A Set of Strategic Freight Performance Measures for Ontario

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Please note that this report seeks to be an objective and impartial effort and may not reflect the views/positions of the Government of Ontario.

Executive Summary

Results from this research indicate that development of a multi-modal freight performance system would be a useful outcome for Ontario. The system could be operationalized through a dashboard which ultimately could be shared on-line with all participants in the freight system and could potentially help raise awareness among the general public on the importance of goods movement. The results of this research derive from two primary streams of inquiry. There has been an extensive review of the available literature (peer-reviewed and otherwise) and secondly, in-person consultations have been undertaken with a varied range of Ontario stakeholders from the public and private sectors. Insights from both processes have been used to derive a list of relevant measures for the province.

Issues/Actors/Infrastructure

In most performance measurement contexts, metrics can be internalized to the organization initiating the measurement but this is not the case for a provincial freight system. In this context, the “system” is very much a collective concept with many private and public players having differing roles, responsibilities and interests. There are multiple modes and jurisdictions of different levels, many types of infrastructure and associated issues, and considerable interaction with non-freight land uses and transport. Among the long list of actors, the Province of Ontario emerges as a logical leader in the development of a freight performance system for Ontario.

In terms of defining issues, consultations revealed that stakeholders are pre-occupied with the performance of road freight transport. Combined with the fact that road accounts for the first and last kilometres of multi-modal movements is the problem of metropolitan traffic congestion which is particularly acute in the Greater Toronto Hamilton Area. At present, capacity constraints on freight movements are not severe in the contexts of marine, rail or air but road infrastructure on some provincial highways, key urban arterials and important interchanges is extremely heavily used for the purposes of freight and people movements and the problem of traffic congestion is gradually evolving into an all-day phenomenon in some places. Impacts are social (e.g. truck driver stress and reduced quality of life), environmental (e.g. congested freight movements produce greater quantities of harmful tailpipe emissions than uncongested movements) and economic (e.g. lost time has real monetary value and slower circulation of trucks promotes a need for larger fleets – higher costs are passed to consumers).

Formulation of Measures

Among other aspects, the literature review revealed that selection of a list of measures has the potential to be overwhelming in terms of the number of unique combinations of measures. A compiled list of freight performance measures that have been used in prior studies and in the planning documents of domestic and international jurisdictions exceeds over a thousand measures and this list is not exhaustive. While it is true that some of these measures vary from one another by degree, it is also clear that there is little standardization of measures across jurisdictions. In contrast, on an intra-organizational basis and often in the private sector, there can be just a single measure that attracts a great deal of attention and becomes a key focus in assessing the prevailing circumstances. This single measure may be complemented by an array of supporting measures. In the United States it has been suggested that the most mature provincial freight jurisdictions typically feature a handful of well-chosen measures to support their frameworks. Ultimately, no two performance systems are likely to be identical and there will be elements of subjectivity. Indeed, it can be argued that each jurisdiction has its own unique circumstances that may demand at least some unique measures.

The availability of good data is the key enabler of good freight performance measurement. A framework depends on the availability of multiple data sources over multiple time periods and applying to multiple contexts. Historically, surveyed data sets have been preeminent in supplying the types of data that would support the measurement of freight performance, but increasingly relevant data are being sourced as “Big Data” with the rise of new data collection capabilities such as GPS and electronic trucking logs. The three ‘V’s” of Big Data are volume, velocity and variety. The freight sector appears to be no exception in its ability to generate a variety of data in large volumes that are high velocity in the sense that they can theoretically be updated in short order relative to survey data that instead might be updated every several years. The velocity aspect of such data sources would help to make a dashboard worthwhile: it becomes a useful exercise to periodically check back to gauge trends in system performance. The rise of new data sources raises the possibility for “leapfrog” potential: a jurisdiction which lags on freight policy and measurement can make rapid progress if it commits to leveraging the new data possibilities.

Results suggest that a freight performance system of reasonable quality could already be put in place in Ontario with existing data sources. Such a system would combine the best of traditional data collection, including surveys, with data derived from new technologies. For example, there are newly emerging private GPS-based data sources available that can provide a travel time distribution for trucks, by time of day, for empirically observed travel times along the entire length of a strategic road corridor. Such detail, which can be periodically updated, would not have been possible only a few years ago.

Performance measures should possess certain characteristics that have perhaps been best articulated through the work of Caplice and Sheffi (1994). They suggest seven criteria that are all worthwhile to consider with “robustness” being arguably one that stands out. A robust measure is interpreted similarly by users, is repeatable, and is comparable across time and location. It could be argued that the popular “travel time index,” a ratio of the peak-period travel time to the free-flow travel time of an identified route or link, for example, fails this criterion in that the same result can be obtained for two quite different corridors. If calculated and summarized for two cities, the same result could be obtained for a dense, compact city as for a sprawled one though the travel time experience would be harsher in the latter city.

The types of measures that best fulfil the criteria of Caplice and Sheffi are generally straightforward, unambiguous metrics with basic and understandable units. Ideally, they are based on empirical and not modelled data. A good measure for the province should stand the test of time in that it can be useful and relevant for many years as opposed to being too focused on a particular freight performance problem that was quickly solved. A good candidate measure can have a normative or aspirational quality to it in terms of generating urgency to make available the type of data that would support it. Above all else, an effective framework for freight performance measurement is less about the development of new and complex measures than it is about applying a well-chosen array of metrics, that people can consistently relate to over a long period of time. This does not imply that metrics will be forever static – a system of measures would unavoidably evolve over time.

Implementable Measures

The chart in Figure 0-1 highlights the measures that have emerged from this research. The discussion here of these measures is higher level. Demand measures across the modes are seen as fundamental and should be captured, where possible, in terms of: the value of goods, tonnages, vehicle kilometres travelled, and tonne-kilometres. Each demand theme is important in its own way. The value of goods moving is seen as an economic measure that highlights the enormous strategic importance to the economy of goods movement. Economic measures derived from economic impact models and the like are best avoided in favour of the empirically-oriented value of goods. Measures related to safety across the modes (fatalities and events causing injury) are included to provide a complete picture of the opportunities and risks associated with goods movement. A focus on the emissions of GHG’s and other pollutants by mode is prudent from the perspective of climate change and given linkages to health impacts on nearby populations. Related to emissions is a measure on the progress of low/zero emission commercial vehicles as a share of the total commercial vehicle stock.

This research promotes the concept of measuring performance in terms of travel times and their variability along strategic corridors within Ontario; this includes critical stretches of major highways and border crossings which can also be conceived of as strategic corridors. The inclusion of border measures highlights the importance of trade to Ontario’s open economy. The focus on strategic corridor measures is aligned with the fact that freight flows tend to concentrate themselves on a few key strategic corridors. Associated with the concepts of travel time and variability is the concept of delay. This measure is fundamental to understanding the magnitude and implications of severe congestion in the road context since this is dependent on the number of trucks that are being slowed. For other modes, delay is captured through dwell times in terminal facilities.

There is an opportunity to break new ground in developing quantitative measures for freight to address issues with "silos" and disconnects within and between public sector organizations. Little evidence has been found that these aspects are covered well in freight performance systems but consultations suggest that this is a big issue. Because truck volume data is much desired by many freight stakeholders as a fundamental data source, it is suggested to develop a measure which captures multi-jurisdictional progress on this front. Another measure is suggested that tracks human resource commitments to freight in the public sector on the basis that larger commitments to freight are associated with more progress on freight.

Gaps that Remain

For road, great detail has been emerging through GPS data and could emerge through electronic truck logs but there remain fundamental gaps in basics such as route-specific truck volumes and it is a work in progress to generate rigorous bottom-up measures of vehicle kilometres travelled. By the nature of their sampling approaches, the MTO Commercial Vehicle Survey and the Trucking Commodity Origin-Destination survey are associated with sampling gaps. They nevertheless are seen as highly useful data sources. It is surprisingly difficult to obtain certain demand data with geographic detail while at the same time, GPS sources are offering enormous geographic detail in certain respects. For rail, the Class 1 operators collect enormous amounts of data. In the end, most of the gaps relate to issues of confidentiality and how that governs what can be released. Lack of released data on the geography of movements is probably the biggest resulting gap and there is also very limited information on shortline operations. In the multimodal chapter of this report, a measure is suggested that would create origin-destination data for Ontario across <u>all</u> modes.

For marine, the biggest gaps would seem to be in leveraging real-time GPS mapping of vessel movements and accessing cargo manifest data to generate detailed demand data at the origin-destination level. The raw ingredients would appear to be in place but combined with a sense of urgency some co-ordinating efforts, discussion and investment might be required. Gaps have also been noted at the port level in compiling detailed data about connections with road and rail and capturing dwell times. For air, the required flight plan and manifest data to enable useful performance measures is collected but there is an opportunity to improve reporting so that information about commodity flows and associated values could be made more transparent. Current data sources from Statistics Canada are quite coarse in geographic terms.

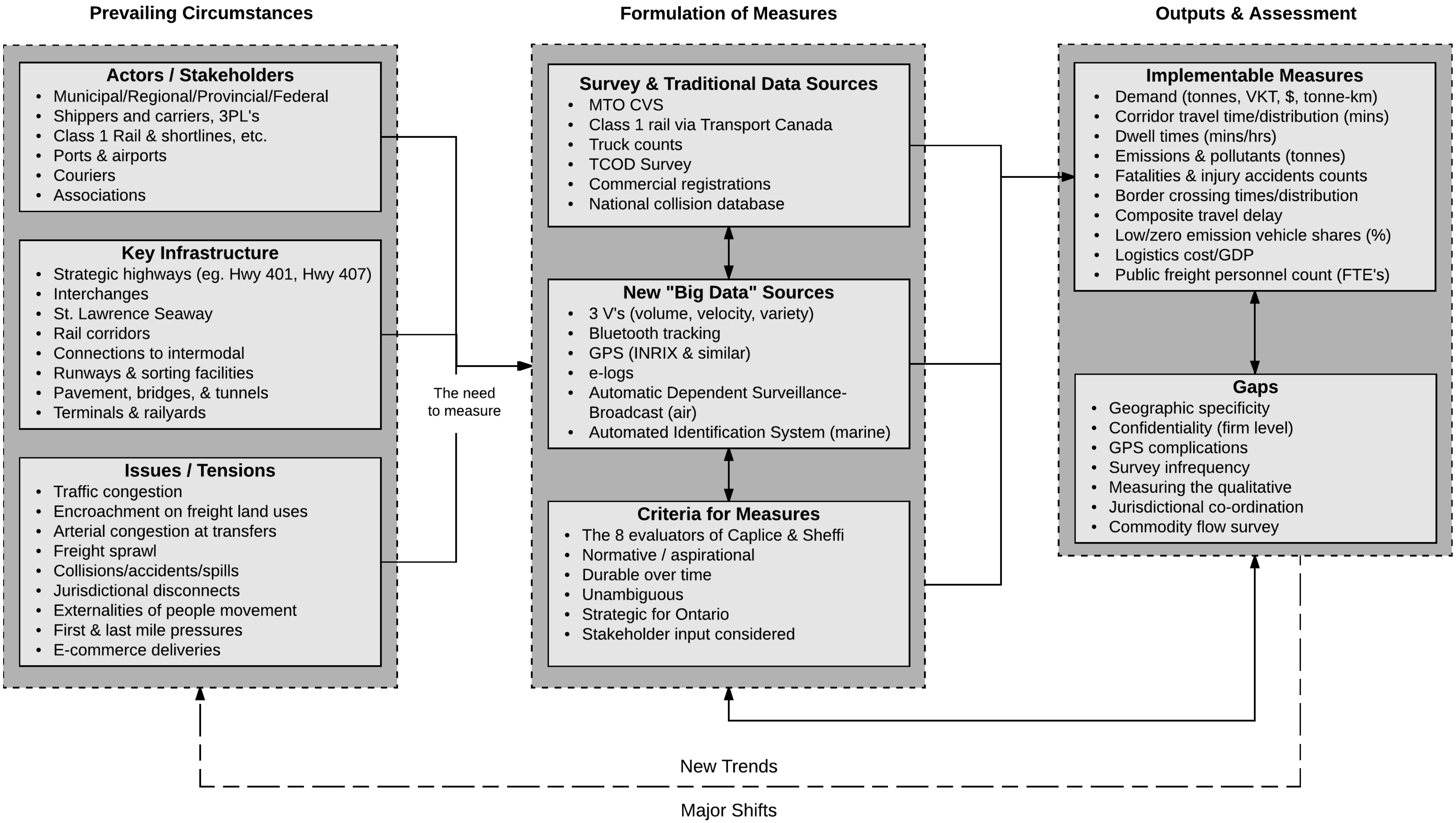
In closing gaps, there may be new ways to collect data based on learnings from other jurisdictions. As an example, the European Union incorporates a large number of countries which suggests that their data collection framework succeeds in transferring well between jurisdictions. The key unit of observation for truck movements in the Euro zone approach is the commercial vehicle itself and these are sampled and their owners surveyed using national vehicle registries in the various countries as the basis. This approach would tend to transcend aspects such as whether a fleet is private or belonging to a carrier, or whether its movements are locally oriented or inter-city, or whether a firm is large or small. Achieving a representative coverage of these aspects in Canada and Ontario has been challenging in the past due to the nature of survey approaches. The launch of a commodity flow survey in Canada, which has been acknowledged by many as a promising approach, could be a mechanism by which aspects of the European Union approach could be considered for implementation.

