larger truck lane network (i.e., GTA West Corridor) • Truck crash rate (115 per 100 million VKT) higher than the criteria defined in the literature (i.e., 101 truck crashes per 100 million VKT) • Truck lane length (18 km) meets the criteria defined in t greater than 16 km)	• HOV lane already being implemented along corridor • Truck volumes (20,000 per day) are lower than the criteria defined in the literature (i.e., 5,000 trucks per lane or more than 60,000 trucks per day) • High construction cost to implement • Additional weaving resulting from truck lane could increase truck collisions • Providing two additional GPLs per direction is likely to outperform two truck lanes per direction • Truck percentage (about 10 percent) is less than the criteria defined in the literature (i.e., 14 to 30 percent)

Truckway – Regina Global Transportation Hub *(Appendix B)*

Favourable conditions for truck lane implementation	Unfavourable conditions for truck lane implementation
• Provides about 30 min in travel time savings for a trip that currently requires 1.5 hours to complete • Removes Turnpike doubles and triples from major commuter route • Ability to delay costs of twinning Pinkie Rd • Helps attract tenants to Global Transportation Hub	• Grade-separated intersection might be necessary at the junction of Highway 11 and the West Bypass to accommodate left-turning Turnpike doubles and Turnpike triples • Potential for many cars violating the truck lane designation since this route would be attractive for passenger vehicles

Truck bypass – Waller St *(Appendix C)*

Favourable conditions for truck lane implementation	Unfavourable conditions for truck lane implementation
• Allows trucks to bypass certain downtown streets • Provides an efficient connection between major freight corridors in Ontario and Quebec • Reduces lane changes made by trucks since the truck lane provides the most efficient route and discourages trucks from deviating from the truck lane • In addition to the truck lane, Waller St also has a bus lane and bike lane – these are effective at segregating different road users at a location where many buses, cyclists, pedestrians, trucks, and cars interact	• Truck queues frequently block bus access to transitway • Truck traffic volumes do not warrant a dedicated lane • Poor compliance by passenger vehicles

Operationally-separated truck lane on a freeway – Glenmore Tr *(Appendix D)*

Favourable conditions for truck lane implementation	Unfavourable conditions for truck lane implementation
• 3 to 4 lanes of traffic per direction • Grade-separated intersections along corridor • Truck lanes would be implemented as newly constructed lanes which could improve compliance by passenger vehicles compared to converting existing lanes to truck lanes • This is currently an unreliable and congested route which negatively impacts truck travel time • Truck traffic volumes are among the highest during the periods with highest total traffic volumes	• Short-spaced interchanges could produce excessive weaving, increasing the risk for truck crashes, and discouraging trucks from using them • Truck lane benefits may be relatively small compared to overall network deficiencies since the distance travelled by trucks on Glenmore Tr may be short compared to their overall trip • Unable to enforce without changes to legislation • Truck traffic volumes may not justify dedicated lane during peak commuter periods and off-peak traffic volumes are likely too low for trucks to benefit from a truck lane

Truck lane on a major arterial – Knight St *(Appendix E)*

Favourable conditions for truck lane implementation	Unfavourable conditions for truck lane implementation
• High truck traffic volumes throughout the day relative to other similar routes in the jurisdiction • Supports trucks carrying high-value, time-sensitive freight generated by the port • Major arterial through the jurisdiction for freight transportation • No expected additional road infrastructure developments in the near term to move trucks into and out of the jurisdiction more efficiently • Some sections along the corridor have 3 lanes of traffic per direction • Long delays for all traffic during peak periods • Much of the truck traffic activity takes place along this corridor during off-peak periods • Long sections of road with desirable cross-sections for the implementation of a truck lane – particularly in the sections with 3 lanes of traffic per direction	• Curbside parking allowed along the corridor • Most of the corridor is located through residential areas • Active transportation network intersecting at various locations along the corridor • Undesirable road geometry along sections of road with 2 lanes per direction. • Potential buy-in difficulty from residents in the area

Truck route for specially-permitted vehicles – Moncton *(Appendix F)*

Favourable conditions for truck lane implementation	Unfavourable conditions for truck lane implementation
• Truck lanes primarily serve industrial land uses • LCV operations on undivided routes benefit from stringent regulatory oversight • Collaboration between the municipality and carriers enhances understanding of vehicle performance characteristics and modification requirements • Restricting LCV operations to certain time periods reduces undesirable interactions between LCVs and other road users	• Truck lanes through residential or commercial areas may induce undesirable interactions between LCVs and other road users • Undesirable road geometry may be present along routes under consideration for LCV access • Adjustments may be necessary and potentially costly • Locations with sustained, high traffic volumes throughout the day and nighttime may be unfavourable • Locations which serve a high proportion of vulnerable road users may be unfavourable

CHAPTER 4 – CONSIDERATIONS FOR URBAN TRUCK LANES IN CANADA

The Technical Report derives urban truck lane considerations primarily from U.S. literature which has little relevance to many Canadian urban contexts. Stakeholder interviews were conducted to supplement these considerations and although most of the stakeholders were Canadian, significant knowledge gaps remained. Six case studies were completed to develop new knowledge to help bridge this gap and reveal urban truck lane considerations specific to Canada.

This chapter aggregates the relevant urban truck lane considerations for Canada from the Technical Report and the new considerations revealed in the case studies. The chapter provides basic issues to consider – users of the Resource Document are strongly encouraged to refer to detailed information provided in the attached Technical Report and case studies contained in the appendices.

4.1 CONSIDERATIONS PRIOR TO IMPLEMENTING TRUCK LANES

Important issues to consider prior to implementing a truck lane are: (1) understanding the urban freight transportation system; (2) defining the problem; (3) identifying options for accommodating urban truck traffic; and (4) if truck lanes are selected as an option, determining the most appropriate truck lane configuration for the given situation.

Understanding the Urban Freight Transportation System

Freight is often ignored and/or misunderstood when planning, designing, and operating the urban transportation system. This is partly due to insufficient data, the confidential nature of freight transportation activity, and the emphasis placed on other modes of transportation (e.g., public transportation, passenger vehicles, and vulnerable road users). Urban trucking comprises a portion of the urban freight transportation system, and truck lanes represent one of the more aggressive measures for accommodating truck traffic. A range of truck-friendly transportation options exists to improve urban freight accommodation that can often be integrated into the existing transportation system more easily and effectively than truck lanes. Furthermore, the issues that truck lanes are intended to address (e.g., travel time, reliability, safety, and emissions) may be symptoms of a larger issue such as poor land use planning.

Prior to considering truck lanes, a thorough understanding of the freight transportation system should be acquired. This understanding should be based on data obtained through permanent data collection programs and through regular collaboration with stakeholders. Data analysis and communication with stakeholders are fundamental for selecting the most effective option, as other strategies may be more effective at addressing urban truck traffic issues.

The appeal of truck lanes is dependent on the commodity being transported, time-of-day traffic characteristics, and truck origin-destination patterns. Corridors with high-value, time-sensitive commodities are candidates for truck lanes. If truck lanes are designed to accommodate heavier trucks, corridors carrying bulk commodities (e.g., low-value, not time-sensitive) are also candidates. Corridors with high truck volumes during morning and afternoon peak periods or with high traffic volumes during the mid-day period might also be candidates for truck lanes, depending on the jurisdiction's approach to freight accommodation.

The origin and destination of trucks can influence the appropriateness of truck lanes. For example, corridors connecting two major freight nodes (e.g., major distribution centres, intermodal terminals, ports) might be candidates for truck lanes. Since most urban pick-up and delivery trips are short and often utilize many different routes, distance travelled along the truck lane by trucks is also an important factor that will affect the benefit of the lane.

Container trucks often carry high-value, time-sensitive commodities

Aggregate trucks often carry low-value, time-insensitive commodities

Defining the Problem

Prior to considering truck lanes as an option, the issue(s) to be addressed must be clearly defined and understood. The literature shows that truck lanes are capable of addressing congestion, safety, and emissions issues in certain situations. However, stakeholders suggest that Canadian urban truck lanes may be better suited for improving accessibility and productivity. Truck lanes are not recommended as a strategy to prolong pavement life, reduce maintenance costs, or generate revenue through tolls. Although carriers are interested in reducing emissions and fuel consumption, this is not viewed as a rationale for implementing them.

Despite the potential for truck lanes to generate benefits for other road users (e.g., reducing congestion, decreasing collisions), they should be implemented primarily to improve truck traffic conditions. Prior to considering truck lanes, careful examination of the transportation system should be conducted to confirm that improving truck traffic operations is the primary objective and that the shared use of lanes by cars and trucks is an underlying cause of the problem.

Identifying Options for Accommodating Urban Truck Traffic

In general, truck carriers do not show an overwhelming support for urban truck lanes in Canada. Many carriers seem skeptical of truck lanes in Canadian urban areas but are willing to further investigate and understand this option, particularly exploring operationally-separated truck lane configurations, no-car lanes, and truck lanes facilitating the operation of longer and/or heavier trucks in urban areas. The general opinion of the motor carrier industry is that other strategies, such as truck-friendly treatments, should be considered first.

