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Regulations Governing the Operation of Longer Combination Vehicles in Canada

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Abstract

The permits governing longer combination vehicle (LCV) activity in Canada aim to leverage LCV productivity advantages relative to other truck configurations while subjecting LCV operations to stringent regulatory controls. As of 2016, nine of the 13 provinces/territories permit LCV operations on a 17,000-km highway network. This article synthesizes LCV regulations in these jurisdictions within five categories: a) carrier permit requirements, b) truck size and weight limits, c) equipment requirements, d) operating conditions, and e) driver qualifications. While jurisdiction-specific differences remain, the synthesis reveals regulatory uniformity at the regional level. The article identifies how these regulations influence highway design, operations, and management decisions concerning the accommodation of LCV performance characteristics, the spatial and temporal control of LCV operations, the eligibility of drivers and carriers to operate LCVs, and opportunities for regulatory harmonization. As LCV activity increases, the need to formally consider the characteristics of LCVs within these decisions becomes more apparent.

Key Words

Longer combination vehicles, truck regulations, traffic operations, geometric design

Introduction

In Canada, longer combination vehicles (LCVs) are truck configurations consisting of a tractor and two or three trailers or semi-trailers with a combined length greater than 27.5 m. The movement of LCVs on Canadian highways occurs pursuant to operating permits issued to trucking companies (carriers) by public transportation agencies. These permits allow LCVs to operate beyond basic truck length limits but also define a regulatory environment which uniquely governs LCV travel. Because of their extended length, LCVs offer a transportation productivity advantage relative to other truck configurations, particularly when hauling low-density freight (Regehr, Montufar, Clayton 2009a).

LCVs have been operating in Canada for nearly 50 years. In this time, the development and application of LCV regulations in Canada have evolved considerably as regulators respond to increasing demand for LCV travel while simultaneously striving to achieve the objectives of safety, productivity, infrastructure protection, and environmental sustainability. From a civil engineering perspective, there is a need to understand the implications these regulations have on how highway systems are planned, designed, operated, and managed. Existing research, such as the work by Burns (1983), Nix (1995), Ray Barton Associates Ltd. (2003), Regehr (2009), and Woodrooffe et al. (2010), provides valuable insights into the regulation and operation of LCVs at jurisdictional or regional scales. However, as the scope and magnitude of LCV operations continue to expand, the need to benchmark the regulations currently governing these operations from a national perspective is evident. This article aims to accomplish this, thereby providing a novel contribution to future LCV-related policy decisions within Canada and beyond.

Specifically, this article has three main objectives. First, to set the context for the review and synthesis of LCV regulations, the article provides an overview of the evolution of LCV operations in Canada. The overview describes the details of common LCV configurations operating in Canada and the current highway network on which these vehicles are permitted. A review of existing literature provides

historical evidence of major network changes that have impacted the utilization of LCVs across the country.

Second, the article reviews and synthesizes the regulations that currently govern LCV operations in Canada. Regulatory details are provided within five categories: carrier permit requirements, truck size and weight limits, equipment requirements, operating conditions, and driver qualifications. The scope of the synthesis is limited to the regulations in effect in the provinces/territories that currently permit LCV operations. Regulations in urban jurisdictions were not specifically investigated, though some information about urban LCV operations (e.g., network access provisions) is included in the provincial/territorial permits. Additionally, peripheral topics such as the development and rationale of LCV permit fees, LCV collision reporting procedures, and certain details about relevant truck size and weight limits are beyond the scope of this article.

Third, the article discusses the implications of LCV regulations for geometric design and highway operations. Vehicle specifications, the control of LCV operations spatially and temporally, and driver and carrier performance criteria directly influence design and operations decisions. When regulatory harmonization improves network connectivity, the potential increase in LCV activity further affects these decisions. The regulations governing LCV operations also influence pavement and bridge design and maintenance; however, these issues will not be discussed in this article.

Overview of LCV Operations in Canada

There are three common LCV configurations in Canada (Table 1): a) turnpike doubles (turnpikes), which consist of a tractor, one 16.2-m (53-ft) semi-trailer, and one 16.2-m (53-ft) trailer or semi-trailer, and are subject to overall length limits between 40.0 and 41.0 m; b) Rocky Mountain doubles (Rockies), which consist of a tractor, one 16.2-m (53-ft) semi-trailer, and one 8.5-m (28.5-ft) trailer or semitrailer, and are normally subject to overall length limits between 31.0 and 32.5 m; and c) triple trailer combinations

(triples), which consist of a tractor, one 8.5-m (28.5-ft) semi-trailer, and two 8.5-m (28.5-ft) trailers or semi-trailers, and are subject to overall length limits between 35.0 and 41.0 m. LCVs are not normally permitted to operate beyond normal axle or gross vehicle weight (GVW) limits.

As of 2016, nine of 13 provinces/territories permit some form of LCV operations. These include: British Columbia, Alberta, Saskatchewan, Manitoba, Northwest Territories, Ontario, Québec, New Brunswick, and Nova Scotia. Many urban jurisdictions also permit LCV operations on selected routes to provide access to shippers, receivers, and carrier terminals.