Summary Schematic

The discussion above largely follows the schematic outlined in Figure 0-1. There are three major sections which define its logic: prevailing circumstances, formulation of measures, and outputs and assessment. Prevailing circumstances describe the general environment associated with a span of time. Aspects include: actors in the freight system, elements of key freight infrastructure, and issues or tensions of the time which could be generating some urgency to measure. Think of a broader period of time rather than a specific one. The formulation of measures, or potentially re-formulation, is a process with feedback loops between new and traditional data sources and a set of criteria that should firm up as freight performance measurement in Ontario becomes fully developed.

The outputs from this process result in a set of implementable performance measures for the province but thorough assessment may reveal gaps which would result largely from the available data not yet supporting all aspirations. Gaps could mean that the measure is covered but perhaps not in as much detail as would be ideal or some useful aspect is not properly addressed. There are possibly intermediate term feedbacks between “outputs and assessment” and “formulation of measures” as data sources continue to improve and evolve or as new ideas emerge from nearby or more distant jurisdictions. A more refined set of implementable measures or improved closing of gaps could result. The broader, longer term feedback at the bottom of the chart, which links back to prevailing circumstances, is meant to reflect a longer term perspective where there is some, more substantial, change that demands a more extensive reappraisal of performance measurement or a strategic reset. It could be something like a major shift in policy (e.g. congestion pricing) or a change in the freight environment (e.g. a major improvement related to autonomous technologies in conjunction with electrified powertrains).

Figure 0-1: Logic Chart and Components for Ontario Freight Performance Measurement



1.0 Introduction

Introduction

Performance measures are the use of statistical evidence to determine progress towards specific organizational objectives. From a public-sector viewpoint, measures allow governments to inform, and increase transparency of, decision-making, increase accountability, and allow for the equitable allocation of limited resources. Measures are an evidence-based method for assessing progress made over a defined period against a baseline or target. Performance measures are tools that evaluate the level to which a process or system performs. Conceptually, the difference between expectation and reality guide the process and it is through measurement that such differences can be assessed.

Performance measurement originated in the private sector but has made its way into the public sector more recently (TX DOT, 2006). Based on evidence in this report, the U.S., U.K., E.U., Japan, Australia, and New Zealand emerge as leaders in performance measurement. This report aims to represent these international perspectives but gives significant weight to what appear to be the most useful and informative sources. In this regard, examples from the U.S. offer relevant insights for consideration in the Ontario/Canada context. As a global leader in freight performance measurement ("FPM"), the U.S. encompasses multiple jurisdictions that may be relevant for the purpose of comparison and the U.S. multimodal freight infrastructure, equipment and operating standards are highly compatible with Ontario's. The fact that many Ontario-based supply chains are linked with these jurisdictions is worthy of due consideration.

Internationally, governments and agencies tend to publish in their national language; despite extensive efforts, this report lays a heavy reliance on English-publishing countries, organizations, and agencies, including the European Union.

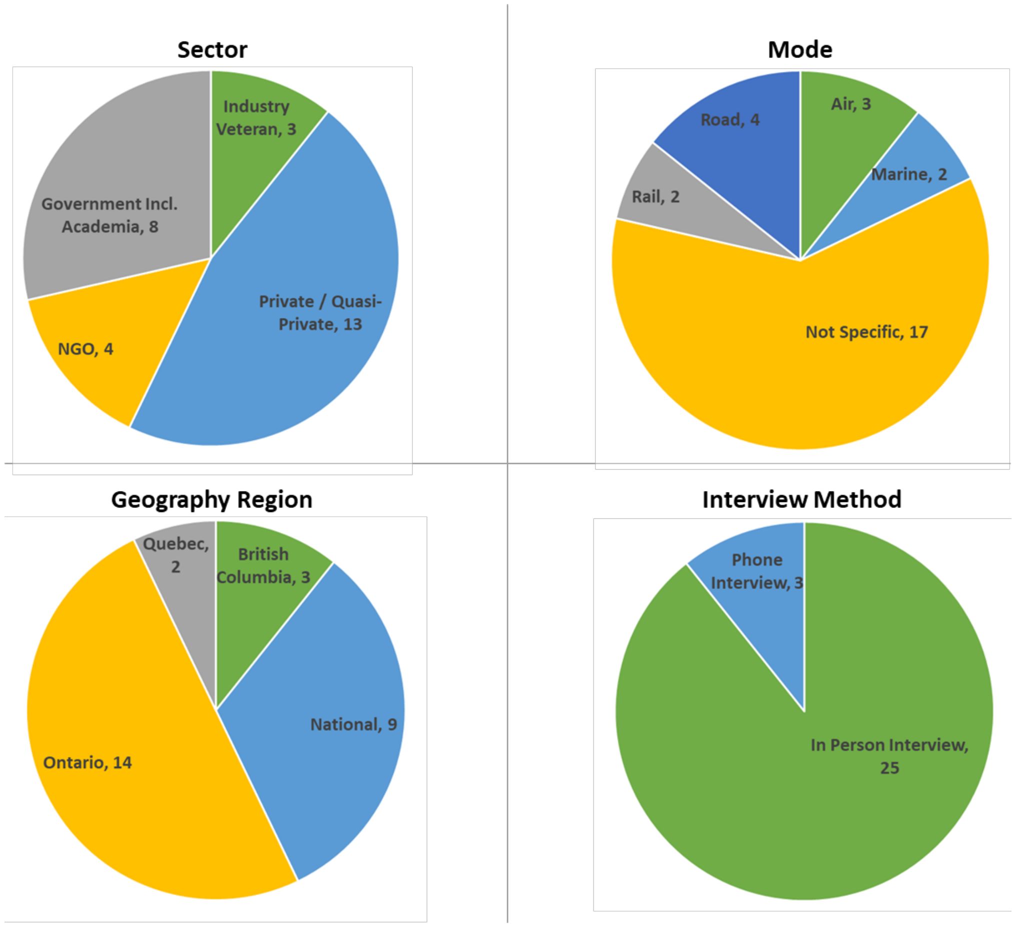
1.1. Objectives and Scope

The purpose of this report, ultimately, is to derive a suggested set of freight performance measures for Ontario. This process is supported by an extensive review of the literature (both academic and non-academic) and through in-person interviews that have taken place with a wide range of stakeholders.

The interviews themselves have been financially supported by the Social Sciences and Humanities Research Council of Canada and have been designed to address the research topic of "Metropolitan Freight Congestion: Measures, Causes, Implications, Policies." The "measures" aspect of that research has been directly relevant and applicable to the current report and there was a specific suite of questions aimed at addressing freight performance through a wider lens than just traffic congestion. Other relevant themes and insights have emerged from the consultation process which also support the current work. Figure 1-1 depicts the breakdown of the interviews by sector type, dominant freight mode (if applicable), the most relevant geography for the organization, and whether the interview is in-person or by phone. Five of the 28 interviews are geographically most relevant to other provinces but have been included in these charts to give a fuller sense of what was done.

The process to derive a "suggested set of freight performance measures" is perhaps a more involved task than it sounds. One issue is that there are a large number of performance measures that have been developed, for almost every conceivable freight context, across the literature; the process to then select a suitable subset of measures is unavoidably subjective and explosive in combinatorial terms. For example, there are 47 trillion unique subsets of measures if the need was to select 30 measures from a potential set of only 50. The current process is more demanding since the set of potential measures, based on a review of the literature, is substantially larger than 50 and this does not allow for new measures. Counterbalancing this is the observation that there is a subset of measures that are likely generally well agreed upon, such as estimates of greenhouse gas and other emissions and tracking of safety through accident and fatality rates.

Figure 1-1: Stakeholder Interview Classifications



Nevertheless, there is no objective way, from such a large set of diverse potential measures, to say with any certainty that some selected subset is the "best" or "optimal" set of freight performance measures. As a result, it should be understood that the process underlying the selection of measures is at least partly subjective and is an attempt by the authors to derive a set of measures for Ontario that, based on all the evidence reviewed, will be most useful for a wide audience. Some of the language and word choices in this report may reflect these elements of subjectivity. Certainly, there is subjectivity and diversity of opinion in the stakeholder consultations that have been carried out.

The issue of the "wide audience" for the end-product of this research is also an important one from the scoping perspective. From project conception, it has been understood that insights from this report could be used to inform a "dashboard" on freight performance measures. The purpose of the dashboard would be to allow a wide range of users, some within government and many outside of government, to interact with freight-oriented performance data to develop an understanding of how the overall system in Ontario is performing and evolving across a range of significant dimensions. This basic idea has been kept firmly in mind as the project work has unfolded, and as will be seen, the types of measures that have emerged are not particularly esoteric. The reasons why will be explored as the report proceeds. To assist with interpretability, measures were selected where it was clear that an increase or decrease in the measure was unambiguously good or bad. It is the intent that the final users of a dashboard would understand, at-a-glance, whether the system is improving or deteriorating over time.

Bearing this background in mind, this report is structured as follows:

- Apart from defining the objectives, scope and outline of this report, this introductory chapter outlines the freight policy backdrop in Ontario, other Canadian jurisdictions, the U.S., and internationally. It also provides insights into the general nature of performance measures in preparation to examine the freight context. In addition, an overview of the regulatory and ownership structure of the multi-modal transportation system in Canada is provided.
- Chapter 2 is a background chapter providing overview information on the types of freight performance measures that have been applied or suggested for various jurisdictions. The discussion is focused on measurement themes; though, many specific measures from other jurisdictions are displayed. Secondly, this chapter offers an overview of the types of data which support the measurement of freight performance and some assessment of what is needed versus what is available.
- Chapters 3 to 7 are mode-specific. They are ordered in the sequence of road, rail, marine, air, and the multi-modal system. After a brief overview of relevant freight circumstances and issues in Ontario, each chapter is structured around a suggested list of performance measures and a discussion of data-oriented gaps that might slow down or prevent the use of such measures in the Ontario context. Each chapter benefits from an extensive review of the literature and discussions with stakeholders, and a review of all relevant sub-themes which leads to the selection of a suggested list of measures.

Note that appendices are an integral part of this document, used extensively at the conclusion of most chapters and at the conclusion of this document.

1.2. Aspects of Measurement of Performance

At the outset, a brief background on the general aspects of performance measurement is considered. This is an expansive field that transcends the freight context across the public and private sectors. Caplice and Sheffi's *A Review and Evaluation of Logistics Metrics* (1994) is a leading and often-quoted article on the measurement of performance in the context of logistics. Among other things, the article provides an example of a series of evaluation criteria to pass metrics through, as presented in Table 1-1. While the paper has a private sector orientation, the criteria outlined are worth considering in many contexts; they are foundational to the authors' evaluation of existing performance measures.

For the first four criteria from Table 1-1 there are trade-offs associated with pursuing each, while the remaining four are secondary concerns. The ideal performance measure is not necessarily a perfect balance of these criteria. The focus is on ensuring that the measure has been properly deployed to address the concern at hand. For example, a highly useful metric for a line manager is not likely to be of use for the local Vice-President, nor would it necessarily be integrative across other business lines. Caplice and Sheffi observe that detailed and complex metrics come at the price of lower comparability.

Table 1-1: Metric Evaluation Criteria and Descriptions

Criterion	Description
Validity	The metric accurately captures the events and activities being measured and controls for any exogenous factors.
Robustness	The metric is interpreted similarly by the users, is comparable across time, location, and organizations, and is repeatable.
Usefulness	The metric is readily understandable by the decision maker and provides a guide for action to be taken.
Integration	The metric includes all relevant aspects of the process and promotes coordination across functions and divisions.
Economy	The benefits of using the metric outweigh the costs of data collection, analysis, and reporting.
Compatibility	The metric is compatible with the existing information, material, and cash flows and systems in the organization.
Level of Detail	The metric provides a sufficient degree of granularity or aggregation for the user.
Behavioural Soundness	The metric minimizes incentives for counter-productive acts of game-playing and is presented in a useful form.

Source: Caplice and Sheffi (1994)

For many public agencies, performance measures add transparency, accountability, and insight (Transportation Research Board, 2011b; Iowa Department of Transportation, 2016; Michigan DOT, 2010; Poister, 2004; WSP Canada Inc, 2015). Measures are presumably objective and bias-free, which explains much of the attraction of the approach. Though, one must be careful to ensure that the measures themselves are not inherently biased or prone to tampering through data collection, processing, analysis, or reporting – referred to as behavioural soundness by Caplice and Sheffi. Performance measurement can conceptually be thought of as an iterative design process wherein the evolutionary development of measures cycles through three major stages. Goals and objectives which accurately reflect the strategic plan of the organization are first identified. A series of indicators and measures are then developed, evaluated, and selected based on their ability to reflect progress towards the organizational goals – any number of conceptual frameworks can be utilized for specific measure selection (Neely et al., 2007; Shahin & Mahbod, 2007; Puckett & Hensher, 2008; Meyer, 2002). After a period, as defined by the organization, has elapsed, a revaluation of the organization's goals and selected measures is undertaken. Measures are adjusted if and only if they will better reflect new or revised goals – it is not advised to alter the measures unless absolutely necessary (Neely & Bourne, 2000a). It is critical to consider that even minor revisions to measurement design and methodology can hinder temporal comparisons.