Alternative options to truck lanes include, but are not limited to: night-time deliveries, improving signage and communication for truck drivers, improving geometry and loading zones in downtown areas, establishing or enhancing truck routes, constructing new general purpose lanes or corridors, and improving traffic management. Specific strategies include implementing and facilitating vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) technologies, and allowing trucks equipped with lane departure technologies to use shoulders during congested periods.

Despite the potential for truck lanes to generate benefits for other road users, they should be implemented primarily to improve truck traffic conditions.

Determining an Appropriate Truck Lane Configuration

If truck lanes are selected as the best option, there are different configurations and operational characteristics that need to be understood. Configurations to consider are physically-separated truck lanes, operationally-separated truck lanes, allowing trucks to use HOV or parking lanes, and interchange bypasses. The problem to be addressed and the site-specific characteristics will influence which configuration is appropriate.

Operational considerations include temporally restricting the operation of truck lanes, weaving interactions between trucks and cars at access/egress points along the truck lane, providing increased accessibility to the lane at the expense of travel time, reliability, and safety, truck diversion rates and truck lane utilization, and opportunities for introducing Intelligent Transportation Systems (ITS) technologies. Each truck lane configuration operates differently and can influence which configuration is appropriate.

Physically-separated truck lanes on freeways designed to address congestion issues are only feasible on corridors with very high traffic volumes (total daily volumes around 200,000 and daily truck volumes greater than 20,000). There are few locations in Canada with these characteristics.

Threshold Criteria for Urban Truck Lanes

Thresholds in the literature are primarily based on U.S. studies and situations and might not be transferrable to Canadian urban areas.

Truck lanes as envisioned in the U.S. are unlikely to be feasible in Canada.

Major decision input variables to consider when planning or implementing truck lanes include: total traffic volume, truck traffic volume, truck percentage of total traffic, proximity to a freight generator, volume/capacity ratio, level of service (LOS), safety, truck lane length, and opportunities to operate longer or heavier trucks in an urban area. Table 6 summarizes the decision input variables and range of thresholds necessary to warrant the consideration of truck lanes as an option, as revealed in the literature. It is important to note, however, that these thresholds are obtained from a small number of reports primarily dealing with large U.S. cities. This table reveals a significant knowledge gap concerning threshold criteria for truckways, truck lanes on arterials, and truck routes for specially-permitted vehicles. However, it is these types of truck lanes that appear most applicable to Canadian urban areas.

The thresholds provided in Table 6 are primarily based on U.S. studies and situations and might not be transferrable to Canadian urban areas. These studies find that truck lane benefits are lower than the cost on corridors exhibiting these threshold criteria. From this perspective, truck lanes as envisioned in the U.S. are unlikely to be feasible in Canada; this conclusion is also supported by stakeholders interviewed for the development of the Resource Document.

In the absence of decision criteria for truck lanes, the literature identifies the following issues to consider:

- Use hourly traffic volumes rather than daily volumes as a threshold; a corridor may have high truck traffic volume during off-peak hours and would not benefit from a separate lane.
- Truck lanes should be at least 500 m long, otherwise there is a risk that benefits will not be realized and the truck lane may actually be detrimental to all road users. However, Waller St in Ottawa is an example of a successful truck lane that is less than 500 m. This underscores the fact that existing literature and experience is not necessarily applicable to Canada.
- The purpose of the truck lane will influence candidate locations. For example, if the purpose is reducing travel time and improving reliability, then corridors with trucks carrying high-value, time-sensitive goods should be selected over other corridors which may have higher truck traffic volume but which are used to transport low-value, time-insensitive products (e.g., bulk commodities).

Table 6: Decision input variables and thresholds by truck lane type based on literature review

Decision input variable	Physically-separated truck lane on freeway	Truckway	Truck bypass	Operationally-separated truck lane on freeway	Truck lane on major arterial	Truck route for specially-permitted vehicles
Total traffic volume	80,000 to 120,000/day		>10,000/day	80,000 to 120,000/day		
Truck traffic volume	>5,000/lane or >60,000/day		>5,000/day	5,000 to 60,000/day		
Truck percentage	14 to 30%			14 to 30%		
Freight generator proximity	<3 km from intermodal terminal			<3 km from intermodal terminal		
Level-of-service	LOS E or worse			LOS E or worse		
Safety	>63 truck crashes per 100 million VMT or truck crash rate > national avg			>63 truck crashes per 100 million VMT or truck crash rate > national avg		
Truck lane length	>16 km		N/A		>0.5 km	
Truck speed reduction	N/A		>32 km/h			
Volume of merging trucks	N/A	N/A	>2,000/day	N/A	N/A	N/A
Volume on upgrade	N/A	N/A	>10,000/day	N/A	N/A	N/A
Truck volume on upgrade	N/A	N/A	>5,000/day	N/A	N/A	N/A
Truck volume on ramp meter	N/A	N/A	>1,000/day	N/A	N/A	N/A
Number of total lanes				4 or more per direction		
Presence of major OD			N/A	Yes		

Blank cells indicate a threshold is unavailable; N/A indicates the decision input variable is not applicable.

4.2 PLANNING AND DESIGN ISSUES AND CONSIDERATIONS

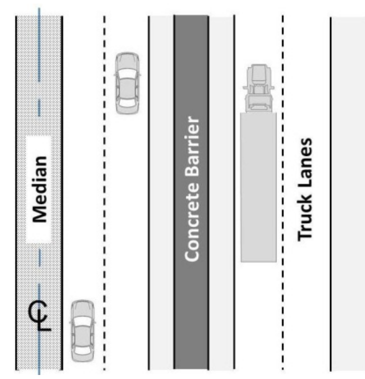
The Technical Report and case studies reveal planning and design considerations for urban truck lanes in Canada. Table 7 provides a summary of these considerations.

4.2.1 Technical Report Considerations

According to Technical Report findings, truck lane planning and design requires making decisions about the type of separation between trucks and cars (i.e., physical or operational), the location of the truck lane (e.g., inner or outer lane), the cross-sectional design (e.g., lane width, geometry), and construction standards (e.g., pavement structure). The Resource Document provides a preliminary discussion about geometric issues and does not address construction standards.

Physically-Separated Truck Lanes

Physically-separated truck lanes can be provided on freeways, as truckways, or as bypasses and may require the construction of new lanes. Separation can be provided by concrete barriers, cables, pylons, guardrails, grass medians, or grade separation. Compared to operationally-separated truck lanes, they typically require more right-of-way (ROW), require constructing acceleration and deceleration lanes, and are more difficult to retrofit into current highway systems.



Physically-separated truck lane on freeway schematic

Physically-separated truck lanes provide a protected driving environment to reduce the potential of truck-car crashes, particularly those caused by weaving and lane change interactions between trucks and cars. Collisions occurring in GPLs generally do not impact the operations in physically-separated truck lanes.

A major challenge of providing barrier separation is determining the location of access points to truck lanes. A balance is required to minimize disruption in truck lanes resulting from merging and weaving trucks but also to provide appropriate accessibility to truck lanes to ensure trucks use these lanes and are able to serve their origins and destinations. The locations of access points are usually based on existing roadway configuration, origin-destination (OD) patterns of trucks, and connections with major freight generators.

Physically-separated truck lanes on freeways are conducive to tolling by minimizing violations and improving the ability to guarantee reduced travel time and increased reliability. They are also more conducive for long-distance truck operations with few intermediate stops. Most investigations into physically-

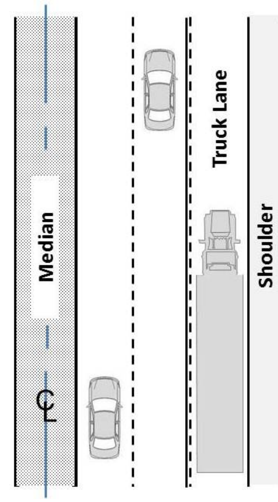
Table 7: Planning and design considerations for truck lane implementation in Canadian urban areas