Fig. 1 and Fig. 2 show the highways on which LCV operations are permitted in western and eastern Canada, respectively, as of August 2016. In Alberta, Saskatchewan, and Manitoba, all three LCV configurations are permitted on divided highways (with four or more lanes) and a limited number of undivided routes. Only Rockies are permitted on undivided roads that meet specified geometric criteria, primarily to provide access to key freight origins and destinations. In these three provinces, the LCV network connects all major urban centres (i.e., Calgary and Edmonton, Alberta, Regina and Saskatoon, Saskatchewan, and Winnipeg, Manitoba). Additionally, the undivided highway network provides connections to rural and northern population centres such as Prince Albert, Saskatchewan and into the Northwest Territories (Di Cristoforo et al. 2012). In British Columbia, LCV operations occur on a limited network in the southwest part of the province and on Vancouver Island. No connection exists between the LCV network in British Columbia and the network in the Prairie Provinces.

The eastern Canadian provinces (Fig. 2) permit the operation of turnpikes on a network that extends throughout southeastern Ontario and southeastern Québec, and includes selected routes in New Brunswick and Nova Scotia. Rockies and triples are not permitted on these routes. As in the Prairie Provinces, this network provides regional connectivity between major urban centres in Ontario and Québec (i.e., Windsor, Toronto, and Ottawa, Ontario, and Montréal and Québec City, Québec) and in New Brunswick and Nova Scotia (i.e., Fredericton, Saint John, and Moncton, New Brunswick, and Halifax,

Nova Scotia). No connection currently exists between these two regional networks, although available evidence indicates that construction on the twinning of this 40-km gap is scheduled to commence in 2017 (Québec Portal 2015).

Canada's current LCV network has evolved considerably, presumably in response to the rising demand for inter-provincial trucking service. Table 2 summarizes the extent of the LCV highway network in each jurisdiction in selected years since 1969. Overall, the network has grown from an initial extent of 300 km (all in Alberta) to its current reach of approximately 17,000 km across nine provinces/territories. For reference, the current extent of Canada's LCV network is nearly half the total distance comprising Canada's National Highway System (Transport Canada 2011). Key network-related developments follow (Nix 1995; New Brunswick Communications 2005; Truck News 2008; McCormick 2009; Regehr 2009; Truck News 2011; Di Cristoforo et al. 2012):

- 1969: Alberta establishes a test program for triples between Calgary and Edmonton, marking the first documented operation of LCVs in Canada.
- Circa 1982: Alberta, Saskatchewan, and Manitoba permit certain types of LCVs on limited intra-provincial networks.
- Circa 1988: Rockies are permitted on selected undivided routes in Alberta, Saskatchewan, Manitoba, and the Northwest Territories, providing regional interconnectivity. Québec permits the operation of LCVs on four-lane divided highways.
- 2005: New Brunswick begins pilot testing turnpike operations and subsequently permits these vehicles on selected divided highways.
- 2008: The completion of the divided highway network enables uninterrupted operation of turnpikes between all major urban centres in the Prairie Provinces. British Columbia commences a pilot project for Rocky operations on a portion of the Coquihalla Highway. Similarly, Nova

Scotia launches its own pilot program with the view to provide connectivity with the New Brunswick network.

- 2009: Ontario initiates a pilot program for the operation of turnpikes on selected 400-series highways. (This program was made permanent in 2011.)

Despite these network-related developments, there is limited publicly-available evidence of the growth of LCV travel across Canada. Regehr, Montufar, and Clayton (2009a) compile historical truck traffic data (1970 to 2005) from a site on the Trans Canada Highway west of Winnipeg, Manitoba. These data capture several changes in the articulated truck fleet mix, including the penetration of LCVs into the articulated truck fleet prior to 2005 resulting from the gradual regionalization of the LCV network throughout the Prairie Provinces. Roadside survey data collected by the University of Manitoba Transport Information Group (UMTIG) in 2013, 2015, and 2016 indicate growth in the proportion of LCVs within the articulated truck fleet at this location, reaching a fleet penetration of more than 10 percent in 2013. Since 2013, the proportional representation of LCVs within the fleet has declined, although the absolute volume of LCVs at this site has remained roughly constant. Di Cristoforo et al. (2012) further reveal that this overall growth is nearly all attributable to the adoption of turnpike doubles, as the operation of Rockies and triples at this location declined to nominal levels by 2009.

Some empirical evidence of the system-wide growth in Canadian LCV travel is also available in the literature. Based on a survey of LCV carriers, Nix (1995) estimates that total annual LCV travel in Alberta, Saskatchewan, Manitoba, and Québec (the four provinces that permitted LCVs at the time) amounted to 71 million kilometres. In Alberta, Regehr et al. (2009b) estimate that LCVs travelled a total of 256 million kilometres in the years 1999 to 2005, inclusive, an average of about 37 million kilometres per year. More recently, Regehr (2009) estimates total LCV travel in the province to be 39 million kilometres in 2006. In Ontario, Truck News (2011) reports that LCVs made 21,000 trips and travelled a

total of 6.6 million kilometres during its pilot program (between 2009 and 2011). In 2014, carriers participating in Ontario's LCV program travelled over 11 million kilometres in 36,000 one-way trips (Ontario Ministry of Transportation 2016).