There is consensus that a very important task is the identification and development of useful and appropriate measures (TRB, 2013; Schofield & Harrison, 2007). Since there are thousands of potential indicators that can be operationalized across various contexts, this can be a complex and arduous task – an indicator can be developed for virtually any phenomena. A variety of approaches have been used to identify sets of measures including: round table discussions, stakeholder and community consultations, advisory councils, Delphi methods, third-party analyses, and in-house development teams (Lindholm, 2012; Chia et al., 2009; Lingle & Schiemann, 1996; Kennerley & Neely, 2003). In all cases of measurement development, subjectivity is an essential part of the selection process – each set of measures needs to accurately reflect the needs of the implementing organization and are biased as such.

1.3. Private/Public Sector Progress on Freight Performance Measurement

In the private sector, performance measures are generally ubiquitous, especially in the age of 'Big Data'. Many large companies devote considerable resources to monitoring supply chains and measuring performance to identify and develop organizational synergies where possible to increase efficiency and decrease costs. Smaller firms may not find the same value and may be reluctant to devote limited resources. Though, as the cost of cloud-based technologies continues to substantially decrease and as new B2B information communication technologies become more accessible, it is possible for smaller firms to enhance their measurement programs in a cost-efficient manner. In consultations, it was suggested by stakeholders that in five years the data gap between small and large firms will diminish.

From a *Management Review* article by Lingle and Schiemann (1996), the authors' most significant conclusion was that "measurement plays a crucial role in translating business strategy into results." Further, they found that the top performing organizations, within their respective industries, had a series of commonalities: "agreed-upon measures that managers understand; balancing financial and non-financial measurement; linking strategic measures to operational measures; updating their strategic "scorecard" regularly; and, clearly communicating measures and progress to all employees" (Lingle & Schiemann, 1996). No doubt performance measurement supports the pursuit of profit and other organizational goals, corporate or otherwise.

Overall, it is perhaps not surprising that the majority of literature on performance measures, and particularly so from academics, relates to their application within private organizations (Bullinger et al., 2002; Bourne et al., 2000; Bhagwat & Sharma, 2007; Braz et al., 2011; Chia et al., 2009; Fields, 2016; Kennerley & Neely, 2003; Gunasekaran & Kobu, 2007; O'Byrne, 2013). Most of the literature reviewed on *public* sector measurement also relates to evaluating performance on an intra-organizational basis, though this can be inherently complex for public organizations with a wide array of stakeholders, such a city government (Litman, 2009; TX DOT, 2009; Russo & Comi, 2011). Consider that a government organization “self-evaluation” is different than such an organization leading a performance measurement initiative for the freight system. There is substantially less literature available on this latter context, which is also the context most relevant to this report.

The use of freight performance measures by public agencies is not yet a widespread practice, this is especially the case in Canada. Even basic, public-facing freight planning documents are rare in Canada. It is then not surprising that there is little jurisdictional information on freight performance measures available. Moreover, the complex nature of the freight system transcends any single organization. One significant inter-jurisdictional success as it relates to freight performance measurement in Canada was the work that resulted from a report led by Transport Canada and the Ontario Ministry of Transportation, through the Ontario-Quebec Continental Gateway Initiative on road network performance (Continental Gateway Road Network Performance, 2008).

There is significantly more evidence of public-facing freight planning in the United States, though there is state-by-state variation in the extent to which performance measures are featured. The Transportation Research Board (“TRB”) (2011b) compares progress by the individual states carefully and notes that some states are more advanced than others in their use of freight measures. There is a noted difference between the States with mature programs and those that are implementing as a requirement of new Federal laws. Performance measures have generally been aimed at evaluating highway and transit infrastructure, with a focus on passenger movements. As traffic congestion grows, demand for same or next-day delivery of goods becomes the new normal, and as technology expands, the focus is expanding to include freight movements (TRB, 2013).

1.4. Public Sector Freight Regulation, Ownership, and Policy

This section provides a brief overview of the mixed ownership and regulatory structure of transportation infrastructure across Canada and Ontario, followed by a review of Canadian and American freight policy. An understanding of the mixed public-private nature of the ownership and control of the multi-modal transportation system can provide valuable context when considering freight performance measurement and will complement the discussions in the following chapters. The ownership, operation, and maintenance of infrastructure and equipment varies by mode, and regulation can occur at any level of government.

1.4.1. Regulation & Ownership

The regulation of Canada's transportation system is distributed between three levels of government: Federal, Provincial/Territorial, and Municipal/Local. An extensive overview of ownership and regulation is available in Appendix 9-5.

The Federal government plays a limited role in the direct provision of transportation infrastructure, while regulation is limited to areas of national concern, as Figure 1-1 highlights. Areas of Federal governance include: air, railways, marine, international borders, and select critical infrastructure. The Federal government maintains a stake in the ownership or shared governance of a number of key pieces of infrastructure, specifically air and harbour ports. The Federal government generally does not provide roadways, but instead is focused on major bridges, inter-provincially and internationally. Generally, the high-level role of the government is focused on the regulation of transportation, especially in regard to safety and emissions.

While the Provincial government is involved with the operation of all modes, to varying degrees and forms, the focus is on the provision and regulation of road infrastructure including highways and bridges. The Provincial oversight structure is shared among multiple Ministries, with the Ministry of Transportation taking the lead role, Figure 1-2. The Province is the owner, operator, and maintainer of most of the highway, bridge, and culvert infrastructure across Ontario, with a handful of privately owned exceptions, primarily the 407 Express Toll Route. Despite the road network focus, the Provinces have vested interests in each mode.

Municipalities, are often considered to play the smallest role in the regulation and provision of infrastructure as it relates to goods movement. In reality, municipalities are tasked with the provision of local and arterial roads enabling the movement of virtually all freight. Municipalities also retain the right to enact by-laws which can affect anything from parking regulations to loading zones; which are often concerns for freight carriers, especially couriers. Detailed in Figure 1-3, municipalities may have a greater level of influence and involvement in the transportation system than their municipal neighbours; not all jurisdictions have railways, harbours, or airports. The design of transportation systems, especially at the municipal level, can greatly influence the fluidity of movement, e.g., timing traffic signals to correspond with truck acceleration.

There are limited examples of direct ownership of infrastructure by private firms, Figure 1-4. Transportation infrastructure is typically considered a public good and is commonly provided by the government. An obvious exception is the railways, which are dependent upon their own infrastructure. Private firms are, generally, the suppliers of the equipment that move across the network, e.g., trucks or airplanes, and not the providers of the physical infrastructure.