Planning and design considerations from the Technical Report	Planning and design considerations from the case studies
• They type of problem to be addressed by the truck lane, and the site-specific characteristics, especially available right-of-way, will influence the truck lane configuration to use. • Physically-separated truck lanes on freeways designed to address congestion issues are only feasible on corridors with very high traffic volumes (total daily volumes around 200,000 and daily truck volumes greater than 20,000). • Major decision input variables to consider when planning or implementing truck lanes include: total traffic volume, truck traffic volume, truck percentage of total traffic, proximity to a freight generator, volume/capacity ratio, level of service (LOS), safety, truck lane length, and opportunities to operate longer or heavier trucks in an urban area. • There is a significant knowledge gap concerning threshold criteria for urban truckways, truck lanes on arterials, and truck routes for specially-permitted vehicles. Yet, these are the types of truck lanes that appear most applicable to Canadian urban context. • Use hourly traffic volumes rather than daily volumes as a threshold to account for temporal variations in truck traffic. • Truck lanes should be at least 500 m long, otherwise there is a risk that benefits will not be realized and the truck lane may actually be detrimental to all road users. • The purpose of the truck lane (e.g., reducing travel time and improving reliability) can influence candidate locations for implementation. • Physically-separated truck lanes can be provided on freeways, as truckways or as bypasses and may require construction of new lanes. • Physically-separated truck lanes provide a protected driving environment to reduce the potential of truck-car crashes, particularly those caused by weaving and lane change interactions between trucks and cars. • A major challenge of providing barrier separation is determining the location of access points to truck lanes. • Operationally-separated truck lanes are generally easier to design and less expensive to construct.	• Truck lanes have the potential to be used as shared facilities with HOV lanes on freeways. • Truck lanes may be used as short connectors from general purpose lanes to freight intensive areas. • Strategic network planning and site design can provide the structure to segregate trucks and cars by designing truck lanes that directly serve freight movement in industrial areas. • Truck lanes have the potential to be used as temporary solutions to certain types of problems. • Truck lanes can be used as a tool for specially-permitted vehicles to access urban staging areas to assemble/disassemble trailers closer to the source of origin or destination. • Strategic land use planning can assist in the creation of “natural” truck lanes by protecting and developing land exclusively for industrial purposes. • Stakeholder engagement and involvement is essential for helping decide if truck lanes are appropriate for a given situation. • Truck lanes should form part of a network. • Land use planning and zoning are critical for the efficient movement of freight in a region. • Threshold criteria that can be used to screen for truck lane candidates are not available for Canadian urban areas. • Physically-separated truck lanes on freeways are unlikely to be successful in Canadian urban areas. • Truck lanes may be appropriate within the internal road network of an industrial area. • Understanding truck routing patterns is necessary to determine if truck lanes should be provided as inner or outer lanes. • Truck lanes are not recommended as a strategy to prolong pavement life, reduce maintenance costs, or generate revenues through tolls. • Truck lanes, operated parallel to dedicated lanes for other road users (e.g., cyclists, transit) might present the next level of urban traffic management to cope with the increasing volume of road users and more importantly, the increasing complexity of road user types.

Source: Developed by Montufar Group, 2012

separated truck lanes along freeways conclude that they are not warranted due to insufficient truck volumes and/or prohibitive costs to implement.

Operationally-Separated Truck Lanes

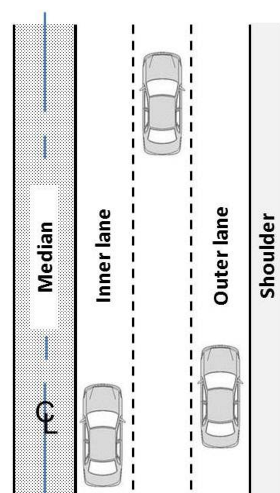


Operationally-separated truck lane schematic

Operationally-separated truck lanes can be provided on freeways, arterials, or as truck routes for specially-permitted vehicles and may be implemented by converting existing lanes to truck lanes instead of constructing new lanes. Pavement markings, rumble strips, or signage are operational options for separating truck lanes from GPLs. Operationally-separated truck lanes are generally easier to design, less expensive to construct, and can often be retrofitted into existing systems. They allow cars to weave through lanes at access/egress ramps and do not necessarily require the construction of an extra shoulder for passing or overtaking inoperative trucks. Their implementation is less risky than physically-separated options, and they are relatively simple to remove if the desired effect is not achieved. Operationally-separated truck lanes generally provide more access and encourage more trucks to use these facilities. However, increasing accessibility also decreases mobility benefits. Their implementation is more favourable for trucks making shorter trips.

Collisions occurring on GPLs will negatively affect the operation of an operationally-separated truck lane. This is due to the increased speed differential between vehicles in GPLs and adjacent truck lanes and cars from GPLs violating the truck lane regulation to avoid congestion.

Inner versus Outer Truck Lanes



Inner and outer lanes

Truck lanes can be implemented as inner (left-hand) or outer (right-hand) lanes. Each type impacts weaving and truck-car interaction differently. Inner truck lanes require trucks to weave across GPLs to enter or exit the facility whereas outer lanes require cars to weave through truck lanes to enter or exit the facility.

Inner truck lanes can be built within existing medians and minimize or eliminate the need to acquire additional ROW, can increase weaving conflicts with trucks and cars in urban areas, and may be infeasible if HOV lanes are already provided in the inner lanes. Outer truck lanes ease the construction of additional ingress and egress points in the future, do not require inner HOV lanes to be relocated, and improve access for emergency vehicles to clear collisions in these lanes.

Cross-Sectional Configuration and Geometry

Cross-sectional design configurations and geometric design include lane and shoulder width, number of lanes, lane separation method, ROW requirements, location of truck lane (i.e., inner or outer), horizontal and vertical alignment, curb radius, and auxiliary lane length.

For physically-separated truck lanes along freeways, the literature recommends constructing at least two truck lanes per direction, separated by Jersey barriers, and with 3.7- to 4.0-metre wide travel lanes, 1.2- to 3.7-metre inner shoulders, and 3.7-metre outer shoulders. While 3.7-metre lane widths are standard to accommodate trucks, studies indicate that truck drivers prefer wider lanes for issues such as off-tracking and super-elevation. In general, truck lane configurations should: (1) address the need for truck passing, (2) provide shoulder widths to accommodate disabled trucks, (3) account for the need for future expansion in existing configurations, and (4) accommodate truck exit/entrance manoeuvres as efficiently and safely as possible. Table 8 lists principal design factors to consider when implementing truck lanes.

Table 8: Principal design factors for truck lanes

Design category	Factors to consider	
Sight distance	• Stopping sight distance • Decision sight distance • Passing sight distance	• Road-rail grade crossing sight distance • Intersection sight distance
Horizontal alignment	• Curve radius • Super-elevation	• Intersection and channelization • Pavement widening
Vertical alignment	• Critical length of grade	• Downgrades
Cross-section elements	• Lane width • Shoulder width and composition • Side slopes and drainage features • Pavement cross-slope breaks • Vertical clearance	• Traffic barrier • Passive signs • Curbs • Acceleration lanes • Pavement structure

Source: Douglas (2004); Middleton, Clayton, Quiroga, and Jasek (2003).

Truck Lane Configurations

In most existing research and practice, truck lanes are presented as a large-scale solution for urban areas in which trucks are physically separated from general traffic, though not always for the purpose of providing preferential treatment for goods movement. The Technical Report broadens the scope of truck lane implementation to include the following eight truck lane categories:

- Physically-separated truck lane on a freeway
- Truckway
- Truck bypass
- Truck route for specially-permitted vehicles
- Operationally-separated truck lane on a freeway
- Truck lane on a major arterial
- Truck lane at a border crossing
- Truck climbing lane

4.2.2 Case Study Considerations

The case studies identify additional applications and purposes for urban truck lanes within the eight urban truck lane categories defined in the Technical Report that may be feasible in Canada. They also reveal planning and design issues and considerations for urban truck lanes specific to Canadian urban areas. This section introduces the new truck lane applications and summarizes planning and design issues.

Additional Applications and Purposes for Urban Truck Lanes in Canada

Truck-HOV lanes on freeways: Some HOV lanes do not have enough demand to designate an exclusive lane for their use. Allowing trucks to share these lanes with HOVs could be an effective measure for balancing demand across each lane; however, this is a relatively new concept that requires further research.

Truck lanes as shortcuts to industrial areas: Truck lanes do not necessarily need to be lengthy and can be used as short connectors from GPLs to freight intensive areas. This application can help trucks avoid congested commuter routes and improve accessibility to freight generating facilities.

Internal truck lane networks in industrial areas: Industrial areas include intense manufacturing, warehousing, and distribution activities. Roads within these areas typically serve trucks and employees. Freight is often trucked to and from these areas during peak commuter periods and increases interaction between trucks and cars. Strategic network planning and site design could provide the structure to segregate trucks and cars by designing truck lanes that directly access loading docks and commuter lanes that access employee parking.

Interim truck lanes: Truck lanes do not necessarily need to be permanent and can serve as temporary solutions for certain problems. One example is providing truck lanes to facilitate major construction projects. These projects generate significant truck traffic throughout the day along specific, and often relatively few, routes. This type of truck lane can address safety issues and also help expedite the completion of these projects. Another example is using truck lanes to allow longer combination vehicles (e.g., Turnpike doubles) to use a two-lane road until funding is secured to construct a four-lane road, as required by most provincial LCV legislation.

Truck lanes connecting to urban staging areas: Longer combination vehicles are increasingly penetrating the truck fleet and have provided significant operational efficiencies for long-haul trucking. However, accommodating these trucks in urban areas remains a challenge. Truck lanes offer an opportunity to allow LCVs to access urban staging areas to assemble/disassemble trailers closer to the source of origin or destination. Importantly, these types of truck lanes can provide the necessary time savings and predictability to allow drivers to complete a long-distance round-trip within hours-of-service regulations.

Strategic land use planning to create "natural" truck lanes: Proposing truck lanes can lead to public resistance and enforcement can be difficult. For greenfield situations, protecting and developing land exclusively for industrial purposes can discourage passenger vehicles from using roads serving these areas (although employees would still use these roads). In this way, roads and lanes will naturally be operated as truck lanes.

Stakeholder engagement and involvement is essential for helping decide if truck lanes are appropriate for a given situation.

As a relatively new approach for accommodating trucks (particularly in terms of implementation), truck lanes are a controversial topic. Extensive stakeholder engagement and involvement can help inform constituents about truck lanes and obtain input for their planning, design, implementation, and operation. Potential stakeholders to consider and examples of questions that can be addressed in the consultation process are:

Planning and transportation departments in the given jurisdiction

- Do truck lanes fit within the transportation network?
- Are truck lanes feasible within existing short- and long-term plans?
- How can truck lanes fit within the jurisdiction's master plan?
- How do proposed land use developments accommodate freight movement?