As the LCV network expands and LCV operations grow, the need for inter-jurisdictional regulatory harmonization has become apparent. The recent (2012) memorandum of understanding (MoU) signed by the four western provinces (i.e., British Columbia, Alberta, Saskatchewan, and Manitoba) demonstrates a desire to create a seamless operating environment for inter-jurisdictional LCV activity. A similar MoU has recently been signed in 2016 by the four eastern provinces (i.e., Ontario, Québec, New Brunswick, and Nova Scotia) with similar intent. Despite progress towards regulatory harmonization, regional and jurisdiction-specific regulatory differences remain.

Synthesis of Current LCV Regulations in Canada

This section synthesizes Canadian LCV regulations within five categories.

1. Carrier permit requirements
2. Truck size and weight limits
3. Equipment requirements
4. Operating conditions
5. Driver qualifications

Findings stem from a comprehensive review of each jurisdiction's LCV permit documentation, supplemented as needed by direct correspondence with officials responsible for these regulations. The review is considered current as of August 2016. The following sections present regulatory details in tabular form to facilitate identification of commonalities and differences.

Carrier Permit Requirements

Table 3 summarizes the general permit requirements for LCV carriers in Canada. There is considerable harmonization of these requirements across Canada. In all jurisdictions, a carrier must obtain a permit prior to operating LCVs; this permit is usually renewable on an annual basis. To renew a permit, carriers must abide by all permit conditions and meet safety-related requirements. In terms of route applicability, permits in British Columbia, Ontario, New Brunswick, and Nova Scotia are typically limited to a specific pre-approved route within the province's LCV network, while permits in western Canada apply to all routes in the province's LCV network.

Truck Size and Weight Limits

Table 4 summarizes certain truck size and weight limits for LCVs operating in Canada. Principal observations about these limits follow:

- Turnpikes are the most widely permitted LCV configuration in Canada, with operations permitted in all jurisdictions except the Northwest Territories. In contrast, only Alberta, Saskatchewan, and Manitoba permit triples, and only the western provinces permit Rockies.
- Vehicle length limits vary by LCV configuration. Where permitted, Rockies are limited to lengths ranging from 31.0 to 41.0 m, turnpikes are limited to lengths of either 40.0 or 41.0 m (Québec specifies the maximum trailer length but does not specify a vehicle length limit for turnpikes), and triples are limited to lengths ranging from 35.0 to 41.0 m.
- Gross vehicle weight (GVW) limits also vary by LCV configuration. For Rockies, the GVW limit is 63,500 kg if the vehicle utilizes a B coupling device; this limit is lower if the vehicle's trailers are connected using an A (53,500 kg) or C (60,500 kg) coupling device. For turnpikes, GVW limits range between 62,500 kg (in Nova Scotia) and 67,500 kg (in Québec), and depend on the number of axles in the configuration. Triples have a GVW limit of 53,500 kg.

- The type of coupling device used between trailers in an LCV configuration influences the dynamic performance of the vehicle. Generally, vehicles equipped with B or C coupling devices have superior stability and are more easily operated in reverse compared to vehicles equipped with A coupling devices; however, they are less maneuverable around corners. Most jurisdictions do not specify the type of coupling device used in an LCV configuration. Exceptions include the prohibition of A coupling devices on triples in Saskatchewan and C coupling devices on turnpikes in Ontario, New Brunswick, and Nova Scotia.

Additional, more detailed regulations related to truck size and weight also exist. Such details involve the relative weights of trailers and/or axles within the configuration and trailer length restrictions.

Equipment Requirements

Table 5 summarizes equipment requirements for LCVs in Canada; these requirements influence vehicle maneuverability, visibility, and dynamic performance. Principal observations about these requirements follow:

- Most jurisdictions control vehicle maneuverability by specifying power requirements for tractors towing LCV configurations (either in terms of a weight-to-power ratio or minimum engine horsepower) and by mandating certain braking equipment (e.g., anti-lock braking systems, relay valves, air reservoirs, compressors, air dryers).
- Except for Alberta, Saskatchewan, and the Northwest Territories, all jurisdictions stipulate visibility aids to improve LCV conspicuity. A variety of visibility aids are specified, including lateral lights for long trailers and rear-mounted signs identifying the vehicle as an LCV.
- Specification of no-slack pintle hooks and maximum lateral trailer sway by some jurisdictions addresses aspects of the dynamic performance of LCVs.

Operating Conditions

LCVs in Canada must comply with a range of conditions which dictate how and when they operate. Table 6 summarizes these conditions; principal observations follow:

- All jurisdictions except the Northwest Territories restrict the maximum operating speed of LCVs at either 90 or 100 km/h. Depending on the route and posted speed limit, these restrictions may introduce an operating speed differential between LCVs and other traffic.
- In five jurisdictions, LCVs are required to operate in the right-hand lane of a multi-lane highway except: a) when conditions are impractical to do so (as in Ontario); b) when passing (as in British Columbia and Manitoba); or c) in case of emergency (as in New Brunswick and Nova Scotia). Alberta, Saskatchewan, Québec, and the Northwest Territories do not specify lane restrictions for LCVs.
- British Columbia, Ontario, Québec, New Brunswick, and Nova Scotia require LCVs to adhere to a minimum spacing within the traffic stream. This minimum spacing ranges from 150 m in Ontario and Québec to 1000 m in British Columbia, but varies depending on the types of vehicles considered. No such requirements are specified by Alberta, Saskatchewan, Manitoba, and the Northwest Territories.
- Except for Alberta, all jurisdictions prohibit LCVs from hauling certain types of cargo. Cargo restrictions include unstable bulk loads, hanging loads, livestock, dangerous goods, and unsecured loads.
- Except in the Northwest Territories, all jurisdictions prohibit LCV operations during adverse weather conditions. Although the definition of these conditions differs, they are typically defined in terms of visibility, traction, and the presence of cross wind.
- Most jurisdictions (except Québec and the Northwest Territories) stipulate safe refuge locations for LCVs in case they encounter adverse weather or experience an emergency. New Brunswick

and Nova Scotia indicate that LCVs must activate 4-way flashing lights if travelling at or below 70 km/h on the arterial highway network.