Figure 1-2: Federal Regulatory and Ownership Roles

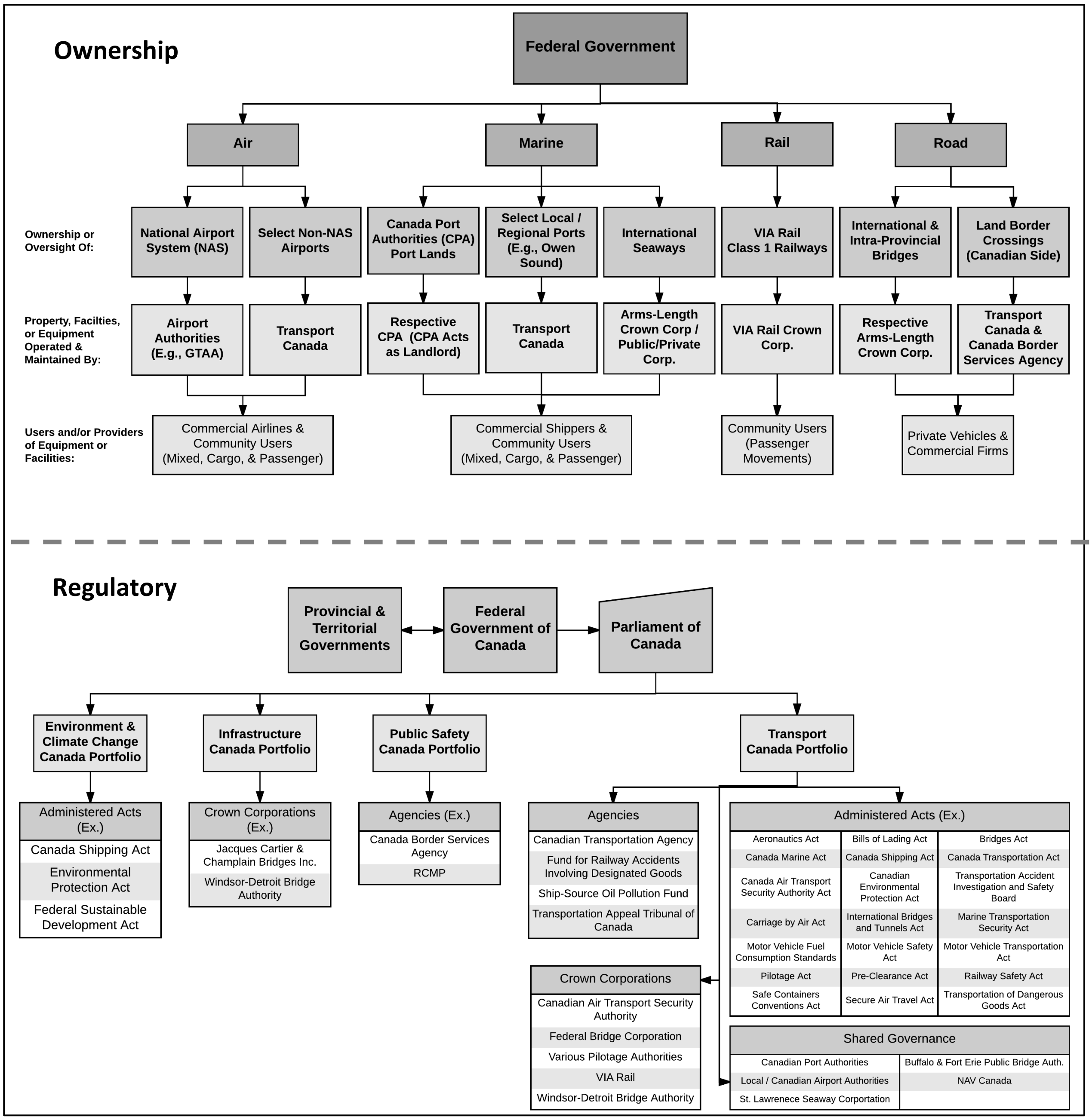


Figure 1-3: Provincial Regulatory and Ownership Roles

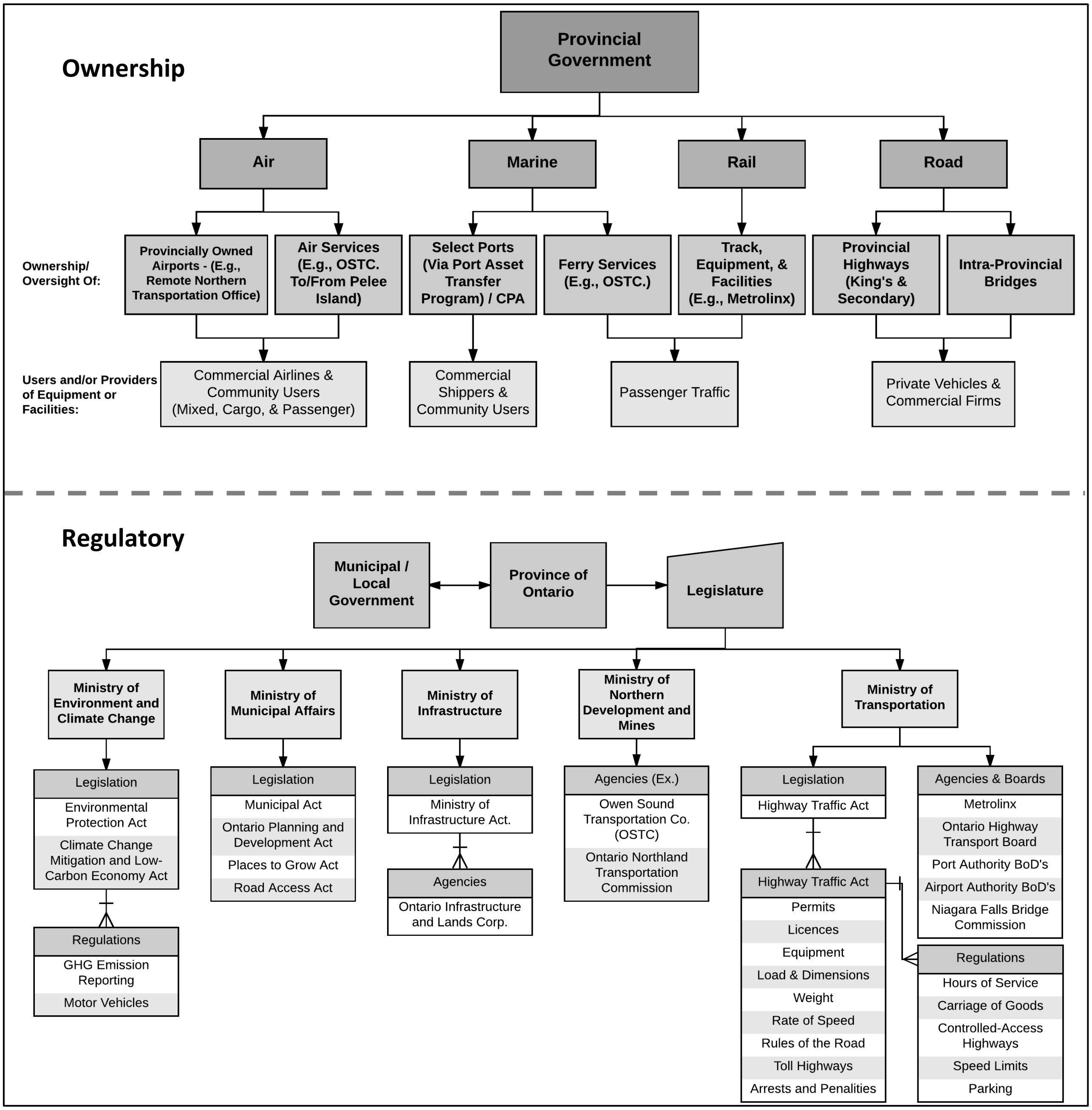


Figure 1-5: Municipal Regulatory and Ownership Role

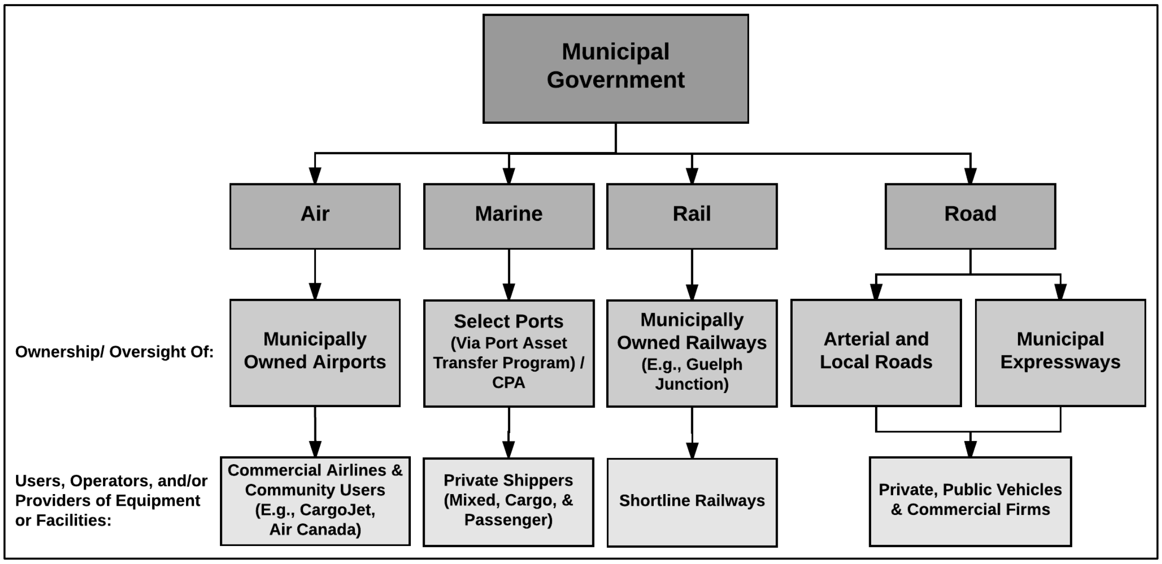
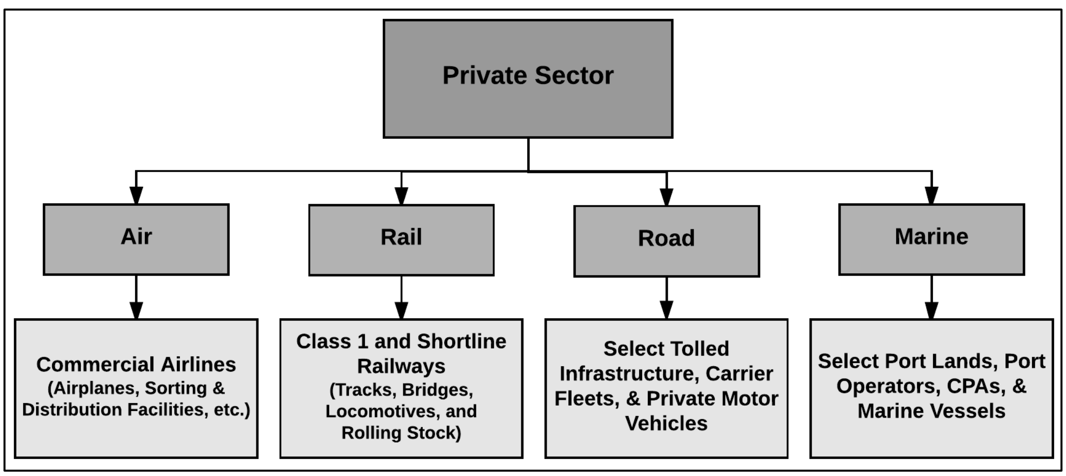


Figure 1-4: Private Sector Ownership Role



1.4.2. Policy

At the Federal level, there are currently no national freight plans for Canada. A recent detailed review of the Canada Transportation Act (Government of Canada, 2015) featured freight issues prominently. However, the review did not delve deeply into matters surrounding freight performance measures other than acknowledging their importance. In Canada, as opposed to the United States, the provinces are not required by Federal law to have a freight strategy or to monitor freight network performance. Federal co-ordination of freight initiatives is important for public-sector measurement. The U.S. Government Performance and Results Act (GPRA) of 1993 had established a requirement for Federal agencies to identify goals and measurable outcomes to gauge performance in meeting program objectives. In response to this requirement, and in seeking to advance its own performance, the Federal Highway Administration (FHWA) developed a National Strategic Plan.

Federal leadership is a significant theme in the United States as it relates to the topic of measuring performance, freight or otherwise. As will be seen in Chapter 2, federal leadership is also a theme in the collection of data that are required to develop performance measures.

In the U.S., the end of 2015 was notable for the passing of the FAST Act (Kane & Tomer, 2015) which, for the first time, allowed for a dedicated source of federal funding for freight projects. Performance measurement is an evaluator of how federal funds get distributed through that program. As part of the FAST Act and the 2012 legislation “Moving Ahead for Progress in the 21st Century (MAP-21)”, states must implement performance management systems and incorporate freight demand into their strategic transportation policies (Walton et al., 2015). MAP-21 includes provisions to improve the condition and performance of the multi-modal national freight network and requires that state DOTs direct resources toward improving freight movement through several initiatives (Eisele et al., 2015). These initiatives require not only access to accurate and reliable freight data but an understanding of current and future freight demand, as well as the different modal transportation networks utilized (Walton et al., 2015).

In Appendix 9-1 an overview is offered of how different jurisdictions, at different levels of government, have advanced with freight planning and FPM. In many cases, there has not been substantial progress with the former let alone the latter. A field has been defined in each case which assesses whether FPM are evident in public-facing documents. Some jurisdictional cases are comparatively well-advanced, though not so much with the Canadian examples. Most jurisdictions have transportation strategies and acknowledge the importance of freight and goods movement, but fail to identify measures or specific actions being taken to track, measure, and improve freight transportation systems.

At the provincial and municipal level within Canada, Ontario has increased the focus on goods movement policies in recent years. As will be discussed in the following chapter, Ontario has designed an extensive set of freight-supportive guidelines to assist local government to better plan for, and understand, freight vehicles and their interactions with local land uses and physical design. Ontario is also in the midst of completing a long-term multimodal transportation plan for southern Ontario. Municipalities are generally considered to be the least active participant in the development of freight policy despite their ground-level and direct interactions with the design and functioning of local road systems and zoning. The Regional Municipality of Peel is a noted exception to this and is considered to be on the forefront of freight/goods movement policy development and action in the country.

2.0 Background

Background

The intent of this chapter is to offer background on freight performance measures and supporting data in preparation for the modal-specific chapters that follow. To do so, there is one major section on the types and themes of freight measures that tend to be employed and then there is another which focuses on data; in particular, the sources of data and not so much the issues that surround data. Broadly speaking, it is impossible to measure freight performance without adequate data. While specific measures are shared in this chapter, the spirit of the discussion is focused on what performance themes are considered important and how these themes appear to vary by jurisdictional context.

With regard to data, an observation at the outset is that capabilities are changing quickly. Traditional data collection processes (e.g. surveys) are being complemented, and ultimately potentially supplanted, by new big data sources such as GPS, internet of things, electronic logs, and so forth (Gingerich et al., 2016). The so called 3 V's of Big Data: "volume, velocity and variety" are all applying well to the freight sector across modes. It is becoming evident that more freight data are being collected than ever before; the question is how to best harness the potential to enhance our understanding of the freight system in support of the best possible policy decisions.

2.1. Review of Types and Examples of Freight Performance Measures

2.1.1. Prevailing Themes

Prior to considering specific measures, it is appropriate to consider, at the broad level, the major themes that need to be addressed in FPM. Table 2-1 assists in this regard with thematic examples from twelve U.S. jurisdictions. The key takeaway is that “freight mode” is not typically featured in high-level thematic classifications, with the exception of New Jersey. The absence of specific modes in the broad themes of the TRB (2011b) approach, which resulted from an extensive process, is noteworthy, evidenced in Table 2-2. The typical number of broad themes is about half a dozen, which appear to meet the strategic needs for measuring freight performance at state and federal levels of government.

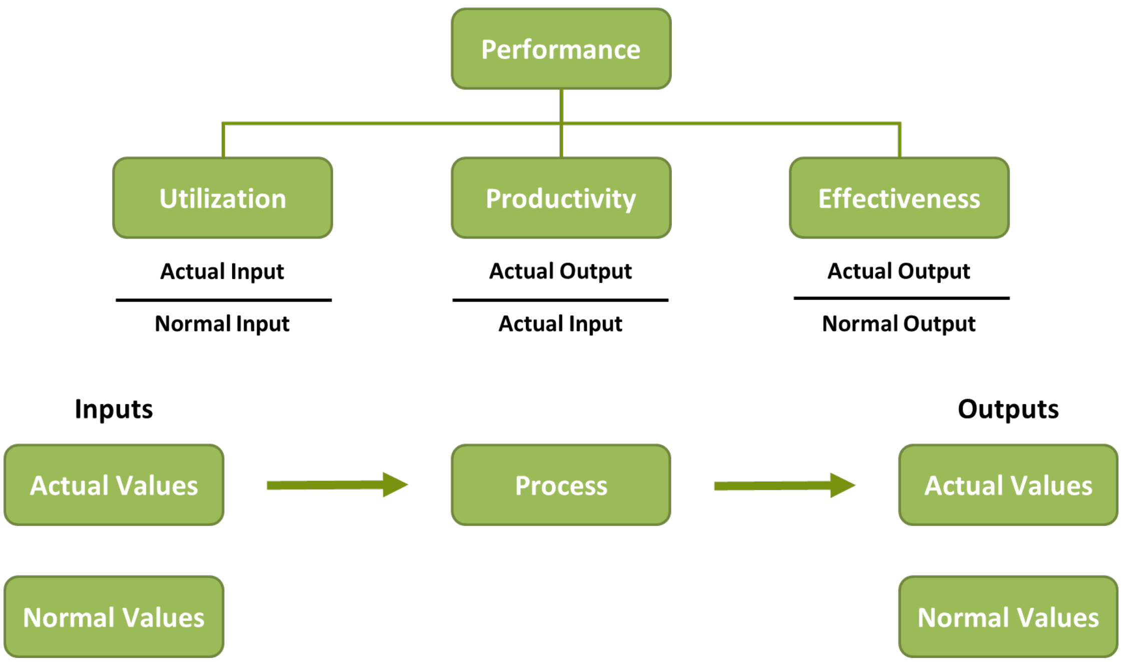


Figure 2-1: Broad Classes of Business-oriented Performance Measures

Source: Caplice and Sheffi, 1994

Figure 2-1 illustrates that the private sector viewpoint is quite different. Caplice and Sheffi (1994) see business performance measures associated with three important aspects: utilization, productivity, and effectiveness. Central to all three is the concept of “inputs” and/or “outputs.” As businesses typically process inputs to produce outputs, this preoccupation is logical. In public sector FPM, it can be argued that there would be less focus on tangible inputs/ outputs and more focus on the integrity of the overall system -- or the ability of the system to accommodate commerce movements. These types of considerations are reflected in Table 2-1.