Truck carriers and shippers

- Are there mobility, accessibility, safety, or productivity issues that need to be addressed by the jurisdiction?
- Are there other options that should be considered besides truck lanes?
- Which routes do trucks use and will the truck lane support this routing?
- Are there opportunities to shift to nighttime deliveries?

Railways and ports

- Can truck lanes improve intermodal freight transportation performance?
- Will truck lanes have a meaningful impact on truck turn times?
- What types of delays do trucks experience during processing at intermodal terminals or ports?

Enforcement

- Can the use of truck lanes be enforced?

Truck lanes should form part of a network.

Truck movements occur across a road network and require efficient connectivity within this network. Truck lanes should be planned as part of a network and within a transportation systems framework. However, the concept of a truck lane network can vary, as follows: it can be represented as a connected series of truck lanes that cross an urban area (e.g., Greater Toronto Area); it can be an isolated truck lane connected to a truck route network that improves the performance of a bottleneck to a level similar to the rest of the network (e.g., Glenmore Tr in Calgary); or it can provide a short connection within a much larger network (e.g., Waller St in Ottawa).

Truck lanes should be considered within the context of a network, should complement a broader group of treatments for truck transportation, and should only be considered after other truck-friendly options have been explored and implemented.

Short truck lanes strategically located and operated within an urban road network that divert trucks away from certain truck-unfriendly routes can allow more flexible infrastructure design. For example, many interchange design elements are (or should be) governed by truck operations, such as acceleration and deceleration lane lengths, curve radii, and vertical grade. Using truck lanes to direct trucks away from interchanges in physically constrained urban environments can allow designers to consider shorter lane lengths, smaller radius curves, and steeper vertical grades. These types of design modifications can result in significant capital cost savings or defer the cost of upgrading interchanges that were not originally designed for current truck configurations.

Land use planning and zoning are critical.

Protecting industrial land and appropriately zoning land adjacent to road corridors serving industrial areas is essential for accommodating trucks. As residential developments emerge around industrial areas (and in some cases industrial zoning is changed for residential and commercial uses), opposition to truck lanes can increase. Proper land use zoning and planning can prevent this situation and may also preclude the necessity of a truck lane by creating industrial areas with roads that only trucks or employees would use. This requires strategic land use planning to create “natural” truck lanes where, because of the nature of the land development, roads can naturally be operated as truck lanes.

Threshold criteria are not available for Canadian urban areas.

The literature suggests that threshold criteria exist to screen for truck lane candidates. The problem with these criteria is that they have been developed using a small sample of U.S. cases and primarily concern physically-separated truck lanes. They are not representative of Canadian urban areas and do not apply to most truck lane configurations that are most appropriate for the Canadian context. According to criteria in the literature, the only successful truck lane in Canada (Waller St in Ottawa) would be rejected as a truck lane candidate. Before considering developing threshold criteria, truck lanes must be implemented on a broader scale in Canada and their performance must be monitored.

Physically-separated truck lanes on freeways are unlikely to be successful in Canadian urban areas.

In-depth analyses of physically-separated truck lanes on highways with some of the highest traffic and truck traffic volumes and severe congestion issues in Canada (e.g., Highway 401 and 427 in the Greater Toronto Area) conclude that physically-separated truck lanes are likely inappropriate. Stakeholder interviews also conclude that physically-separated truck lanes should be avoided in Canada. Although there may be specific situations in Canada where physically-separated truck lanes could be feasible, they are generally not applicable to most of Canada.

Truck lanes may be appropriate within the internal road network of an industrial area.

Traffic within large industrial areas comprises mainly trucks accessing loading docks and employees commuting to their workplace. Experience regarding manufacturing operations in the Greater Toronto Area indicates that freight demand for industrial facilities commonly mirrors business hours and peak truck traffic can coincide with peak commuting traffic periods. Strategic site design, both at an area-wide scale and at the individual establishment, can produce conditions where a truck only network provides accessibility to loading zones and a passenger car/bus only network provides accessibility to employee parking lots or bus stops. This minimizes truck-car interactions, improves truck accessibility, and can also improve mobility for cars and trucks.

Understanding truck routing patterns is necessary to determine if truck lanes should be provided as inner or outer lanes.

Inner truck lanes are usually associated with through-movements and often produce superior mobility benefits (in terms of travel time, reliability, and emissions) compared to outer truck lanes. However, they can also be inferior to outer truck lanes in terms of accessibility. In urban areas, accessibility can be just as important to trucks as mobility. Both types of truck lanes produce different types of weaving issues. If most trucks using the truck lane corridor are not turning or making left turns to and from the truck lane, then an inner truck lane may be appropriate. If many trucks are making right-turns to and from the truck lane, an outer truck lane may be appropriate. The appropriateness and performance of an inner or outer truck lane is dependent on these types of operational truck characteristics.

Truck lanes, operated parallel to dedicated lanes for other road users (e.g., cyclists, transit) might present the next level of urban traffic management to cope with the increasing volume of road users and more importantly, the increasing complexity of road user types.

Truck lanes have typically been approached as a means to address truck mobility issues in response to increasing traffic volumes. The Technical Report emphasizes that the safety benefits of truck lanes could be equally as important. A subset of the safety issue is separating all road users, not just trucks and cars, to minimize interaction between modes with significantly different physical and operational characteristics. As traffic volumes in urban areas increase, so does the complexity and mix of road users. Mode-shifts from passenger vehicles to transit continue to occur and active transportation modes are increasingly becoming part of the urban transportation system fabric. Assigning each mode to a specific part of a road corridor and defining strategic, and in some cases exclusive, networks for each mode may become an attractive method for managing urban traffic.

4.3 OPERATIONAL CONSIDERATIONS

The Technical Report and case studies reveal operational considerations for urban truck lanes in Canada. Table 9 provides a summary of these considerations.

4.3.1 Technical Report Considerations

Findings from the Technical Report identify temporal segregation of trucks and cars, truck-car interaction, mobility improvements versus accessibility requirements, and mandatory versus voluntary use as important operational issues to understand. They also indicate that the operation of operationally-separated truck lanes is comparable, but more complicated, to the operation of bus lanes. Complications occur due to a wider range of vehicle types using truck lanes and larger number of truck operators. Decisions about the types of vehicles allowed to use a truck facility should be based on the objectives that the facility is intended to achieve. For example, if the objective of a truck lane is to ensure the free-flow movement of goods, only trucks should be allowed. However, if the objective is to enhance safety by separating heavy vehicles from general traffic, then eligibility to use a lane may be determined based on vehicle type, weight, or axle loads.

From left-to-right: bus lane, truck lane, bike lane, and general purpose lane on Waller St in Ottawa

Decisions about the types of vehicles allowed to use a truck facility should be based on the objectives that the facility is intended to achieve.

Temporal Segregation of Trucks and Cars

Urban trucks avoid travelling during morning and afternoon peak periods as possible. Most truck trips are made during the mid-day (between 10:00 and 15:00) and at night and may not require a separate lane to improve performance. However, many trucks operate during peak periods to satisfy customer demands which require pick-ups to be made between 07:00 and 09:00 and deliveries to be performed between 15:00 and 17:00. In these cases, carriers build in a buffer time to account for unreliable travel time and ensure on-time shipment arrival. Truck lanes may provide benefit for these operations.

Truck-Car Interaction

Operationally-separated truck lanes increase truck-car interaction (weaving and lane changing). This interaction is especially prominent at the beginning and end of the truck lane and on outer truck lanes with high truck volumes. This interaction increases the risk of crashes and can hinder mobility benefits of truck lanes.

Table 9: Operational considerations for truck lane implementation in Canadian urban areas

Operational considerations from the Technical Report	Operational considerations from the case studies
• Truck-friendly treatments should be explored and implemented prior to truck lanes. • Truck lanes may be beneficial for truck operations during peak periods. • Operationally-separated truck lanes increase weaving and lane changing, which increases the risk of crashes and can hinder mobility benefits of truck lanes. • Truck lanes require a balance between mobility and accessibility. Reducing truck lane accessibility generally improves truck mobility benefits (in terms of travel time, reliability, safety, and emissions) but reduces the number of trucks using the truck lane. • Mandatory use of truck lanes is viewed as a restriction by the trucking industry and may draw opposition from them, especially if adequate alternative routes are not provided.	• Defining the problem that the truck lane is intended to address, and understanding its underlying causes are essential before considering truck lanes as an option. • Truck lanes should be considered as one component of a much broader group of treatments and policies to improve truck travel time, reliability, safety, and reduce emissions. • Truck-friendly treatments should be explored and implemented prior to truck lanes. • The safety performance of truck lanes may be the deciding factor for implementation as they must produce significantly greater reliability and safety benefits than general purpose lanes to justify their implementation. • Trucks entering and exiting truck lanes can increase weaving interaction between trucks and cars, therefore, creating safety concerns. • Operating combined truck and HOV lanes on freeways can provide sufficient volume to warrant a dedicated lane for these road users without compromising performance. • Truck lanes do not necessarily need to be bi-directional as truck demand and traffic characteristics can vary by direction of travel. • Truck lanes can be implemented to address non-truck specific issues such as problems associated with other modes. • Truck lanes on arterial roads can be appropriate on short, low volume downtown streets. • Enforcing truck lane compliance can be difficult and sometimes illegal without legislative changes. • Truck lanes have the potential to allow round-trips on certain corridors without exceeding Hours-of-Service Regulations. • Truck lane compliance may be higher for newly constructed truck lanes compared to converted lanes. • Temporally restricting truck lanes to off-peak hours may not provide benefits for trucks. • Experience shows that adding capacity to address traffic congestion is often unsustainable – but adding capacity specifically for trucks may be sustainable.