In addition to the foregoing operating conditions, most jurisdictions impose temporal restrictions designed to limit or prohibit LCV operations during peak traffic conditions. Despite numerous differences in the details of these restrictions across the country, three general types of temporal restrictions are evident:

1. Business: These restrictions primarily prohibit LCV operations during daytime weekday hours. In some cases, these restrictions are limited to short morning and afternoon timeframes during peak commuting hours. In other cases, these restrictions extend from the morning to the afternoon hours and occasionally into the late afternoon.
2. Recreational: These restrictions prohibit LCV operations during certain weekend hours or around statutory holidays. Weekend restrictions prohibit operations at the start, middle, and/or end hours of the weekend or extended weekend. For statutory holidays, restrictions prohibit operations on the statutory holiday itself and sometimes on the day or latter portions of the day preceding a statutory holiday.
3. Hybrid: These restrictions prohibit LCV operations at a range of times which fall within both the business and recreational designations.

Fig. 3 and Fig. 4 identify routes subject to temporal restrictions and the type of restriction for western and eastern Canada, respectively. The maps reveal that LCV operations are commonly temporally restricted:

- around weekend peak recreation hours or on holidays on rural highways and in or near urban areas (this is especially evident in eastern Canadian jurisdictions except Nova Scotia);

- during peak weekday rush hour(s) in or near urban areas (primarily evident in Saskatchewan, Ontario, Québec, New Brunswick, and Nova Scotia); and
- on certain two-lane undivided highways.

Driver Qualifications

Drivers operating LCVs in Canada must comply with certain requirements before receiving their LCV driver's certificate. Table 7 summarizes LCV driver qualifications. Principal observations about these qualifications follow:

- In all jurisdictions, LCV drivers must hold a valid license for operating a commercial truck equipped with airbrakes.
- Beyond holding a valid commercial driver's license, LCV drivers in all jurisdictions must have a minimum level of experience and training prior to operating an LCV. Minimum experience levels—expressed in either years or distance driven—vary between jurisdictions. The western provinces require at least two years of experience driving articulated configurations whereas the eastern provinces require five years of experience. Moreover, all jurisdictions require drivers to complete an LCV driver training course.
- Except in Québec, LCV drivers must maintain a minimum level of performance. In most cases, drivers must not have more than two moving violations within a 12-month period and not more than three moving violations within a 36-month period.

Implications for Geometric Design and Highway Operations

The regulations governing LCV operations in Canada directly influence geometric design and highway operations by defining vehicle specifications and performance, controlling LCV operations spatially and temporally, and stipulating driver and carrier performance criteria. Perhaps less obviously,

the extent of network connectivity enabled by the regulations and the degree to which they provide inter-jurisdictional uniformity also affect the quantity of LCV activity. As LCV activity increases, these vehicles become a more prominent factor in the design and operation of highways. This section describes details of these effects.

Vehicle Specifications and Operating Performance

Size and weight limits are a primary feature of LCV regulations across Canada. Despite some variability in the details of these limits for LCVs in Canada, from a geometric design perspective, the principal consideration is the extended length at which these vehicles operate relative to other truck configurations. In most jurisdictions, the GVW and axle load limits are not higher than those governing other articulated truck configurations. Notably, the excess vehicle length has not been formally recognized in Canadian highway design guidance. According to the current version of the *Geometric Design Guide for Canadian Roads* (Transportation Association of Canada 1999, p. 1.2.4.1), LCVs “are normally expected to operate within a limited jurisdiction” and are “normally of local interest”. Adjustments to design vehicle specifications were not within the scope of the forthcoming update to this *Guide*. Despite this, highway designers in jurisdictions where LCV operations are commonplace have recognized the need to adapt geometric features such as intersection turning radii, intersection sight distances, and lane widths to better accommodate the performance characteristics of LCVs (Barton and Morrall 1998; Kenny, Kwan, and Morrall 2002; Harwood et al. 2003; Woodrooffe and Milliken 2007; Billing and Madill 2010; Maranchuk and Regehr 2015).

LCV regulations also define aspects of vehicle performance by establishing limits for dynamic performance measures or prescribing equipment-related criteria known to influence dynamic performance. Common dynamic performance measures for trucks include (Harwood et al. 2003, OECD 2011, FHWA 2015): turning radius, offtracking and swept path width, trailer swingout, braking distance, driver eye height, acceleration characteristics, speed-maintenance capabilities on grades, rearward

amplification (i.e., trailer sway), suspension characteristics, load transfer ratio, and rollover threshold. Based on the synthesis of regulations in the previous section, of these performance measures, only trailer sway is explicitly limited within Canadian LCV permits. Other performance measures are controlled indirectly. Table 8 lists aspects of LCV operating performance stipulated by Canadian regulations, the dynamic performance measures that these regulations primarily influence, and illustrative interdependencies between these measures and geometric design elements.