Table 2-1: U.S. Freight Performance Themes

Arizona, State of ○ Economic development ○ Local land use planning ○ Preserve & prioritize key infrastructure ○ Improve freight operations ○ Safety and security ○ Environmental preservation & energy efficiency	**California, State of** ○ Congestion ○ Infrastructure ○ Reliability ○ Safety ○ Economic vitality ○ Environmental sustainability
Colorado, State of ○ Accessibility ○ Mobility ○ Safety ○ Economic development ○ Environmental and resource conservation ○ Efficiency ○ System preservation and expansion	**Minnesota, State of** ○ Safety ○ Environment and community ○ Infrastructure condition ○ Mobility ○ Demand and economy
New Jersey, State of ○ Highway Freight ○ Rail Freight ○ Maritime Freight ○ Air Freight ○ Warehousing Freight and Distribution Centres ○ System Wide Factors	**Oregon, State of** ○ Safety ○ Maintenance and preservation ○ Mobility, reliability, and congestion ○ Accessibility and connectivity ○ Environmental
Virginia, State of ○ Safety ○ Pavement condition ○ Bridges ○ Freight ○ System performance ○ Congestion mitigation ○ Air quality	**Washington, State of** ○ Aviation ○ Bridge & highway conditions (e.g. pavement) ○ Environmental stewardship ○ Incident response ○ Safety on state highways ○ Truck freight
Federal Highway Administration (USA) ○ Reliability ○ Travel time reliability ○ Congestion	**I-95 Corridor Coalition** ○ Travel time ○ Travel time reliability ○ Cost
Marine Transportation System ○ Economic benefits to nation ○ Capacity and reliability ○ Safety and security ○ Environmental stewardship ○ Resilience	**Transportation Research Board Proposed Methodology (USA)** ○ Freight demand measures ○ System efficiency measures ○ System condition measures ○ Environmental condition measures ○ Freight safety measures ○ System investment measures

Sources: (Arizona DOT, 2006); (Caltrans, 2015); (Minnesota DOT, 2016); (Oregon Transportation Vision Panel, 2016); (Virginia DOT, 2013); (Washington State DOT, 2014); (I-95 Corridor Coalition, 2016); (Transportation Research Board, 2011b)

2.1.2. Frameworks at Federal & Provincial/State Level

On the following pages are a series of five tables that illustrate thematic classifications and chosen measures for a series of federal and state contexts. In sequence, the first table is U.S. Federal (though TRB) and the three following tables relate to the states of Iowa, Oregon, and Missouri. The tables are worthy of review because they essentially show complete structuring of performance systems. While there are similarities, generally measures differ from table to table. The final table is a summary of the transportation specific measures available from Ontario's iCorridor system, which provide some context of the Province's current reporting abilities, as are made publicly available.

Table 2-2 provides an overview of the TRB (2011b) framework that was developed via an extensive stakeholder consultation process. As mentioned, the framework measures are categorized thematically as opposed to modally. I.e., there is a lack of mode-defined categories. Nevertheless, the specific measures identified in the framework are directly associated with specific modes. With the exception of measures estimating freight demand and greenhouse gas emissions, there are no apparent measures that generically apply across the modes.

Table 2-2: Freight Performance Measures from the TRB Report Card

Categorization	Performance Measure
Freight Demand Measures	Freight Demand Measures, All Modes
	Truck Freight Volumes
	Rail Freight Volumes
	Inland Water Freight Volumes
	Containerized Waterborne Freight Volume
System Efficiency Measures	Interstate Highway Speeds
	Travel Speeds at Top Interstate Highway Bottlenecks
	Interstate Highway Reliability
	Class I RR Operating Speed
	Cost of Logistics as a Percent of GDP
System Condition Measures	NHS Pavement Conditions
	NHS Bridge Conditions
Environmental Condition Measures	Freight-Produced Greenhouse Gas Emissions
	Truck Greenhouse Gas Emissions
	Rail Greenhouse Gas Emissions
	Freight-Produced Ozone-Related Emissions
	Truck-related VOCs
	Truck-related NO_X emissions
	Rail NO_X Emissions
	Rail VOC Emissions
	Truck Particulate Emissions
	Ship Produced NO_X and Particulate Matter
Freight Safety Measures	Truck Injury and Fatal Crashes
	Highway / Rail At-Grade Crashes
System Investment Measures	Estimated Investment in NHS to Sustain Conditions
	Rail Freight Industry Earning Cost of Capital
	Estimated Rail Capital Investment to Sustain Market Share
	Inland Waterway Investment to Sustain Lock and Dam Average Age at Less than 50 Years

Source: (Transportation Research Board, 2011b)

The Iowa approach in Table 2-3 is probably the classification most focused on modes among those reviewed (even including pipelines). The system is not set up in alignment with other non-modal themes. There are also a relatively large number of measures associated with road presumably because road is of high relative importance as a freight mode in Iowa. It is interesting to note that the "Producer Price Index" repeats across multiple modes. Such macro-economic measures seem somewhat out of place.

Table 2-3: Iowa Freight Performance Measures

Category	Performance Measure
Air	Percentage of airports that meet all facility targets for their role
	Percentage of airports that meet service targets for their role
	Percentage of airports with clear runway approaches
	Pavement Condition Index on paved runways
	Multifactor per Labour Productivity Index
Highway	Percentage of highway miles that meet or exceed a sufficiency rating of tolerance or above
	Percentage of bridges on the Primary Highway System that are structurally deficient or functionally obsolete
	Percentage of the Primary Highway System below pavement condition index cut off across all planning classes
	Highway fuel use per vehicle-mile
	Percentage of Interstate Highway System operating at level of service "C" or better
	Overall crash rate
	Number of fatalities
	Overall annual percentage of all districts' A and B highway miles returned to a reasonable, near-normal surface condition within 24 hours after the end of a winter storm
	Average international roughness index rating weighted by length on the Primary Highway System
	Real cost per vehicle-mile
	U.S. Bureau of Labour Statistics Labour Productivity Index
	Producer Price Index
	Travel times along 25 "freight significant corridors"
Pipeline	Propane storage levels
	Delay at pipeline per truck terminals
Rail	Rail ton-miles per gallon of fuel
	Percentage of track-miles able to operate at 40 miles per hour or higher
	Percentage of track-miles to handle 286,000-pound cars
	Total crashes at railroad-highway crossings
	Derailments per million ton-miles
	Real cost per ton-mile
	Multifactor per Labour Productivity Index
	Producer Price Index
	Terminal dwell time
	Average speed
	Rail defects per mile
Waterway	Delays at locks
	Unscheduled lock closures
	Lock availability
	Producer Price Index

Source: (Iowa Department of Transportation, 2016)

Table 2-4: Suggested Freight Performance Measures for Oregon

Mode/Category	Measure
Safety	
Highway	Motor carrier crash rate and triple trailer crash rate
	Motor carrier truck at-fault crash rate
	Total cost of freight loss and damage from accidents per vehicle mile travelled
Railway	Total loss and damage from accidents per route-mile
	Total loss and damage from accidents per tons moved
	Trail derailments per tons moved
Water	Value of cargo lost or damaged per tons or value of cargo moved
	Containers damaged or lost per containers handled per total containers
Air	Total loss and damage from accidents per value of freight
	Incidents per 1,000 operations at freight-significant airports
Maintenance and Preservation	
Highway	Percent of pavement in good condition (or unacceptable, etc.) on freight significant highways
	Number of weight restricted bridges per total number of bridges
Railway	Miles of track in expected or FRA Class 1 divided by total miles of Class 1 track
	Number of double-stack tunnel restrictions per number of tunnels
Water	Percent of tons on river moving through locks with constraints
	Unscheduled lock closure time (hours)
	Channel depths at the port divided by depths at competitive ports
Air	Percent of pavement in fair or poor condition at freight-significant airports
Mobility, Reliability and Congestion	
Highway	Urban: hours of congested conditions per day
	Urban: average hours of delay per day for freight vehicles on freight-significant links
	Urban: travel time index (TTI) on freight-significant links
	Urban: buffer index on freight-significant links
	Rural: average hours of delay per day for freight vehicles on freight-significant links
	Rural: average travel time on freight-significant links
Railway	Tons or ton-miles of freight over relevant period
	Average terminal dwell time train-hours of delay
	Railroad corridor level of service
Water	Tons of traffic arriving at Port of Portland by barge
	Twenty-Thousand Equivalent Units passing through port (port throughput)
	Gate reliability or truck turn time
	Ship unload rate (time per container)
	Ship load rate (time per container)
	Average delay per barge tow on Columbia River
Air	Flight frequency by airlines with cargo capacity (number per day)
	Average time between flights by airlines with cargo capacity (minutes)
	Percent of on-time departures at freight significant airports
	Percent of on-time arrivals at freight significant airports
Accessibility and Connectivity	
Highway	Triple trailer vehicle mile travelled as a percent of total freight vehicle mile travelled
	Percent of shippers with access to triple network
Railway	Class I: ratio of unit train carloads (or tons) per total carloads (or tons)
	Percent of shippers within 50 miles of intermodal trailer-on-freight-car facility
	Number or capacity of intermodal facilities
Water	Shippers within 50 miles of river port (for barge accessibility)
Air	Flight frequency by airlines with cargo capacity (number per day)
	Average time between flights by airlines with cargo capacity (minutes)
	Average travel time delay on airport access roads
	Number of docks or acres of cargo-handling facilities
Environmental	
All	Pounds of greenhouse gas emissions

Source: McMullen and Monsere, 2010

Table 2-4 illustrates a set of proposed performance measures that were developed for the Oregon Department of Transportation by researchers at two Oregon universities (McMullen & Monsere, 2010). The proposed list is comprehensive but presumably should carry less weight than the prior TRB table which incorporated more viewpoints. Measures are broken down by theme and by mode, unlike the TRB effort. In comparing the sets of measures for both, it seems clear that the Oregon measures are somewhat more esoteric than the TRB measures but exhibit greater modal sensitivity. Of the tables reviewed, Oregon pays significant attention to air freight. The Oregon set pays less attention to the environment and mentions only greenhouse gases.

Table 2-5: Missouri Freight Plan Goals and Associated Performance Measures

Freight Plan Goal	Performance Measures
Maintenance *Maintain the freight system in good condition*	Percent of the major highways in good condition Percent of structurally deficient deck area National Highway System bridges
Safety *Improve safety on the freight system*	Number of commercial vehicle crashes resulting in fatalities or serious injuries Rail crossing crashes or fatalities
Economy *Support economic growth and competitiveness*	Goods movement competitiveness Job and economic growth by key sector, including: • Agriculture • Manufacturing • Transportation / Logistics
Connectivity and Mobility *Improve the connectivity and mobility of the freight system*	Freight tonnage by mode Annual hours of truck delay Truck reliability index

Source: (Missouri DOT, 2014)

Table 2-5 outlines favoured measures suggested for Missouri. A long-term commitment to performance measurement is exhibited through the existence of the "Missouri Tracker." This is an on-going quarterly state electronic publication with archives back to January 2005, which follows a series of measures over time. Some of these focus on freight/goods movement, with a heavy emphasis on trucking movements. The resulting measures in Table 2-5 are concisely chosen. There are only four main themes and specific modes can be identified only at the level of the individual measures. The overall simplicity of the chosen measures is striking.

Table 2-6 represents a minority selection of measures available from Ontario's Ministry of Transportation *iCorridor* performance measurement dashboard. The selected indicators are representative of freight movements and concerns while the other measures included in the task consist of land use planning, demography, and other important descriptive statistics for provincial planning considerations. The measures provide an understanding of the public-facing data capabilities of the Province and the types of information utilized.

Table 2-6: Ontario *iCorridor* Freight-Related Measures

Thematic Area	Measure
Road Travel Speed and Performance Indices - Commercial Vehicles	Weekday AM, PM Peak Travel Speed
	Weekend Day Travel Speed
	Weekday AM, PM Buffer Time Index
	Weekend Day Buffer Time Index
	Weekday AM, PM Peak Travel Time Index and Delay Index
	Weekend Day Peak Travel Time Index and Delay Index
Regional Summaries of Provincial Highways	Annual Total Traffic Delay
	Annual Total Truck Delay
	Average Travel Time Index
	Average Delay Index
	Average Value of Goods
Transportation Planning and Forecasting	Commercial Vehicle Traffic Volume
	Equivalent Single Axel Load
	Level of Service
	Level of Service Forecast

Adapted From: (Ontario MTO, 2015)

2.1.3. Frameworks at Municipal Level

Metropolitan areas are the places where goods most often originate and terminate and the regions that support logistics clusters. The first and last kilometres are typically within metropolitan areas. On this basis, one might expect a far greater focus on freight planning and performance measurement at the municipal level than seems to be the case. The purpose of this section is to focus some attention on municipalities that show the most tangible evidence of progress on this front.