Source: Developed by Montufar Group, 2012

While there is no published data about collisions due to truck-car interaction on truck lanes most multiple vehicle collisions on truck lanes are expected to result from merging/lane change conflicts and rear-end conflicts.

Mobility Improvements versus Accessibility Requirements

Truck lanes require a balance between mobility and accessibility. Reducing truck lane accessibility generally improves truck mobility benefits (in terms of travel time, reliability, safety, and emissions) but reduces the number of trucks using the truck lane. Insufficient truck lane access can result in low truck diversion rates to these lanes and decrease the overall performance of the corridor.

Mandatory versus Voluntary Use

The literature discourages mandating trucks to use truck lanes since this is viewed as a restriction by the trucking industry and because it can limit truck accessibility. Mandatory truck lane use may draw opposition from the trucking industry, especially if adequate alternative routes are not provided. These types of truck lanes may be more applicable and amenable to the trucking industry if they are serving specific truck trip purposes (e.g., truck lanes that connect directly to major freight generators such as seaports or intermodal terminals).

Adequate accessibility must be provided to accommodate the routing needs of urban trucks without degrading the mobility benefits to the point where the truck lane is no longer attractive for trucks.

4.3.2 Case Study Considerations

The case studies find that safety, compliance and enforcement, and temporal truck lane operation are important operational issues and considerations for urban truck lanes in Canada. The following synthesizes these findings. Additional details are contained in the Technical Report and in the case studies in the appendices.

Defining the problem, understanding the underlying cause of the problem, and determining the purpose of the truck lane are essential.

Before considering truck lanes as an option, a thorough understanding of the problem being addressed is required. Initial questions that should be answered are: Is the problem related to mobility, accessibility, or safety? Is the shared use of lanes by cars and trucks the underlying cause of the problem? Is the primary objective of the truck lane to improve truck traffic operations? If the problem appears to be unrelated to trucks, could truck lanes be used as an effective treatment? Truck lanes are also ineffective for addressing certain problems – for example delays caused by at-grade rail crossings.

Truck lanes should be considered as one component of a much broader group of treatments and policies to improve truck travel time, reliability, safety, and reduce emissions.

As indicated, truck lanes should form part of a larger network; similarly, truck lanes should be implemented as part of a larger strategy to improve truck mobility. Urban truck issues are frequently systemic while truck lane benefits can be localized to a corridor or segment and may be unable to fully or significantly address these issues. Combining truck lanes with truck-friendly infrastructure design and operations, land use planning, and introducing truck-friendly policies are necessary to generate meaningful performance improvements for trucks.

Truck-friendly treatments should be explored and implemented prior to truck lanes.

Truck lanes should be considered as one of the last options for improving truck operating efficiency since they are a relatively extreme measure compared to other alternatives. Truck-friendly treatments should be explored and implemented prior to considering truck preferential treatments such as truck lanes. This approach was shared by all trucking companies interviewed as part of the Technical Report.

The safety performance of truck lanes may be the deciding factor for implementation.

For truck lanes to outperform GPLs, they must produce significantly greater reliability and safety benefits (from a congestion relief perspective). Previous studies show that adding a GPL almost always outperforms adding a truck lane for mobility purposes. If adding GPLs outperforms truck lanes in terms of mobility, then the only way for a truck lane to outperform the overall performance of adding a GPL is to produce a significantly higher safety benefit – but the safety performance of truck lanes is currently unknown. Without this knowledge, it is difficult to justify truck lane implementation as a congestion relief treatment.

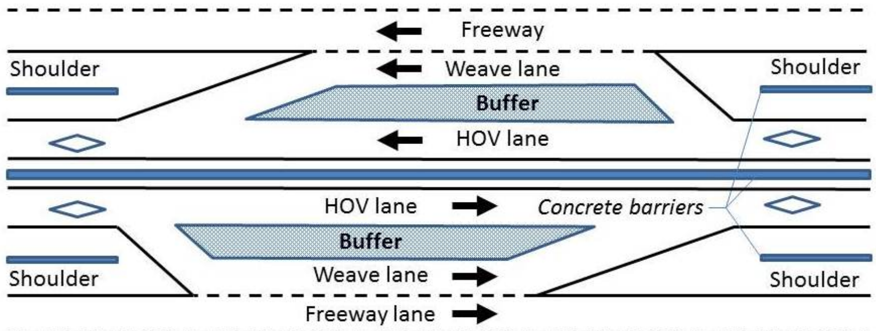
Trucks entering and exiting truck lanes can increase weaving interaction between trucks and cars.

Weaving creates a safety concern by increasing the risk of a collision and also negatively impacts traffic flow. Weaving is expected to occur for all truck lane configurations, with the possible exception of truckways in some instances. Therefore, the effects of weaving cannot be eliminated entirely but should be minimized as possible. The lack of truck lane experience creates difficulty in identifying successful approaches to deal with truck lane weaving; however, best practices from other types of dedicated lane applications can be observed.

- *Priority signals at intersections:* Bus lanes have addressed weaving in a variety of ways, including using traffic signals. For example, bus priority signals provide a dedicated phase for buses in a bus lane that stops traffic in GPLs and allows buses to advance ahead of other traffic and perform an unobstructed lane change if necessary.
- *Exceed interchange design minimums:* For weaving that occurs at interchanges, following existing design principles and standards but applying designs above recommended minimums can improve lane changing and vehicle interactions. This includes considering truck operational performance characteristics when designing acceleration and deceleration lanes, interchange radii, sightlines and sight distances, and using parallel merge lanes instead of tapered lanes.

- *Construct slip ramps:* Slip ramps have been used in some places to address weaving caused by HOV lanes and are a recommended practice in the AASHTO HOV design guide where limited ROW exists and/or high costs prohibit elevated flyovers.

HOV lane slip ramp



Source: Adapted from: Fitzpatrick, K., Brewer, M., and Venglar, S. (2003). *Managed lane ramp and roadway design issues*. Texas Transportation Institute, College Station, TX.

- *Provide ramp meter bypasses:* Australia has had success with operating two separate on-ramp lanes – one for passenger vehicle traffic that is controlled with ramp meters and a separate lane for trucks without a ramp meter. The truck lane ramp meter bypass allows trucks to maintain a relatively high speed and facilitates their integration with through-movements on the freeway compared to stopping at a ramp meter and trying to accelerate to freeway speed.

- *Lane drops:* At the end of a truck lane, instead of dropping the truck lane and requiring trucks to merge with adjacent lanes, a GPL lane could be dropped that would require cars in those lanes to merge with other cars in adjacent lanes. For example, consider four northbound lanes with an inner truck lane. When the truck lane terminates, this lane could continue as a GPL and the outer lane could be dropped resulting in three northbound GPL lanes and no truck lane. In this situation, trucks would not be required to change lanes to exit the truck lane.

- *Use advanced signing:* Provide adequate warning about upcoming weaving areas and instruct motorists to change lanes in advance of the weaving area to accommodate merging traffic. This can help minimize vehicle interaction or encourage more controlled lane changing over a longer distance. The New Jersey Turnpike is an example of applying this type of signing practice.

Operating combined truck and HOV lanes on freeways might provide sufficient volume to warrant a dedicated lane for these road users without compromising performance.

HOV lanes are an approach to encourage carpooling and reducing traffic volumes; however, HOV demand does not always warrant an HOV lane. On some corridors where the combined truck and HOV volumes exceed the lane capacity, it can make sense to explore the option of providing combined truck and HOV lanes that allow both types of users. On a freeway with few speed changes and grade-separated intersections, this option could provide both trucks and HOVs with improved performance compared to GPLs. As traffic volumes grow, particularly truck and HOV volumes, and the truck-HOV lane approaches capacity, new definitions of truck and HOV can be introduced to restrict eligible users. For example, trucks could initially include single-unit trucks but change to only include 5-axle articulated trucks. Similarly, HOVs could initially be defined as 2+ persons per car and could change to 3+ to unlock capacity.

Truck lanes do not necessarily need to be bi-directional.

Truck demand and traffic characteristics can vary by direction. Subsequently, a truck lane may be appropriate in one direction and not the other. Obtaining traffic data by vehicle type, hour-of-day, and direction is important for this decision. Waller St in Ottawa is an example of a uni-directional truck lane.

Truck lanes can be implemented to address non-truck specific issues.

Intuitively, truck lanes are considered treatments to address issues associated with trucks. The Waller St truck lane proves that they can be effectively applied for issues primarily associated with other modes and providing a secondary benefit for trucks. From this perspective, the option of truck lanes will likely be overlooked; however, this example shows that truck lanes could be successfully implemented for a variety of transportation issues.

Truck lanes on arterial roads can be appropriate on short, low volume downtown streets.