Spatial and Temporal Controls

Spatial and temporal controls are common elements of LCV permits across Canada. All Canadian jurisdictions impose spatial controls by designating the highway network on which LCVs can operate as part of the permit. Normally, the criteria used to define such networks include cross-sectional features (e.g., divided or undivided, number of lanes, paved shoulder width on two-lane undivided roads) and the potential magnitude of demand for LCV travel on a network link. Thus, the LCV regulations help define and control the vehicles that should be accommodated in the design of a highway and how it is operated and managed. Experience in some jurisdictions also provides evidence that design-related changes sometimes cause changes in the LCV network—seemingly inadvertently. For example, in the Canadian Prairie Provinces, LCV permits allow turnpike doubles and triples to operate on divided highways. In the last decade, each of these provinces have invested in highway twinning projects, presumably for the purposes of improving traffic operations or safety, but likely not with the direct intent of expanding the LCV network. Nevertheless, as twinning projects were completed, jurisdictions modified their LCV networks to reflect the new infrastructure conditions. Principal examples of these effects occurred along the Trans Canada Highway in Manitoba and Saskatchewan, along the Yellowhead Highway in Saskatchewan, and along Highway 43 between Edmonton and Grande Prairie, Alberta.

Additionally, many jurisdictions impose temporal controls that prohibit LCV movements during certain days of the year, hours of the day, or days of the week, particularly around more congested

urban areas. These regulations limit the potentially adverse operational interactions that may occur when LCVs operate within the traffic stream. Weather-related restrictions are less predictable, but are similarly aimed at limiting (or prohibiting) LCV operations during adverse road or weather conditions. The diverse application of temporal restrictions (see Fig. 3 and Fig. 4) and the inconsistent definitions used to specify weather-related restrictions pose challenges for scheduling and dispatching long-distance trips through multiple jurisdictions. Montufar and Clayton (2002) recognize these challenges in the application of seasonal truck weight limits, and emphasize opportunities for regional regulatory rationalization and harmonization. Opportunities applicable to the context of LCV operations include (Montufar and Clayton 2002):

- simplifying regulations to eliminate minor variances between jurisdictions if there is no scientific basis for the variances;
- considering harmonization opportunities across regions or along multi-jurisdictional corridors; and
- leveraging technologies to support better communication of regulations, potentially as part of the permitting process.

LCV Driver and Carrier Performance

LCV regulations specify strict driver qualifications as a prerequisite for the operation of LCVs, including licensing requirements and minimum levels of training and experience. Moreover, all jurisdictions consider carrier safety performance prior to granting LCV operating permits. A driver's history of involvement in crashes and driving violations is known to be a strong predictor of future crash involvement (Knipling 2009, OECD 2011). Indeed, Woodrooffe (2001) identified driver qualification requirements as one of the permit conditions "found to be a vital influencing factor in the creation of a safe [LCV] operating environment in Alberta". There is also evidence that the safety culture of a carrier influences the safety performance of the driver (Knipling 2009).

From a highway engineering perspective, the expectation that LCVs are being operated by highly qualified drivers offsets the potentially difficult operational maneuvers that these vehicles encounter. Thus, maintaining stringent driver and carrier qualifications appears prudent. However, current driver shortages in the trucking industry and the potential for increased demand for LCV operations to deplete the pool of qualified drivers may challenge the sustainability of this expectation in the future.

Network Connectivity and Inter-Jurisdictional Regulatory Harmonization

Physical changes to certain roadway design features—such as twinning a previously undivided highway or widening the paved shoulder width—define whether LCV travel may occur on that link and impact the system-wide extent of LCV activity if they contribute to regional network connectivity. The example of the ever-expanding network of divided highways in the Canadian Prairie Provinces is again appropriate to consider. Ten years ago, the LCV network in Alberta, Saskatchewan, and Manitoba was incomplete from the perspective of facilitating regional LCV travel between major origin-destination pairs. That is, while it enabled intra-jurisdictional movements (e.g., between Calgary and Edmonton, Alberta; between Regina and Saskatoon, Saskatchewan; between Winnipeg and Brandon, Manitoba), gaps in the network precluded significant levels of inter-jurisdictional LCV movement. As these gaps were closed, however, available evidence shows a corresponding increase in the levels of LCV activity in the region (Regehr 2009; Regehr, Montufar, and Clayton 2009a; Regehr et al. 2009b; Di Cristoforo et al. 2012).

In addition to network connectivity, LCV travel may also be influenced by the degree of regulatory harmonization. A lack of uniformity of regulations between jurisdictions can render a physically connected network ineffective if compliance with disparate cross-jurisdictional regulations becomes too onerous for a carrier. Public agencies have demonstrated recognition of the benefits of harmonizing LCV regulations and have made progress in achieving this goal. Principal examples are the

recent signing of the Turnpike double MoU among western Canadian provinces and the subsequent signing of the Turnpike double MoU among eastern Canadian provinces.

From a highway engineering perspective, awareness of the status of these efforts may help define future LCV volumes on specific network links. As LCVs become more prominent within the traffic stream, there is a need to explicitly consider their performance characteristics when designing geometry and managing operations.