The Regional Municipality of Peel (consisting of the City of Mississauga, City of Brampton, and the Town of Caledon) finds itself at the heart of the most intensive logistics cluster in Canada. As such, the movement of freight is a real focus in Peel and it has led to long term stakeholder-oriented initiatives such as the Peel Goods Movement Task Force. It has also led to the consideration of freight performance measurement frameworks. The 2013 Peel Strategic Goods Movement Network Study includes a thorough educational description of freight performance measures and describes some specific measures and their utility, but does not link any of these measures specifically to Peel. Two years later, a consultant report (WSP Canada Inc, 2015) was developed with the mandate to focus on the economic performance of the freight cluster in Peel. This publication does mention specific measures which are reproduced below in Table 2-7.

Table 2-7: Region of Peel Recommended Performance Measures

Performance Measure	Description
Goods Movement GDP	Indicator measures the GDP of goods movement industry sectors in Peel Region
Freight Tonnage by Mode	Measure of gross tonnage of freight broken down by freight mode – truck, rail, air cargo
Level of Goods Movement Activity in Peel	Measures the level of origin-destination truck trips, provides a good indication to vitality of goods movement business and impact on road network
Value of Industrial Building Permits	Reports the number of industrial building permits issued in the past year
Percent of Roadways in Good Condition	Reports on the existing pavement conditions along Peel strategic goods movement network, measuring the proportion in good condition
Percent of Bridges in Good Condition	Indicator measures the proportion of bridges located along the goods movement network that are in good condition
Annual Hours of Truck Delay	Tracks the travel time deviation above the congestion threshold, or ideal travel times and speed for trucks on the strategic goods movement network
Truck Reliability Index	Measures the deviation of travel times or speeds from the average or expected times, assists with understanding recurring congestion
Levels of Service (LOS) for Major Truck Routes	Indicator measures the levels of service of major truck routes, helps identify current and future congestion hot spots and areas to target investments

Source: (WSP Canada Inc, 2015)

The measures do seem to reflect the mandate to focus on economic performance. There are no measures, for example, that focus on the environment. While freight tonnage is suggested to be tracked by mode, the measures are generally tailored mostly to trucks whose free movement is clearly seen as a concern. In reviewing the consultant's report for Peel, it was clear that insights from TRB (2011b), on what a goods movement report card should look like, were influential. This is evidence that aspects of freight performance measurement can translate to different levels of government.

It appears that Peel Region is unique in Canada and many stakeholders consulted agreed. Peel is a leader in goods movement initiatives for the Greater Toronto Hamilton Area (GTHA) while making up less than 20% of the region's population. As stakeholders have pointed out, Peel Region is home to one of the largest intermodal rail yards in the country, Pearson International Airport, and extensive distribution centre and warehousing activity. All of which contribute to the major role of the Region. Investigations into other Canadian municipalities, indicate less progress on goods movement and certainly FPM. In various planning documents, numerous potential goals are identified that recognize the strategic importance of certain freight infrastructure but no metrics are indicated for measuring progress on these potential objectives or policy actions.

In the United States, the City of Portland, Oregon is showing more progress on FPM. It is interesting that Portland is showing up in the freight context because it is often seen as a leader in the progressive movement of people. Achievements in light rail transit, transit oriented development and promoting active modes of travel are often noted. Having said that, Portland also ranks highly for metropolitan traffic congestion (Texas Transportation Institute, 2015). The measures indicated in Table 2-8 are focused on trucking with only a single mention of rail. Some metric descriptions are vague.

Table 2-8: City of Portland Freight Performance Measures and Description

Measure	Description
Hours of truck delay in the PM peak and mid-day	• Tracks hours of delay as a result of congested roadways • Enhancements include truck delay at key intersections and along freight corridors, and distinguishing between re-occurring and non-reoccurring events
Travel time in ITS corridors for average PM peak, AM peak, and off-peak	• Evaluates travel time performance in corridors using ITS technology, especially those critical for freight movement
Assessment of unmet pavement need	• Assess and report pavement condition along major freight corridors
Employee participation in Transportation Management Associations (TMA)	• Tracks progress of TMA programs encouraging use of single-occupancy vehicle alternatives for work trips
Annual truck collisions/million vehicle miles of travel	• Number of reported collisions that involve trucks and other modes, including rail
Elimination of weight-restricted bridges on truck streets	• Tracks progress in rehabilitating or replacing weight-restricted bridges
Assessment of truck compliant resolution	• Evaluates number of freight-related complaints received by PDOT and status of resolution

Source: (City of Portland, 2006)

2.1.4. Conclusions

The previous eight examples of measurement frameworks indicate that while there are commonalities in the broad themes addressed, the specific measures and criterion evaluated are often custom solutions to the implementing authority. Measures have been selected for a compilation of legislative and organizational-objective reasons, but there is also a level of continuity and similarity amongst the measures selected between jurisdictions. Environment and safety are reoccurring themes along with travel times, reliability, level of service, and delay. Mode-specific measures are also common; there is a generalized focus on road movements, but rail, air, and marine movements are often included. There is a limited emphasis on economic indicators. Jurisdictions tend not to explicitly monitor the profitability or revenue generation of freight carriers or the specific rates that they charge customers; likely due to the confidentially surrounding pricing as well as the difficulty incumbent in that level of data collection. The majority of economic measures rather are focused on the costs required to maintain the operations of the network and the percentage of GDP for a region/jurisdiction that logistics makes up; the lower the overall percentage, arguably the more efficient the system.

2.2. Data Sources for Measurement of Freight Performance

The degree to which data is a major issue within the realm of freight performance measurement and in numerous other transportation contexts cannot be overestimated. A very important note that came out of the recent Canadian Transportation Act Review process (Government of Canada, 2015) was: "If one message was clear during this review, it is that all stakeholders across Canada, including government agencies want better access to transportation data." It was further noted for Canada that the "lack of sufficient data or common performance metrics makes it extremely difficult to analyze, forecast, or plan for efficient use of the system." These are very strong words as commentary on the state of transportation data in Canada. Some stakeholders have suggested inter-governmental working groups between the municipal, provincial, and federal level stakeholders as a means to overcome the associated costs of purchasing or producing accurate and valid datasets as well as reducing duplicate analysis of patterns and phenomena. Such a working group could be instrumental in reducing many of the limiting factors that hamper freight transportation analysis across Canada.

There is inherent complexity to freight data. For example, freight transportation aspects include the number and varying characteristics of the decision makers, the diversity in the types of goods (i.e., commodities) carried, origin-destination and routing patterns, freight costs, and units of measure. The supply chain involves multiple decision makers in both the public and private sectors: the former typically as providers of freight infrastructure and services – including infrastructure planning and maintenance - and as regulators; the latter as shippers, carriers, and distributors of goods. The movement of freight can involve several transportation modes, intermediate transfer and processing facilities, and numerous jurisdictions. These complexities also result in a range of freight survey practices (TRB, 2011c).

Freight performance measures are certainly dependent on available data. Data availability is the single greatest constraint to FPM and, pragmatically, one of the determinants of what can be done. At the same time, the rise of new technologies provides great opportunities to leverage existing, and generate new, data sources. The CTA Review notes that a new workforce cohort is entering the labour force with new perspectives on and familiarity with advanced information technologies (Government of Canada, 2015). There may be an opportunity to fix aspects in need of improvement in Canada while leveraging new technological and human resources to help produce the required data to better support FPM. The notion of leapfrogging previous standards of data collection with new intelligent transportation systems, crowdsourced data, high-resolution satellite imagery and other remotely sensed data is discussed further in the following subsections and represents an opportunity for advancing the collection of transport-related data.

Prior to commencing discussion on freight data sources, public and otherwise, that will support FPM, it is useful to review Table 2-9, below. This table is organized according to the same freight performance themes as McMullen and Monsere (2010) used for Oregon (refer to Table 2-4) but what is interesting is that it links the themes and associated modes to specific data sources in the United States. There are a diverse set of sources that mix federal, state, private sector and association data to achieve performance monitoring, albeit not always to the level of geographic specificity desired (TRB, 2011c; Monsere et al., 2009; McCormack et al., 2010). Significantly, there is little mention of municipal data sources for provincial or state level frameworks despite the municipalities being able to provide the highest level of data granularity for movements across their roads. It is understood that not all municipalities have the capacity, financial or otherwise, to operate widespread transportation data collection schemes, but there are certainly municipalities that do or are emergent in their design – e.g., City of Montreal and City of Calgary. These cities are using Bluetooth ITS technologies coupled with high-speed broadband to count traffic on major municipal streets to inform their transportation management systems (CBC News, 2016; CTV Calgary, 2014). The City of Kansas, Missouri is able to provide real-time parking availability along a 2-mile "smart district," a desire for such real-time information has been mentioned by Ontarian stakeholders, especially for Toronto and other big cities (Maddox, 2016).

TRB (2011c) provides a very interesting overview of how a wide range of public and commercial data sources were used by mostly government practitioners. The highest positive ratings were related to the Freight Analysis Framework and the U.S. Commodity Flow survey. The former, of course, depends quite a bit on the latter, but incorporates other data sources to help define the overall framework. The Rail Waybill Sample, managed by the Surface Transportation Board ranks highly as well along with the TRANSEARCH Insight Database. The latter of which represents detailed characterizations of shipments by commodity group and mode down to the county level. The Waterborne Commerce database maintained by the U.S. Army Corps of Engineers is well used, as are Border Crossing data maintained by the U.S. Bureau of Transportation Statistics.

Table 2-9: FPM Categories and Modal Breakdown with U.S. Data Sources

Performance Measure	Potential Source of Data
Safety	
Highway	Accident Crash Report Systems (State Level)
	Fatality Analysis Reporting System
	Motor Carrier Management Information System
	Safety Measurement System
	Safety and Fitness Electronic Records
Rail	FRA State Freight Rail Safety Statistics
Air	Accident/Incident Data System
	Aviation Safety Reporting System
	Near Midair Collision System
	Runway Safety Office Runway Incursion Database
Ports / Marine	Marine Information for Safety and Law Enforcement
Maintenance / Preservation	
Highway	Pavement Management System (State Level)
	National Bridge Inventory
Rail	Rail Network Data (State Level)
Air	Airport Pavement Management System (State Level)
Ports / Marine	USACE Navigation Data Center
Mobility, Congestion, and Reliability	
Highway	Highway Performance Measurement System
	ATRI N-CAST
	INRIX Probe Vehicle Data
	Weigh-in-motion Data
Rail	Association of American Railroads' Railroad Performance Measures
Air	Air Carrier Statistics
Ports / Marine	USACE Lock Performance Measurement System
	Maritime Safety and Security Information System
	Port Import and Export Reporting System
Accessibility and Connectivity	
Highway	State, Regional, or MPO-Level GIS Databases
Rail	Carload Waybill Sample
Ports / Marine	USACE Lock Performance Measurement System
Air	Air Carrier Statistics
Commodity Flow Data	State-level Commodity Flow Models
	Freight Analysis Framework
	Transearch Database
	Commodity Flow Survey
Environment	
Highway	The EPA's MOVES2010

Source: (Walton et al., 2015), Adapted from McMullen et al., 2010, and NCFRP Report 10

2.2.1. Federal Sources

Federal governments are important in the development, use, and sharing of freight transportation data. In Table 2-10, which has been reproduced from the Canadian Transport Act Review (2015), a useful overview of available Canadian transportation data is offered. Many of the sources are relevant in the freight context. One of the most interesting aspects is that seven of the sources were cancelled in recent years. Cancellation of data hinders the ability to study performance trends over time. Though not related directly to freight, the replacement of the long-form census in Canada by the National Household Survey for 2011 was particularly harmful for data continuity over time. Changes to data collection methodologies can affect the temporal usefulness of a dataset and can alter the validity and accuracy of performance measurement.

Other relevant federal sources that are not included in Table 2-14 include:

- The Dangerous Goods Accident Information System from Transport Canada which tracks incidents that involve dangerous goods, including those related to their transport;
- The National Collision Database from Transport Canada which tracks all vehicular incidents in the country; and,
- The Air Pollutant Emissions Inventory from Environment and Climate Change Canada which tracks air pollutants at the national and provincial/territorial level

Data source tables are further developed in the mode-specific chapters of this report.

The U.S. experience suggests that leadership at the federal level is important to create ideal circumstances for standardized and well-conceived data collection to support FPM. An example is the U.S. Highway Performance Monitoring System (HPMS). The HPMS is oriented to passenger and freight movements but is more dependent on sampling approaches for the latter. The HPMS was initiated at the federal level but there is participation from each State in collecting comprehensive data at the road link level and feeding it into the overall system. The HPMS is a national program that includes inventory information for all public road mileage. A detailed field manual exists to ensure that all stakeholders follow the same data collection processes. The net result is that road infrastructure and associated traffic activity is very well characterized in the U.S, as a result of federal reporting requirements linked to funding mechanisms. There is good data on traffic volumes at the level of road links along with the extent to which truck movements contribute. The HPMS supports the Texas Transportation Institute's annual report, measuring traffic congestion across U.S. metropolitan areas (TX DOT, 2006). The HPMS helps to support monthly reports that accurately capture changes in national aggregate vehicle miles travelled. The HPMS is one important example but there are others which show the central role that the U.S. federal government is playing.