Literature findings consistently conclude that truck lanes should not be implemented on short, low volume roads. However, these findings originate from studies conducted for urban interstate highways in U.S. cities. Few studies have been conducted for truck lanes on arterial roads in downtown areas; consequently there is little guidance for these situations. The Waller St truck lane in Ottawa is the only truck lane in Canada and has been operational since the 1980s. This example provides evidence that truck lanes on arterial roads can be successful on short, low volume downtown streets which is contrary to the literature and international experience.

Truck lanes have the potential to allow round-trips on certain corridors without exceeding hours-of-service regulations.

The urban component of a long-haul truck trip can sometimes include a truck-staging area as an intermediate stop. Staging areas are commonly used by trucks to assemble or disassemble Turnpike double configurations before or after a long-haul trip. Staging areas located within a city minimize travel distance and time by trucks operating as a single trailer configuration. The further inside a city the staging area becomes, the more difficult it is and the longer it becomes for a Turnpike double to access. On certain routes (e.g., Regina to Winnipeg) it is possible and desirable for Turnpike double drivers to make a round-trip within a single day of driving as defined by federal hours-of-service regulations (currently 13 hours). On these routes, it is sometimes possible that a half-hour delay could prevent the round-trip from occurring. In these cases, using a truck lane to connect to urban staging areas could facilitate Turnpike double operation in cities, maximize truck productivity, and provide the necessary travel time savings and predictability to reliably allow round-trip movements.

Enforcing truck lane compliance can be difficult and sometimes illegal without legislative changes.

For jurisdictions that have legislation pertaining to priority lanes, truck lanes can be enforced by specifying the mode for which the priority lane applies. However, jurisdictions without this type of legislation will not be able to enforce truck lanes.

Truck lane compliance may be higher for newly constructed truck lanes compared to converted lanes.

Experience with bus lane compliance shows trends that violations are higher on bus lanes that have been converted from a GPL compared to bus lanes that have never been used as a GPL. This experience suggests similar compliance behaviour could be expected for truck lanes.

Cars travelling on Waller St truck lane

Temporally restricting truck lanes to off-peak hours may not provide benefits for trucks.

As much as possible, urban trucks try to travel during off-peak periods, particularly during the mid-day. However, many customers that trucks are serving require pick-ups or deliveries during morning and afternoon peak periods. Trucks may need truck lanes the most during these peak periods but there may not be enough capacity to dedicate a lane for trucks. Traffic during off-peak periods may be low enough that the performance of a truck lane might not be better than GPLs.

Experience shows that adding capacity to address traffic congestion is often unsustainable – but adding capacity specifically for trucks may be sustainable.

Latent commuter demand and the flexibility of commuter travel choices are underlying factors that sometimes prevent the construction of additional lanes from sustainably addressing traffic congestion. When an extra lane is constructed on a congested corridor, there is a temporary and significant improvement in mobility which attracts additional commuter traffic. As more traffic shifts to the new lane, performance erodes and approaches previous conditions. The flexibility of commuters to decide where, when, and how to travel is a contributing factor to this situation.

Trucks often have much less flexibility in terms of changing their travel patterns. Existing freight demand, which is usually unaffected by the addition of a lane along a corridor, is fixed and largely influences truck traffic volume. Truck routes and customer requirements for pick-up and delivery times are also fixed and largely influence truck routing and temporal operation characteristics. Therefore, adding a truck lane may not produce the same level of traffic diversion and increase in volume as adding a GPL.

4.4 ANALYSIS AND EVALUATION CONSIDERATIONS

The Technical Report and case studies reveal evaluation considerations for urban truck lanes in Canada. Table 10 provides a summary of these considerations.

4.4.1 Technical Report Considerations

When analyzing and evaluating the performance of urban truck lanes, the Technical Report identifies the following as important issues to consider: (1) demand for truck lanes; (2) data requirements and limitations; and (3) operational characteristics.

Demand for Truck Lanes

There must be sufficient demand for truck lanes to warrant their implementation. There must also be sufficient truck lane utilization to ensure the corridor is operating at maximum efficiency and to avoid opposition from other road users. Striking a balance in terms of demand is important. If too many trucks use truck lanes that are designed to improve travel time and reliability, the benefit of these lanes is lost. However, if not enough trucks use the lanes, the corridor will be operating inefficiently and other motorists may express opposition to reserving lanes for trucks if they are underutilized.

Data Requirements and Limitations

Traffic volume by time-of-day, vehicle type, commodity type, and vehicular speed data are necessary to quantify the travel time and reliability saving benefits of truck lanes. However, this type of data is not readily available in most Canadian urban areas. Microsimulation modelling can estimate vehicle conflicts as a surrogate measure for safety but cannot quantify collision frequency and severity or determine the number of single vehicle collisions. Emission estimates are a direct function of traffic volume by time-of-day, vehicle type, and speed and are therefore difficult to quantify for truck lane analyses. These data impediments are limitations associated with all prior truck lane studies and are expected to exist for future analyses.

4.4.2 Case Study Considerations

Primary issues and considerations regarding truck lane analysis and evaluation concern data and modelling. Despite ongoing research and advancement, urban truck models have many limitations associated with data availability and quality. Without data and modelling improvements, using models to quantify truck lane benefits will continue to rely almost entirely on assumptions.

Table 10: Analysis and evaluation considerations for truck lane implementation in Canadian urban areas

Analysis and evaluation considerations from the Technical Report	Analysis and evaluation considerations from the case studies
• There must be sufficient demand for truck lanes to warrant their implementation. There must also be sufficient truck lane utilization to ensure the corridor is operating at maximum efficiency and to avoid opposition from other road users. • Traffic volume by time-of-day, vehicle type, commodity type, and vehicular speed data are necessary to quantify the travel time and reliability saving benefits of truck lanes. • The provision of truck lanes requires trade-offs between mobility and accessibility. In urban areas, accessibility is critical for urban pick-up and delivery trucks. Urban truck lanes with insufficient accessibility risk underutilization. • Speed differentials produced by truck lanes are an important safety consideration.	• Without empirical data or truck lane experience in Canada (except for Waller St in Ottawa), truck lane pilot tests in Canadian urban areas are necessary to accurately assess truck lane performance and feasibility. • Operationally-separated truck lanes (e.g., truck lanes on arterials) are candidates for pilot testing truck lanes due to their relative ease of installation, operation and removal. • Urban truck lanes require a trade-off between accessibility and mobility and their performance is a function of truck diversion and utilization rates. • Microsimulation models are better suited for analyzing truck lanes than travel demand models. • Daily traffic and truck traffic volumes can be insufficient for identifying corridors as candidates for truck lanes and for quantifying truck lane benefits. Hourly traffic distributions by vehicle type and direction are also important. • Truck lane benefits are a function of the value of time of a truck. There is currently insufficient data to accurately calculate truck lane benefits due to the multi-dimensional aspect of truck travel. • Truck trip distance along a truck lane is critical for calculating benefits associated with the truck lane. • Site delays (e.g., loading docks, intermodal terminals) are often the source of the largest truck delays and travel time unreliability. • Without collision data, the safety performance of truck lanes will remain a knowledge gap. • Truck percentages can be an inappropriate metric for truck lane analysis because they are reflective of changing total traffic volumes, and not only truck volumes. • Analysts should use caution when applying passenger vehicle equivalents (PCEs) to calculate truck lane performance because they are not usually uniform for all truck types or urban situations. • Consensus on defining and calculating truck travel time reliability has yet to be reached.

Source: Developed by Montufar Group, 2012

Without empirical data or truck lane experience in Canada (except for Waller St in Ottawa), truck lane pilot tests in Canadian urban areas are necessary to accurately assess their performance and feasibility.

U.S. experiences with truck lanes and the general body of knowledge of truck lanes are largely inapplicable to truck lanes in Canada (due to populations, traffic volume characteristics, infrastructure, network design, policies and regulations, others). Insufficient urban truck traffic and freight data limit the ability of models to evaluate truck lane performance and preclude the ability to validate and verify model results. The safety performance of truck lanes is one of the most important characteristics of truck lanes, yet this is one of the weakest components of microsimulation models. Pilot testing truck lanes in Canadian urban areas is necessary and recommended for proper evaluation of the performance of these facilities for improved truck transportation.

Operationally-separated truck lanes (e.g., truck lanes on arterials) are candidates for pilot testing truck lanes.

Whereas physically-separated truck lanes, truck bypasses, and truckways require significant investments, operationally-separated truck lanes can be relatively inexpensive to implement, operate, and remove. Providing signage and pavement markings may be the only investment required. This lends itself to pilot testing and evaluating the benefits of a truck lane. If successful, no major changes are necessary to pilot conditions. If unsuccessful, signage and pavement markings are relatively easy to remove.

Urban truck lanes require a trade-off between accessibility and mobility and their performance is a function of truck diversion and utilization rates.

Truck lane mobility performance in terms of travel time, reliability, and safety for trucks using the truck lane is expected to be maximized when accessibility is minimized. However, as accessibility decreases, truck diversion to these lanes (and hence utilization) also decreases, particularly in urban areas. A balance is required to maximize truck lane mobility performance while also maximizing truck lane utilization. Finding this balance prior to implementation could be elusive and making adjustments to the truck lane design after implementation could be infeasible.