Concluding Remarks

LCVs have been operating in Canada for decades, but with nine provinces/territories now permitting LCV operations in some form, these operations have never been so widespread or extensive. Based on evidence from across Canada compiled for the first time in this article, LCVs currently operate on a network of approximately 17,000 km. This network comprises fully interconnected regional systems throughout the Prairie Provinces and the Northwest Territories, between Ontario and Québec, and between New Brunswick and Nova Scotia. Forthcoming highway upgrades are expected to provide operational connectivity for LCVs from Windsor, Ontario through to Halifax, Nova Scotia. A fully national system would entail substantial efforts to close existing gaps between selected routes in British Columbia and the network in the prairies, and between the prairies and the eastern Canadian network.

Canadian LCV regulations govern how carriers obtain operating permits, truck size and weight limits, equipment requirements, operating conditions, and driver qualifications. The national-level synthesis of regulations presented in this article reveals many similarities—particularly at the regional scale—owing principally to recent regional agreements aimed at improving regulatory uniformity. Achieving such uniformity is neither straightforward nor inevitable, but rather the outcome of ongoing collaborative efforts among jurisdictions and between government and private industry. Despite these general commonalities, opportunities remain to work towards increased regulatory harmonization

across the country. From the highway geometric design and operations perspectives, improved regulatory harmonization provides the impetus and opportunity to consider LCVs and their unique operational characteristics more formally.

The following points summarize key findings from the regulatory review and the implications of these regulations for geometric design and highway operations:

- In all jurisdictions, only certified LCV carriers may operate LCVs. This, coupled with enhanced and mostly standardized qualification requirements for LCV drivers, fosters an environment which promotes the responsible driving habits needed when LCVs encounter challenging geometric or operational conditions.
- Turnpikes are the only LCV configuration permitted in all jurisdictions; Rockies and triples are not permitted in the eastern Canadian provinces. The size and weight limits applicable to these configurations exhibit some variation between jurisdictions. When explicitly stipulated in the permit, equipment requirements exhibit only minor variations between jurisdictions; the more apparent difference here is the lack of specification of certain equipment requirements by some jurisdictions. The regulations governing vehicle dimensions, weights, and equipment influence a vehicle's dynamic performance and consequently affect the design of various geometric elements.
- Operating conditions define and control where and when LCVs operate and consequently the circumstances in which design and operational decisions should account for their unique characteristics. These operating conditions exhibit variability between jurisdictions and present opportunities for improved regulatory harmonization.
- The network connectivity afforded by LCV regulations and the inter-jurisdictional harmonization of LCV regulations indirectly influence the magnitude of LCV activity. As LCV activity increases,

the need to consider their unique performance characteristics in design and operations becomes more apparent.

Canada has a long history of adopting approaches to commercial vehicle regulation that aim to balance the often-competing objectives of productivity, energy efficiency, infrastructure preservation, and safety. The regulations set out in provincial/territorial permits help to achieve this balance by transparently subjecting more productive vehicles to more stringent operating requirements.

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Tables

Table 1. Three common LCV configurations in Canada.

LCV configuration	Diagram of a typically-configured LCV	Axle configuration
Turnpike double		3-S2-3, 3-S2-4 (shown), 3-S2-5, others
Rocky Mountain double		3-S2-2 (shown), others
Triple trailer combination		2-S1-2-2 (shown), 3-S1-2-2, others

535 **Table 2.** Kilometres of LCV highway network in Canadian jurisdictions, 1970-2016 ^a.

Jurisdiction	c. 1970	c. 1982	c. 1988	c. 1995	2007	2016
British Columbia	0	0	0	0	0	700
Alberta	300	1300	2400	3900	5300	6100
Saskatchewan	0	500	3100	3600	4100	4200
Manitoba	0	300	400	700	1600	900
Ontario	0	0	0	0	0	1600
Québec	0	0	1800 ^b	1800 ^b	1800 ^b	1800
New Brunswick	0	0	0	0	200 ^c	800
Nova Scotia	0	0	0	0	0	300
Northwest Territories	0	0	300	300	600 ^d	600
Total	300	2100	6200	10,300	13,600	17,000

536 ^a The historical statistics presented in the table are compiled from available evidence provided by Burns 1983;

537 Girling 1988; Nix 1995; Communications New Brunswick 2005; and Regehr 2009. The authors consider the values
 538 presented to be estimates, as it is difficult to independently validate the data. Statistics for 2016 are based on
 539 original analysis by the authors.

540 ^b For the purpose of this research, the distances reported for Québec in 1988, 1995, and 2007 are assumed to
 541 equal the 2016 distance. This distance generally agrees with the estimate provided by Nix (1995).

542 ^c Communications New Brunswick (2005) indicates that the original one-year pilot project for LCV operations in
 543 New Brunswick commenced in February 2005. It is unclear whether this network had been extended by 2007.

544 ^d For the purpose of this research, the distance reported for the Northwest Territories in 2007 is assumed to equal
 545 the 2016 distance.

546 **Table 3.** Permit requirements for LCV carriers in Canada, 2016.