Table 2-10: Summary of Federal Transportation Data by Mode

Mode	Data Type	Agency / Department	Present Status
Aviation	Airport Data	Statistics Canada	Active
	Airport Activity	Transport Canada	Active
	Financial and Operating Data	Statistics Canada	Active
	Fare Data (Pricing)	Statistics Canada	Active
	Passenger Origin-Destination	Statistics Canada	Active
Couriers and Messengers	Financial and Operating Data	Statistics Canada	Cancelled after 2008
Marine	Financial	Statistics Canada	Cancelled after 2008
	Port Activity	Statistics Canada	Cancelled after 2011
	Commodity Origin-Destination	Statistics Canada	Cancelled after 2011
	Vessel Movements	Canadian Coast Guard	Active
Passenger Bus and Urban Transit	Financial and Operating Data	Statistics Canada	Active
Rail	Financial	Canadian Transportation Agency, Transport Canada, Statistics Canada	Active
	Cargo Origin-Destination	Canadian Transportation Agency, Transport Canada, Statistics Canada	Active
Taxi and Limousine Services	Financial and Operating Data	Statistics Canada	Cancelled after 2007
Trucking	Financial and Operating Data	Statistics Canada	Cancelled after 2011
	Commodity Origin-Destination	Statistics Canada	Active
Trucking and Couriers	Pricing	Statistics Canada	Active
Vehicle Survey (Canadian Vehicle Survey)	Activity of Registered On-Road Vehicles	Statistics Canada	Cancelled after 2009
Vehicle Survey (Canadian Vehicle Use Survey)	Activity of On-Road Vehicles	Transport Canada	Active for limited number of provinces

Source: (Government of Canada, 2015)

The collection of freight data at the federal level, is currently "piecemeal." One tendency is to focus on carriers rather than the shippers and to collect data one mode at a time. In a commodity flow survey, the emphasis is on the decisions that the shippers make. Which can represent a good approach for government as commodity flows can be associated with supply chains which can be associated with economic sectors. This assists in determining which economic sectors have what freight issues and the identification of relevant improvement opportunities. There is evidence that Canada is moving in this direction.

The trucking commodity origin destination survey (TCOD) is an example of an approach that could be improved upon. The TCOD is a valuable source of data but the approach taken is not ideal. Gagnon and Cook (2007) offer an interesting overview of this trucking-oriented survey.

At the time of their publication, nearly 2,000 firms were surveyed to capture the shipments they make with the restriction that the company required revenues of $1.3 million or more for inclusion. This would exclude, for example, a lot of owner-operators. Also excluded, are dedicated private fleets associated with firms that are not in the business of carrying goods for clients (e.g. Wal-Mart and many others). These are both significant omissions in terms of capturing the total amount of truck travel to assist in FPM.

2.2.2. Provincial and State Sources

With respect to provincial data that could be relevant to freight performance measures, there are several potential sources:

- Bridge Condition Data that reports on the state of all bridges in the province;
- Pavement Condition Data that reports on roads under MTO's responsibility;
- MTO Commercial Vehicle Survey (CVS) which is based on intercepting trucks and then collecting data on a wide range of variables such as origin, destination and cargo among other aspects;
- Traffic Counts on Provincial Roads and good counts of trucks by size at select stations across Ontario; and,
- GPS data sourced from a variety of sources on vehicle position, dwell times and speeds.

It is natural that the most relevant provincial sources of data relate to the 400-series highways, considering their scale, traffic volumes, and their connections within and outside of Southwestern Ontario. The set of highways represent some of the most critical pieces of road infrastructure in the province for both passenger and goods movement. This focus on provincial infrastructure can have implications for how representative associated data are. For example, the CVS has historically under-represented local truck movements which would ideally be well-captured in a provincial FPM initiative. We understand that the Ministry of Transportation is seeking to increasingly conduct its data collection at key municipal locations more-oriented to local traffic and at key sites located off of major highways such as rail intermodal and airport cargo terminals. There are also efforts to extend the use of commercial fleet management GPS data to improve their transportation demand models. While these efforts are in their infancy, and challenges remain in the expansion of these data layers, vehicle tracking from multiple GPS data sources has important potential to be maximized.

Provincial or State jurisdictions have the power to create new, powerful data sources. In Oregon, there is an interesting pilot project (www.myorego.org) where people are installing data loggers in their vehicles so that they have the opportunity to pay a "mileage tax" rather than a fuel tax. They pay the tax per mile rather than per gallon. With the rise of plug-in electric vehicles that may not consume gasoline, some governments are concerned that the fuel tax revenue source will ultimately be in jeopardy. In the heavy truck segment, electric mobility may be slower to catch on (notwithstanding the Tesla Semi) as "EV technology is not commonly [a] viable option for long-haul heavy freight" due to range limitations, battery dimensions and weights, and owner concerns relating to maintenance and resale values, according to a recent Canadian Senate report (Decarbonizing Transportation in Canada, 2017). Though the idea that mileage might be tracked in new and detailed ways is an interesting prospect for freight management.

With regard to data sources that are specific to road freight, government practitioners seem to emphasize fundamental data sources. For example, almost all practitioners stated that they used truck traffic count and classification data and had good access to it (Table 2-11). Of all sources, this was the one most frequently used (by far) across practitioners. Other prominent basics included information about vehicle types and sizes. An additional survey question was asked as to which types of survey data collection the practitioners *most wanted to see expanded*. Again, topping the list by a wide margin was truck traffic counts. Despite using this type of data extensively already, there seemed to be a very strong desire for more. It may be tempting to assume that gaps along data themes where little has been done but this result suggests that the most pressing gaps could be along dimensions that some might think are already covered. Such summaries as Table 2-11 have not been found in the Canadian context.

Table 2-11: U.S. Practitioner Use and Need of Highway/Truck Freight Data

Data Type	Currently Use	Need but Not Available	Not Available
Vehicle Type	23	6	7
Vehicle Size	26	5	5
Average Vehicle Speed	16	9	11
Vehicle Emission Data	6	15	14
Traffic Counts and Classification Data	33	1	2
Cargo Type	19	10	5
Payload Weight	15	11	8
Shipment Value	12	13	8
Truck O/D Patterns	15	19	1
Trip O/D Patterns	16	17	1
Travel Time	11	18	6
Travel Time Reliability	5	21	10
Number of Truck Stops for LTL Shipments	0	19	15
Incident Data	17	7	11
Line-haul Costs	3	16	15
Drayage Costs	4	14	16
Freight Rate (e.g. cost per ton-mile)	4	17	13
Other	2	1	12

Source: (TRB, 2011c)

With regard to the time dimension, data are becoming increasingly available that allow a greatly increased temporal understanding of traffic patterns that can be relevant for truck movements. Time buckets for analysis as short as per minute are possible. For the current performance measure context, coarser aggregations would be desirable. In the context of workplace commuting it would make sense to focus on AM and PM peaks since this is when the large majority of commuting movements take place, as Ontario's iCorridor program does. In the trucking context, this is less clear as movements are much less concentrated in the peaks.

2.2.3. Municipal Sources

Of the three levels of government, municipalities are arguably the least active in data collection that will support a Provincial FPM. This has been observed, for example, in frameworks that have been highlighted in the earlier part of this chapter. While municipalities may currently be considered a less active source, it is arguable that as rapid and cost-effective data collection systems become increasingly practical for municipalities and regional governments to invest in, municipalities may become one of the focal points of freight data collection. Many freight externalities occur in urban areas (e.g. congestion, air pollutants, noise, accidents). Municipal data may be key to achieve urban data granularity (node/terminal level data, and key shipper/receiver locations and activity levels).

The most important role for municipal data, appears to relate to the roads that it manages and the level of activity that is occurring on these roads. Most often these roads are arterials but in some cases, they are significant freeways. In Toronto, the Gardiner and Don Valley Expressways are not provincial. In Hamilton, the Lincoln Alexander and Red Hill Valley Parkways are significant freeway infrastructure managed by the City of Hamilton. Whether arterials or freeways, the most important source of municipal data will relate to traffic counts but in many cases, there will be less detail for trucks than for passenger vehicles. One recent noted exception is the proposal from the City of Hamilton City-Council to track license plates on the aforementioned parkways, with a focus on heavy truck movements (Craggs, 2017). Municipalities also collect detailed data on traffic collisions, including those that involve trucks, which get fed to higher levels of government to populate their databases.

Within major and medium sized municipalities, urban congestion is a major concern and cities have been building sophisticated Intelligent Transportation Systems to monitor and manage traffic flows. Toronto and Montreal are using Bluetooth technologies in street posts to count traffic volumes continuously and in near real-time, for example. Montreal, through its Urban Mobility Management Centre, also recently became the first city in Canada to provide real-time traffic data that it collects from arrays of sensors, radar devices, and cameras, to the Google Waze project to provide road users with as much information as possible. As earlier noted, many urban municipalities are rolling out real-time city street parking systems to help reduce driver stress and unnecessary arterial congestion.

Despite efforts, and major publications, e.g., TRB *Improving Freight System Performance in Metropolitan* Areas, there is a noticeable gap in the collection of data related to commercial / freight vehicle movements in cities. While many cities designate truck routes and are deeply concerned about pedestrian interactions with large vehicles (see the New York City program on intra-city mobility) there is an ambivalence towards the efficiency of freight movements. In regard to truck routes, it is a major stakeholder complaint that the truck routes are too often changed as knee-jerk responses to complaints as opposed to well thought-out and designed long-term plans. It is arguable that given the existing ITS infrastructure (cameras, sensors, loops, etc.) in many cities throughout Ontario, it would be possible to implement technologies to specifically monitor freight vehicles to enhance their existing Traffic Management Centres – the City of Hamilton LINC/Red Hill Expressway proposed tracking being a good example.

There have been shipper surveys executed by the University of Toronto on behalf of Peel Region and Metrolinx. Both of these efforts have taken place within the last decade and both have yielded freight datasets that help to understand commercial vehicle movements at the intra-metropolitan scale. Data from the Peel Region Goods Movement Survey supported efforts by the McMaster Institute for Transportation and Logistics (Ferguson et al., 2010) to micro-simulate commercial vehicle movements within the GTHA. Models developed from a comprehensive goods movement survey in Calgary also helped this 2010 effort.

As an interesting federal/municipal case study, consider the comparison of the process for estimation of Truck Vehicle Kilometres Travelled in Canada versus the U.S. This is an example where a shortage of data that could be collected/coordinated at senior levels of government, leads to municipalities taking unilateral action. In Canada, accurate statistics that quantify aggregate travel tends to be obtainable on a jurisdiction-specific, “hit and miss” basis. Link-specific traffic volumes for trucks and passenger vehicles are fundamental building blocks for such statistics. In the U.S., monthly reports are released on vehicle miles travelled (VMT) based on data that are essentially collected and tabulated from the bottom-up by the local State Departments of Transportation and are reported on at the national level.

It is noted in TRB (2011a) that VMT estimation is probably the most common use of the Highway Performance Management System (HPMS). In contrast, seeing the need to fill a perceived vacuum, the City of Calgary (2010) released a report on a suggested methodology to estimate passenger VKT. The report notes: “It is important to develop a methodology that can be standardized, is consistent and easy to use nationwide. Estimated VKT (using different sources and/or methodologies) have been used for comparison with other cities or for benchmarking, which can be misleading if a standardized methodology is not used.”

When there is a high quality, well-conceived and fundamental data source like the U.S. HPMS available, then other important data sources can be linked to it. For example, safety databases related to vehicle collisions can be combined with HPMS data to report accurately on fatality and injury rates by road class. HPMS data would have an obvious link with accurately measuring vehicle emissions by class of vehicle. These are all key performance themes in the freight context and these are the types of over-arching efforts that municipalities can link into in their work. This would appear to be a good model for senior levels of government.

2.2.4. Private Sector

Freight transportation in Canada is conducted primarily by private companies operating with confidential information in a competitive marketplace. Accordingly, there is information collected relating to freight performance measurement that will not be transparent to government or other stakeholders. Due to the limited accessibility of private sector data, freight planners have traditionally had to rely on: publicly available datasets; purchased datasets; available industry association datasets; and, collection of survey data (Transportation Research Board, 2013b; Transportation Research Board, 2011c; Walton et al., 2015).

One important consideration for FPM, especially in the trucking context, is the rise of big data and the internet of things. With respect to some aspects of truck operation, large databases are being generated every day that capture minute details through GPS and telematics devices. For now, many of these large databases are also being developed by the larger companies. As such, even if the public sector were to tap into such data, the tendencies of larger companies might be over-represented. The types of data that are being generated are very good for tracking the movement of trucks but other data elements, such as the extent to which trucks are filled, are harder to come by with new technologies.