Microsimulation models are better suited for analyzing truck lanes than travel demand models.

The state of urban truck traffic modelling continues to advance; however, the accuracy of these models are limited by the availability and accuracy of the data used in their construction. Travel demand models are not recommended for analyzing and evaluating truck lanes since these models are designed for regional scales using daily traffic volumes and are unable to capture important operational characteristics of trucks (e.g., hourly traffic distribution by direction). Predicting truck diversion rates to truck lanes, estimating the length of a truck trip on a truck lane, determining the commodity being carried in the truck, and placing a value of time and reliability for each truck are examples of issues that microsimulation models struggle to quantify due to data limitations. Each of these aspects of urban trucking can significantly affect truck lane benefits.

Hourly traffic distributions by vehicle type and direction are important.

Daily traffic and truck traffic volumes can be insufficient for identifying corridors as candidates for truck lanes and for quantifying the benefits of truck lanes. Hourly distributions and directionality are usually different for passenger vehicles and trucks. The performance benefits of a truck lane with hourly truck traffic volume distributions occurring during the same time and in the same direction as passenger vehicles will be very different than if the hourly distributions are not coincidental and occur in opposite directions.

There is insufficient data to accurately calculate truck lane benefits.

Truck lane benefits are a function of the value of time of a truck. This value comprises many dimensions, including truck type (e.g., single-unit, articulated), commodity, truck operation (e.g., truckload, less-than-truckload, owner-operator, for-hire, private), trip type (e.g., long-distance/rural, drayage/urban), late delivery penalties, driver remuneration type (e.g., hourly, by trip, mileage), and others. Truck traffic volume estimates in urban areas are often weak since many are based on short-term data collection programs on a dense network. Further, data is unavailable to disaggregate truck volumes by the different dimensions of value. Other key variables used for calculating truck lane benefits for which data is unavailable are truck diversion rates from GPLs to truck lanes and truck trip length on a truck lane.

Without empirical collision data, the safety performance of truck lanes will remain a knowledge gap.

Empirical collision data is unavailable for truck lane configurations in Canadian urban areas (an exception is Waller St in Ottawa). Modelling has been used to predict collision frequency in the absence of this data. However, models are unable to estimate crash frequency directly and cannot estimate single-vehicle crashes or crash severity. Microsimulation models use vehicle conflicts as a surrogate for crash frequency which produces varying levels of accuracy. Without actual collision data to validate or verify these results, the safety performance of truck lanes will remain an important knowledge gap.

Truck trip distance along a truck lane is critical for calculating benefits.

Truck lane benefits are a direct function of the distance travelled by a truck along the lane. For example, if trucks only use a portion of a truck lane and never travel the entire length, it is inaccurate to apply travel time savings along the corridor to a daily truck traffic volume on the corridor, especially if the daily volume does not capture trucks entering and exiting the facility. Furthermore, the travel time benefits for a truck using only a small part of the truck lane will likely be small and perhaps insignificant compared to the entire trip. The literature presents varying opinions about whether these savings should be aggregated across all vehicles and presented as overall savings or if they should be ignored since they may be meaningless for individual road users.

Site delays (e.g., loading docks, intermodal terminals) are often the source of the largest truck delays and travel time unreliability.

The benefits of truck lanes primarily serving trucks accessing a major freight facility can be negated if the delays at the freight facility are excessive. In these situations, truck lanes are helping trucks reach a bottleneck faster and not actually improving the overall freight movement. In this context, truck lanes should be viewed as part of an entire freight trip, not just as an isolated connector or corridor. Without this perspective, an evaluation of the truck lane may indicate that the lane is performing as anticipated and result in misleading conclusions that the truck lane is improving freight movement when in reality there is no overall benefit at all.

Truck percentages can be an inappropriate metric for truck lane analysis.

Truck volumes are sometimes represented as a percentage of total traffic volume, particularly total daily traffic volume. Truck percentages can inaccurately represent truck traffic volumes and are often reflective of changing total traffic volumes. For example, corridors with high truck traffic volumes (and possible candidates for truck lanes) may have high total traffic volumes and low truck percentages. Other corridors could have low truck traffic volumes and high truck percentages if total traffic volumes are also low. Truck traffic volumes estimated using truck traffic data should be used for all truck lane analyses and evaluations.

Analysts should use caution when applying passenger vehicle equivalents (PCEs) to calculate truck lane performance.

For truck lane analyses, PCEs are sometimes applied to calculate additional capacity experienced on GPLs due to trucks diverting to truck lanes and also to calculate traffic volumes on truck lanes. PCEs are not usually uniform for all truck types and urban situations; however, the choice of PCE can significantly affect performance results. Inappropriate use of PCEs can lead to false conclusions and expectations about truck lane performance.

Consensus on defining and calculating truck travel time reliability has yet to be reached.

There is ongoing research and investigation into the definition and measurement of travel time reliability. In terms of trucking, some research suggests that travel time reliability should be valued the same as travel time while others suggest that reliability should be valued at four times the value of travel time. Ultimately, reliability is a function of the truck operation – trucks carrying non-time-sensitive commodities will have a much different value for reliability than those carrying time-sensitive products. Even if data were available to disaggregate truck traffic by commodity time sensitivity, disagreement on appropriate reliability metrics is an issue to overcome. Types of reliability metrics include statistical measures (e.g., variability index), buffer time indices (e.g., planning time index), and tardy trip indicators (e.g., misery index).

CHAPTER 5 – SUMMARY AND FUTURE OPPORTUNITIES

This Resource Document is intended to assist transportation professionals in Canadian urban areas to make more informed decisions regarding the potential use of truck lanes as a tool for efficient sharing of facilities by all road users. Specifically, this document assists transportation professionals in identifying various truck lane applications and issues to consider regarding truck lane planning and design, operations, and evaluation. Information to support these decisions is compiled from an extensive literature review and stakeholder interviews (contained in the *Investigating the Potential for Truck Lanes in Urban Areas Technical Report*) and through analyses resulting from six case studies conducted in different Canadian urban areas.

This chapter summarizes principal issues that practitioners should consider when planning, designing, operating, and evaluating truck lanes in the Canadian urban setting (each of these considerations has been addressed in detail in Chapter 4 of this Resource Document). The chapter also recommends future research and additional steps with respect to truck lanes in Canada.

5.1 PLANNING AND DESIGN CONSIDERATIONS

The following are considerations regarding planning and design of truck lanes in Canadian urban areas.

Application of urban truck lanes

Truck lanes should be considered as one component among a much broader group of treatment and policy options that can be used to improve truck travel time, reliability, safety, and reduce emissions in urban areas. This Resource Document considers truck lanes as a truck-preferential option; however, truck-friendly options, which are generally less aggressive than truck lanes, should be explored and implemented prior to truck lanes. Selection of an appropriate option—either truck-friendly or truck-preferential—should rely on a clear definition of the problem being addressed.

There are several potential applications of truck lanes in Canadian urban areas. Specifically, there may be potential to use truck lanes as: (1) shared facilities with HOV lanes on freeways; (2) short, physically-separated connectors from general purpose lanes to freight intensive areas; (3) short connectors alongside general purpose lanes of an arterial road; (4) temporary or interim solutions to traffic engineering problems arising from construction; (5) access to staging areas for assembly/disassembly of specially-permitted vehicles; and (6) lanes within the internal road network of an industrial area. Physically-separated truck lanes on freeways as envisioned in the U.S. are unlikely to be successful in Canadian urban areas since feasibility studies in the U.S. commonly conclude that the implementation costs exceed their benefits. Whatever the application, truck lanes should form part of an easily-understood truck route network in urban areas.

Land use planning and zoning

Strategic land use planning and zoning are critical for the efficient movement of freight in a region. Natural segregation of cars and trucks is possible by protecting and developing land exclusively for industrial purposes and thereby discouraging passenger vehicles from using roads serving these areas.

Need for data to promote understanding and decisions

A lack of empirical data about urban truck lane performance currently hinders their planning and design, particularly for the types of truck lane applications that appear most relevant for Canadian urban areas. At the planning stage, this lack of data means that threshold criteria used to help screen for truck lane candidates are unavailable. Nonetheless, the transportation professional must strive as possible and reasonable to estimate the economic benefits and costs to the involved government(s), users, industry, and the public. To this end, active stakeholder engagement and involvement is essential for helping decide if truck lanes are appropriate for a given situation.

5.2 OPERATIONAL CONSIDERATIONS

The following are considerations regarding the operation of truck lanes in Canadian urban areas.

Mobility issues associated with the operation of truck lanes

The extent to which truck lanes (of various types) are able to address mobility for trucks and/or other transportation modes depends on a number of operational considerations. First, truck lanes which require weaving interactions between cars and trucks may pose concern from operational and safety perspectives. The specific truck routing needs should be understood as they will impact how trucks access the facility, the configuration of the truck lanes (e.g., inner versus outer lanes), and the amount of weaving that is likely to occur. Second, truck lanes do not necessarily need to operate bi-directionally as truck demand and traffic characteristics vary by direction of travel. Third, the mobility benefits of truck lanes should be considered at a macroscopic scale. In certain cases, truck travel time and reliability are most impacted by mobility problems at trip endpoints (i.e., origin and destination), which normally exist in urban areas. Depending on specific origin-destination characteristics, alleviating mobility issues at these endpoints through appropriate implementation of truck lanes may have important economic benefits at a much broader scale. This is particularly true given the discrete nature of many inter-urban truck trips and the need to comply with hours-of-service regulations. Finally, while restricting truck lane operations temporally (e.g., during off-peak periods) may be an effective method of segregating trucks from other types of traffic, the mobility benefits of the truck lane may be limited by doing so.