Jurisdiction	Permit required?	Term length	How to maintain permits
British Columbia	Yes	N/A	Abide by permit conditions and maintain safety rating of “Satisfactory”
Alberta	Yes	Maximum 12 months	Abide by permit conditions and Traffic Safety Act
Saskatchewan	Yes	12 months	Abide by permit conditions
Manitoba	Yes	Maximum 12 months	Abide by permit conditions
Ontario	Yes ^a	12 months	Abide by permit conditions and maintain safety rating of “Satisfactory”
Québec	Yes	3 to 9 months	Abide by permit conditions
New Brunswick	Yes	12 months	Abide by permit conditions and maintain safety rating of “Satisfactory”
Nova Scotia	Yes	12 months	Abide by permit conditions and safety requirements
Northwest Territories	Yes	12 months	Abide by permit conditions and safety requirements

547 ^a In Ontario, LCV operations are limited to a maximum of 100 carriers, with no more than 16 vehicle permits per
 548 carrier.

549 **Table 4.** Truck size and weight limits governing LCV operations in Canada, 2016.

Jurisdiction	LCV configuration	Vehicle length limit (m)	Gross vehicle weight limit (kg)	Coupling device ^a between trailers
British Columbia	Rocky	31.0 - 32.0 ^b	63,500 ^{c, d}	A, B, C
	Turnpike	41.0	63,500 ^d	A, B, C
Alberta	Rocky	31.0	63,500 ^c	A, B, C
	Turnpike	41.0	63,500 ^d	A, B, C
	Triple	38.0 ^e	53,500	A, B, C
Saskatchewan	Rocky	31.0 or 41.0 ^f	63,500 ^c	A, B, C
	Turnpike	41.0	63,500	A, B, C
	Triple	41.0	53,500	B, C
Manitoba	Rocky	32.5 or 41.0 ^f	63,500 ^c	A, B, C
	Turnpike	41.0	63,500	A, B, C
	Triple	35.0	53,500	A, B, C
Ontario	Turnpike	40.0	63,500	A, B
Québec	Turnpike	Trailers limited to 16.2	67,500	A, B, C
New Brunswick	Turnpike	40.0	63,500 ^d	A, B
Nova Scotia	Turnpike	40.0	62,500 ^d	A, B
Northwest Territories	Rocky	31.0	63,500 ^{c, d}	A, B, C

550 ^a Three main coupling devices are used to connect trailers within an LCV configuration. An A coupling device
 551 contains a pintle hook attached to single or tandem axle group and a fifth-wheel. This device contains two
 552 articulation points: one at the fifth-wheel and one at the pintle hook on the rear of the lead trailer. It does not
 553 transfer roll between vehicle units. A B coupling device contains a tandem or tridem axle group rigidly fixed to the
 554 lead trailer and a fifth wheel. This device contains one articulation point at the fifth-wheel and transfers roll
 555 between the vehicle units. A C coupling device contains double draw bars attached to a single or tandem axle
 556 group and a fifth-wheel. This device contains one articulation point at the fifth-wheel and transfers roll between
 557 vehicle units.

558 ^b depending on route

559 ^c only for B coupled vehicles

560 ^d only for vehicles with eight or more axles

561 ^e only for double B coupled vehicles

562 ^f lower limit applies to two-lane highways; upper limit applies to four-lane highways

563 **Table 5.** Equipment requirements for LCV configurations in Canada, 2016.

Jurisdiction	Weight to power ratio (kg/hp)	Brake requirements	Pneumatics	Special visibility aids	A and C coupling devices	Maximum lateral trailer sway (cm)
British Columbia	150	Anti-lock braking system (tractor only)	N/A	Lateral lights (for trailers > 8.6 m)	No slack pintle hooks	N/A
Alberta	160	Relay valves	Air reservoirs, compressors	N/A	No slack pintle hooks	10
Saskatchewan	160	Relay valves	Air reservoirs, compressors	N/A	No slack pintle hooks	10
Manitoba	160	Relay valves	Air reservoirs, compressors	“LONG LOAD” sign. ^a	No slack pintle hooks	10
Ontario	425 hp minimum	Anti-lock braking system, relay valves	Air compressor, air dryers	Side marker lights, “LONG” sign	No slack pintle hooks	N/A
Québec	180	Relay valves	Air compressor	“LONG” sign	N/A	8
New Brunswick	460 hp minimum	N/A	N/A	LED lighting, “LONG” sign	No slack pintle hooks	N/A
Nova Scotia	460 hp minimum	N/A	N/A	LED lighting, “LONG” sign	No slack pintle hooks	N/A
Northwest Territories	N/A	N/A	N/A	N/A	N/A	N/A

564 ^a for two-lane, undivided highways only

565 **Table 6.** Operating conditions for LCVs in Canada, 2016.

Jurisdiction	Maximum speed (km/h)	Lane restrictions	Required spacing (m)	Cargo restrictions	Restricted weather conditions	Emergency operations
British Columbia	100	Right hand lane, except when passing; left hand lane prohibited on six-lane highways	1000 ^b , 500 ^c	Unstable bulk loads, hanging loads, dangerous goods	Adverse weather, visibility < 300 m, precipitation affecting traction	Drivers must stop at next safe location
Alberta	100	N/A	N/A	N/A	Adverse weather, hazardous precipitation/fog ^e	Drivers must stop at next safe location
Saskatchewan	90 – 100 ^a	N/A	N/A	Unstable bulk loads, hanging loads, livestock	Adverse weather, hazardous precipitation/fog ^e	Drivers must stop at next safe location
Manitoba	100	Right hand lane, except when passing	N/A	Unstable bulk loads, hanging loads, livestock	Adverse weather	Drivers must stop at next safe location
Ontario	90	Right hand lane when practical	150 ^b	Dangerous goods, livestock	Snow/ice on road, visibility < 500 m	Drivers must proceed to the nearest rest/emergency stop or safe point off the travelled portion of the highway
Québec	90	N/A	150 ^d	Dangerous goods	Snow/ice on road, visibility < 500 m	N/A
New Brunswick	90	Right hand lane, except for emergencies	300 ^b	Dangerous goods, livestock	Hazardous precipitation/fog/cross wind, snow/ice on road, visibility < 500 m	Driver must exit the highway at first designated refuge area; activation of 4-

						way flashing lights required at speeds ≤ 70 km/h
Nova Scotia	90	Right hand lane, except for emergencies	500 ^b	Dangerous goods, livestock	Hazardous precipitation/ fog/cross wind, snow/ice on road, visibility < 300 m	Driver must exit the highway at first designated refuge area; activation of 4-way flashing lights required at speeds ≤ 70 km/h
Northwest Territories	N/A	N/A	N/A	Unsecured loads	N/A	N/A

566 ^a depending on route

567 ^b between two LCVs

568 ^c between LCV and commercial vehicles

569 ^d between LCV and any vehicle

570 ^e only for two-lane highways

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571 **Table 7.** Qualifications for drivers operating LCVs in Canada, 2016.

Jurisdiction	Required license	Experience with articulated vehicles	Training	Moving violations
British Columbia	Class 1 or equivalent	24 months or 150,000 km	Canadian Trucking Alliance's (CTA) LCV Course or equivalent	≤ 2 in past 12 months and ≤ 3 in past 36 months
Alberta	Class 1 or equivalent	24 months or 150,000 km	Alberta Motor Transport Association's LCV Course or equivalent	≤ 2 in past 12 months and ≤ 3 in past 36 months
Saskatchewan	Class 1 or equivalent with airbrake endorsement	24 months or 150,000 km	CTA's LCV Course or equivalent	≤ 2 in past 12 months and ≤ 3 in past 36 months
Manitoba	Class 1 or equivalent with airbrake endorsement	24 months or 150,000 km	CTA's LCV Course	≤ 2 in past 12 months and ≤ 3 in past 36 months
Ontario	Class A with airbrake endorsement or equivalent	5 years	Ontario Trucking Association's LCV Program or equivalent	≤ 2 in past 12 months and ≤ 3 in past 36 months
Québec	Class 1 with "T" certification	5 years	"T" certification or equivalent	N/A
New Brunswick	Class 1 with airbrake endorsement	5 years and 150,000 km	Atlantic Provinces Trucking Association's LCV Course or equivalent	≤ 2 in past 12 months and ≤ 3 in past 36 months
Nova Scotia	Class 1 with airbrake endorsement	5 years and 150,000 km	CTA's LCV Course or equivalent	≤ 2 in past 12 months and ≤ 3 in past 36 months
Northwest Territories	Class 1 with airbrake endorsement	2 years	LCV course or verifiable instruction from employer	≤ 6 demerit points in past 12 months

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Table 8. Regulations governing LCV operations and their relationship with dynamic performance measures and geometric design elements.

Regulated item	Examples of related dynamic performance measure(s)	Examples of related geometric design elements
Trailer sway	Trailer sway	Lane width, pavement widening on horizontal curves
Coupling device	Turning radius, offtracking and swept path width, trailer sway, load transfer ratio, rollover threshold	Lane width, horizontal curve radius and superelevation, pavement widening on horizontal curves, intersection and channelization geometrics
Engine power	Acceleration, speed-maintenance on grades	Critical length of grade, acceleration lanes, intersection sight distance
Braking systems	Braking distance	Stopping sight distance, intersection sight distance, deceleration lanes, downgrades
Maximum speeds	Offtracking and swept path width, braking distance, trailer sway	Sight distance, lane width
Lane restrictions	Acceleration	Passing sight distance
Required spacing	Braking distance, acceleration	Sight distance
Cargo restrictions	Load transfer ratio, rollover threshold	Horizontal curve radius
Restricted weather conditions	Braking distance, trailer sway	Sight distance, lane width

List of Figure Captions and Notes

Fig. 1. LCV routes in western Canada, 2016.

Fig. 2. LCV routes in eastern Canada, 2016.

Fig. 3. Temporal restrictions on LCV routes in western Canada, 2016 ^a.

^a Three generalized types of LCV temporal restrictions are evident in Canadian jurisdictions: (1) business restrictions, which typically prohibit operations during daytime hours on weekdays, (2) recreational restrictions, which typically prohibit operations during certain hours on weekends or around statutory holidays, and (3) hybrid restrictions, which represent a range of restrictions with both business and recreational components.

Fig. 4. Temporal restrictions on LCV routes in eastern Canada, 2016 ^a.

^a Three generalized types of LCV temporal restrictions are evident in Canadian jurisdictions: (1) business restrictions, which typically prohibit operations during daytime hours on weekdays, (2) recreational restrictions, which typically prohibit operations during certain hours on weekends or around statutory holidays, and (3) hybrid restrictions, which represent a range of restrictions with both business and recreational components.