Safety performance of truck lanes

The safety performance of truck lanes may be the deciding factor for implementation. From a truck mobility perspective, research shows that adding a general purpose lane outperforms the implementation of a truck lane. Therefore, justification of the truck lane relies on demonstration of its superior safety performance; however, the safety performance of truck lanes is currently uncertain.

Truck lane compliance

Compliance with truck lanes will impact operational performance. Based on experiences with providing preferential lane treatments for other modes, compliance for truck lanes may be higher for newly constructed lanes compared to lanes that are converted from general purpose lanes. In certain jurisdictions, enforcing truck lane compliance may be difficult and may require legislative changes.

5.3 ANALYSIS AND EVALUATION CONSIDERATIONS

The following are considerations regarding analysis and evaluation of truck lanes in Canadian urban areas.

Empirical data can be gained through pilot testing and microsimulation

As for planning and design, a lack of empirical data about truck lane performance and their economic costs and benefits hinders analysis and evaluation of the potential use of these lanes in Canadian urban settings. Pilot testing and purposeful monitoring and evaluation of truck lanes are a principal means of developing the empirical knowledge necessary for analysis and evaluation. It is suggested that such pilot testing should be undertaken—starting from simple, low cost ideas and progressing to more complex, costly ones—as data supports. For example, among the types of truck lanes relevant in Canadian urban areas, operationally-separated truck lanes (e.g., truck lanes on arterials) may be the most feasible for pilot testing because of their relative ease of installation, operation, and removal. In addition to pilot testing, additional understanding of truck lane performance may be gained through the development of comprehensive microsimulation tools.

Quantifying the benefits of truck lanes

A number of uncertainties in the usage of truck lane facilities hinder the quantification of their benefits, and therefore the evaluation of their performance. Specifically, truck diversion rates, the value of truck travel time savings and travel time reliability, truck trip distance along a truck lane, site-related delays, and safety performance are principal uncertainties that impact truck lane evaluations.

Evaluation with appropriate metrics

When analyzing and evaluating truck lane performance, consideration should be given to establish and monitor metrics (or performance indicators) that are appropriate to determine whether the intended objectives are achieved. Detailed characterization of traffic and truck traffic volumes (e.g., temporal and directional distributions) is necessary and should be done in an absolute sense wherever possible, rather than relying on metrics such as truck percentages or passenger car equivalents (PCEs) which may mask the true performance impacts of truck lanes.

5.4 FUTURE OPPORTUNITIES AND RECOMMENDATIONS

There are many critical research and knowledge gaps that are necessary to understand for calculating truck lane benefits, assessing their performance, and recommending their implementation. Following is a list of questions regarding urban truck lanes derived from the Technical Report and case studies. Some of these questions are applicable to urban trucking in general but are nonetheless important for truck lanes. As more information about truck lanes is obtained, additional questions and areas of research are expected to emerge.

General Urban Truck Traffic Knowledge Gaps and Research Opportunities

- What is the truck traffic volume on each road segment in a city?
- What are the performance characteristics for trucks on each road segment in terms of travel time, operating speed, delay, collision frequency and severity, and emissions?
- What are the performance characteristics (e.g., acceleration, deceleration, turning radius, stability) of trucks operating on the urban road network?
- What type of urban truck traffic data exists, what is needed, what is missing, and what opportunities are there to obtain missing data?
- What are the dimensions of truck traffic volumes on each road segment in a city in terms of temporal distribution, origin-destination patterns, routing, truck type, commodity type, value, and weight distribution?
- What is the value-of-time for different commodities and how much money is saved per tonne or per cubic volume for each unit of travel time reduction?
- What is the value-of-time for trucks, considering the different variables affecting this value, including truck type (single unit, articulated), commodity, truck operation (truckload, less-than-truckload, owner-operator, for-hire, private), trip type (long-distance/rural, drayage/urban), late delivery penalties, and driver remuneration type (hourly, by trip, mileage)?
- How might the emergence of longer combination vehicles affect urban truck traffic characteristics and accommodation?
- How does non-recurring congestion impact urban truck operations?

Urban Truck Lane Knowledge Gaps and Research Opportunities

- What is the economic impact (positive or negative) of truck lanes?
- How can urban truck traffic modelling capabilities be improved, including the ability to model different truck lane designs and configurations?

- What are the safety impacts of separating trucks and cars in terms of changes in crash frequency, type, and severity?
- How can weaving and truck-car interactions produced by truck lanes be minimized and controlled?
- How do differences in hourly traffic distribution between cars and trucks impact truck diversion rates to truck lanes?
- What effects do operationally-separated truck lanes have on travel time, reliability, and safety of trucks and total traffic?
- What effect do no-car lanes have on truck travel time, reliability, and safety for trucks and total traffic?
- Are truck-HOV lanes feasible and what effect do they have on truck travel time, reliability, safety, and emissions for trucks and total traffic?
- Do truck lanes increase noise and vibration impacts?
- Will truck lanes produce a change in hourly truck traffic distributions?
- Do some commodities benefit more from truck lanes than others?
- How can truck lane benefits be converted to monetary terms to facilitate benefit-cost analyses?
- What are the public and private benefits of allowing LCVs in urban areas and how can these be estimated and quantified?
- Do urban truck lanes produce meaningful emissions reductions?
- Do truck lanes produce speed differentials between (1) trucks in truck lanes and cars in general purpose lanes and (2) trucks in truck lanes, some of which may have speed limiters?
- Do inner and outer truck lanes perform differently in terms of collisions, mobility, and accessibility?
- What is the effect of relocating curbside parking and implementing full- or part-time truck lanes in the curb lane?
- How can technologies and ITS complement urban truck lane operations (e.g., vehicle-to-vehicle and vehicle-to-infrastructure communication systems, lane departure warning systems)?
- Is it feasible to allow trucks to operate on shoulders during peak periods, especially with the assistance of ITS technologies?

- How should small travel time savings be calculated and should they be applied differently for different trucking operations, such as local and long-distance truck trips?
- Can urban truck lanes be applied as a treatment for controlling and managing the increasingly complex traffic mix (as opposed to improving travel time, reliability, safety, and emissions)?
- What rationale, other than financially-driven cost-benefit analyses, can be used to justify urban truck lane implementation and investment?

5.5 FUTURE OPPORTUNITIES FOR ADVANCING URBAN TRUCK OPERATIONS IN CANADA

The development and implementation of research that creates more information about urban truck operations is essential for Canada. The extent to which freight is accommodated in the planning, design, and operations process of a jurisdiction is highly linked to the existing level of understanding about the needs and characteristics of goods movement in the region. The following are practical opportunities for advancing not only truck lanes in Canadian urban areas, but urban truck operations in general.

- **Development of resources and guidelines for improving truck accommodation in urban areas using truck-friendly approaches and treatments:** Findings from the Technical Report clearly show that truck-friendly treatments should be implemented prior to considering truck lanes. However, there are limited resources to help guide practitioners in this area. A freight-supportive guideline that includes various modes of freight transportation (or a truck-supportive guideline as an initial step) could prove beneficial to practitioners across the country in the efficient accommodation of freight in their jurisdiction.

- **Collection of empirical data through implementation of truck lane pilot tests:** A recurring limitation of truck lane analyses and research identified in the literature is a lack of empirical data. This data can be obtained by conducting urban truck lane pilot tests. Perhaps the simplest pilot test, and arguably the most useful for Canadian urban areas, involves operationally-separated truck lanes on arterials or freeways. The cost of implementing these types of truck lanes is relatively low and may only include signage and lane markings. Furthermore, if the truck lanes are shown to be ineffective, removal is also inexpensive. The data obtained from pilot tests can be used to better understand truck lane operations and also for model calibration and validation.

- **Development of guidelines for the implementation of truck lanes:** As the research develops and empirical urban truck lane data is collected and made available (either through pilot tests or from other jurisdictions' experience), there will be better information on where and how urban truck lanes can be implemented. This Resource Document and the Technical Report can serve as a logical foundation for further, more specific guidance on truck lane implementation.

The development of a research agenda will require a paradigm shift in the way in which many jurisdictions operate with respect to freight accommodation. Until freight is explicitly recognized as an essential element for economic development, it will be challenging to obtain support from the public and decision-makers regarding the implementation of measures that give preferential treatment to freight movement. Yet, as freight transportation continues to grow nationally and internationally, and the demands on the system continue to increase, it will become necessary to implement mechanisms by which freight can be properly accommodated in planning, operations and maintenance practices across the country.

In a world which is constantly changing, and resources are shrinking, the challenge will lie in doing more with less. As a result, measuring system performance will become critical and more challenging given that treatments, such as truck lanes, when installed within the context of a broader transportation system that is constantly changing, will also exhibit dynamic performance.

Any research agenda that is intended to advance urban truck operations in Canada must consider the challenges and opportunities associated with a dynamic system, and the importance of freight transportation as a fundamental user of the transportation system.

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