There have also been significant private and public-sector developments in Intelligent Transportation Systems that could have profound implications for the types of data that will become widely available. The use of ITS allows for the identification of problem areas on links, providing qualitative and/or quantitative data to assess the problem. In Japan, ITS is used to identify crash hotspots and then measures are put into place to reduce crashes (redesign the road, slow traffic, etc.) to reduce the impact that crashes have on traffic flows. Some ITS examples include:

- use of GPS systems to track marine or aircraft vessels;
- use of Remote Sensing systems to track vehicles (of all modes) and emissions / environmental impacts of incidents;
- use of port management software to manage traffic flows, E.g., Rotterdam

- use of Weight-in-motion devices to count traffic flows or for inspection stations;
- use of Bluetooth, cellular and other radio frequency tracking to assess traffic counts and traffic speeds;
- use/integration of APIs such as Google Waze to track traffic flows;
- modernized virtual truck distribution centres to pair empty/half trucks with loads, as especially noted by logistics companies like Amazon building freight brokerage apps;
- traffic cameras and other sensor devices to count and assess speed of traffic and profile vehicles types based on machine-learning visual recognition algorithms;
- electronic logging for trucks (as opposed to paper loggers for counting working hours);
- managed expressways which use ITS to improve the performance of roads on the fly (e.g. hard shoulder running, control over the opening/closing of lanes, speed limits, etc.)

It had been expected by many public freight practitioners that with the advent of the Internet, a variety of new logistics tracking technologies, the expansion of wireless technology, and an increasing integration of, and reliance on, just-in-time supply chains, that there would be a large influx of freight data available for the public sector (Transportation Research Board, 2013b). To the extent to which this has happened, it still appears to be in the early stages.

Private sector sources of data can be from carriers that physically transport goods or it can be from firms that compile valuable data sources. There are private firms for example that are GPS data vendors and government itself collects some GPS data. INRIX Corporation is an interesting example of a private sector firm that has marshalled many sources to assemble arguably the most comprehensive available international database on vehicle speeds; other such companies providing similar Canadian data include *HERE* and *StreetLightData*. Such data should be quite relevant for performance measurement.

Overall, there can be difficulties in government interacting directly with the private sector in using private sector data, in particular with respect to the release of privately held data that may have the ability to support improvements to the transportation system. Careful consultation and partnership between the public and private sector is required to identify opportunities for mutual benefit from more robust data-sharing. The public sector is further removed from the equation when the private sector owns the infrastructure. Examples of such infrastructure can include: airports, rail lines, seaports, intermodal terminals, waterway locks, and terminals. However, this ownership obstacle is something that can be overcome with the proper engagement and a deep recognition of the private sectors concerns regarding data, business practice confidentiality, and the alignment of private profit objectives with public benefit objectives.

From the public-sector viewpoint, it may be difficult for government to act on private sector data to develop performance measures; there is a need to manage expectations. For example, it may not be easy to obtain a complete multi-modal picture based on data derived for the purposes of somewhat narrow corporate interests. Some contend that the public sector does not fully appreciate the breadth of data potentially available and the scale to which modeling and visualization efforts can be undertaken with private sector data (Transportation Research Board, 2013b). Perhaps this is an area where the public and private sector can work together to ensure that public officials are well aware of *all* the possibilities with new data and technologies.

2.2.5. Associations

Most, if not all, industry associations collect data from their members, collectivize it appropriately, and provide it back to members and other stakeholders in a way that does not share sensitive information about any one firm. The Railway Association of Canada, the Ontario Trucking Association, American Association of Railways, the American Trucking Association, the Intermodal Association of North America, are all examples. Third-party organizations have a unique ability to gather data from the companies that they represent. In the example of the American Transportation Research Institute (the research arm of the American Trucking Association) nondisclosure agreements are put in place along with individual contracts and data scrubbing to remove identifying information (Transportation Research Board, 2013b). A similar relationship is later discussed in the rail chapter on the relationship between Transport Canada and the Class 1 rail carriers in Canada in regards to data sharing.

The role of associations as an intermediary between the private and public sectors appears to be a very promising one indeed. Many potentially complex dealings between the public and private sector are avoided if an association manages the data relationship with private sector firms. The data that are aggregated across multiple firms can be focused on what is most important to share; there does not need to be esoteric data that is more of internal interest to firms. It becomes possible, if necessary, for the public sector to compensate the given association for the privilege to make use of association data for the broader good.

The need for an association as an intermediary does not necessarily mean that the private sector is not willing to co-operate with the public sector or academia. McCormack et al. (2010), in a study with firm-provided GPS data in Washington State, found that virtually every firm was willing to share data to support the study. However, it was discovered that actually obtaining the data from companies was challenging. Even if a company were willing to spend staff resources, it was difficult to work out technical details with in-house staff, if the firm possessed in-house staff. This example illustrates that it may be better for an association to do the "heavy lifting" of defining and executing a process to secure data across many firms.

Other examples of how associations have an important role to play in delivering data for FPM are discussed in mode-specific chapters to varying extents.

2.3. International

The previous sections of this chapter have had a demonstrated focus on the domestic North American perspective of freight performance measurement and data sources, this section introduces a number of major international sources into the discussion. Beginning with an in-depth review of the freight data collection framework and methodology for the European Union, Table 2-12, followed by frameworks and examples from the United Kingdom, Table 2-13 and 2-14.

The European Union collects and reports extensive freight transport data, which is collected nationally by the relevant sub-national organizations. Data is aggregated and reported on by Eurostat, the statistical office of the EU. The requirements for freight data reporting are entrenched in European law at the supranational level, as well as through non-binding agreements. These mandates set forth the types of data to be collected, where to collect it from, and various methodological approaches that may be employed (European Parliament, 2003).

Issues of statistical quality between countries are dealt with by the regulations themselves, which set forth that Eurostat must both publish methodological recommendations and evaluate the quality of data received from countries, as well as their data collection procedures. (European Parliament, 2003). An example of the methodological recommendations made by Eurostat is the 2016 *Road Freight Transport Methodology* guideline and manual. The handbook focuses on three major data collection themes: recommendations for sample surveys; recommendations for the variables; and, data transmission and dissemination recommendations (Eurostat, 2016b). Such documents are produced for each of the major freight movement modes.

The specific modal data collection methodologies vary by nation and mode. For example, road freight statistics are collected from surveys designed and implemented by each country, but a base set of indicators are mandated by Eurostat. The list of EU road freight variables are listed in Table 2-12 and optional/required reporting status. Variables are categorized into three themes, namely: Vehicle; Journey; and, Goods-related (European Parliament, 2012). For road, a high-level generalization of the process is available. Each country has a national register comprising of commercial vehicles licensed in that country, not dissimilar from the vehicle registries in each province in Canada. From this registry, the collecting agency generates a sample of the tractive vehicles used for goods movement. From the sample, the agency has the registration information for the vehicle and are able to contact the owners to complete the survey (Eurostat, 2014b).

Data are collected through the *Common Questionnaire* of the United Nations Economic Commission for Europe (Eurostat, 2016c). In addition to road, the *Common Questionnaire* collects data on railway and inland waterway transport but is a voluntary mechanism. The EU has implemented regulations requiring the collection of data statistics for rail, marine, and air freight transport (Eurostat, 2017). Data for these modes are typically provided by the individual operators, handling agents, associated ports, lading documents, or industry-standard communication systems. Specific data collection processes can include: compulsory surveys; administrative data; statistical estimation; and/or, through ad hoc studies (Eurostat, 2015).

The framework established by the European Union presents an interesting example that Ontario could emulate for the establishment of their own comprehensive freight data collection and reporting system. Namely in the creation of standardized set of indicators for each municipality to track, the methodologies that can or should be employed to carry out that data collection, and how to share that data in a constructive fashion back to the Provincial government. Utilizing a provincial vehicle registry also provides an opportunity to more directly track and survey goods movement vehicles as opposed to intercept surveys. Though at a Provincial level, more would need to be done to include modes outside of the provincial jurisdiction. For road movements, the EU process could result in a greater level of detail and a larger sample size than is available through current reporting means.

Within the European Union, the United Kingdom presents an interesting case for evaluating foreign freight performance measurement systems at a national level. Given the unique nature of the United Kingdom's economic trading relationship with mainland Europe and within and across the UK itself, there is a predominant focus on truck movements, but also a focus on the marine and rail modes. Table 2-13 is produced by an industry association supported by member firms and generally reflects more of an industry focus in its metrics. There is significant emphasis on trucking in the dashboard which is consistent with the relative predominance of the mode for freight movements in the UK. Rail and marine freight are addressed in the considerations of traffic flows and are representative of how the majority of goods make their way to the islands of the UK. Air freight is not mentioned. There is not a category that deals with the environment; to the extent that the environment is addressed, it is via efficiency measures through an assumed alignment of efficiency and the environment. Such an assumption is in line with comments made by stakeholders wherein improved fuel economy and environmental impacts are directly correlated; less fuel spent on a greater number of vehicle kilometres travelled is a benefit to both industry and the environment. This table is a majority excerpt of a larger table which also features some macro-economic indicators.

Table 2-12: Road Transport Variable Reporting Requirements of the EU

Variable Theme	Variable	Required / Optional
Vehicle	Possibility of using vehicle for combined transport	Optional
	Axle Configuration	Optional
	Age of vehicle in years	Required
	Maximum Permissible Weight	Required
	Load Capacity	Required
	Vehicle Operator's NACE	Optional
	Type of Transport (Hire or Reward)	Required
	Total Kilometres Travelled during Survey Period: Loaded and/or Empty	Required Empty Kilometres is optional
	Vehicle Weighting	If applicable to statistical weighting
Journey	Type of Journey	Required
	Weight of Goods Carried During the Journey, or Each Stage of the Journey	Required
	Place of Loading	Required
	Place of Unloading	Required
	Distance Travelled	Required
	Tonne-Kilometre effected during the Journey	Required
	Countries crossed in transit	Required
Goods	Type of Goods	Required
	Gross weight of goods	Required
	Classification of Dangerous Goods	Required if applicable
	Type of Freight	Optional
	Place of loading goods	Required
	Place of unloading goods	Required
	Distance Travelled	Required

Adapted From: (European Parliament, 2012)

Table 2-13: Logistics Indicators of the 2016 Edition of the Logistics Dashboard in the UK

Road Transport Industry
Reported profit margin of top 100 road hauliers
Number of goods vehicle operator licenses
Population of heavy goods vehicles licensed
Population of vans licensed
Population of heavy goods vehicles trailers (based on number tested)
Heavy goods vehicles registrations
Van registrations
Number of heavy goods vehicles drivers in employment
Claimant count (heavy goods vehicles drivers for December)
Heavy goods vehicles laid up
Safety
Heavy goods vehicles motor vehicle test pass rate initial (>3.5 tonnes gross vehicle weight)
Van test pass rate initial
Heavy goods vehicles roadside encounter prohibition rate percentage – mechanical checks
Heavy goods vehicles roadside encounter failure rate percentage – drivers' hours checks
Heavy goods vehicles roadside encounter failure rate percentage – weight checks
Reporting of injuries, diseases and dangerous occurrences workplace accidents for transport
Road casualties linked to heavy goods vehicles (number killed or seriously injured)
Efficiency
Percentage of heavy goods vehicles empty running
Percentage of inland freight moved by rail (billion tonne kilometres)
Lading factor percentage for heavy goods vehicles (>3.5 tonnes gross vehicle weight)
Heavy goods vehicles fuel consumption (miles per gallon) (articulated vehicles)
Use of alternative fuels in heavy goods vehicles
Average heavy goods vehicles payload capacity (tonnes)
Traffic Flows
Containers handled by major UK ports (thousands Twenty-Thousand Equivalent Units)
Freight handled by air (tonnes)
Goods moved by heavy goods vehicles (>3.5 tonnes gross vehicle weight) (billion tonne kilometres)
Van kilometres (billion vehicle kilometres)
Cabotage within the UK (million tonnes kilometres)
Goods moved by rail (billion tonne kilometres)
Goods moved by domestic intermodal rail (billion tonne kilometres)
Channel Tunnel rail freight volumes (tonnes)
Number of rail freight train movements
Rail freight delivery metric (percentage of trains arriving within 15 minutes of scheduled time)
Percentage of penetration of Cross-Channel market by UK heavy goods vehicles
Heavy goods vehicles movements to mainland Europe (unaccompanied trailers only)
Heavy goods vehicles movements to mainland Europe (all powered vehicles)

Source: (Freight Transport Association, 2016)

McKinnon and Leonardi (2008) offer an evaluation of the road freight sector in Europe in terms of the data that ideally would be available to answer the comprehensive set of research questions that in their view need to be answered, Table 2-14. They set out a dozen different data dimensions that would be covered in an ideal world and note in the European road freight context that most of these elements are not collected. For performance measures, aspects such as level of activity and externalities would arguably be the most important themes from the list below. Some of the aspects such as supply chain structure and intermodal links are linked to trucking but not purely focused on it.

Table 2-14: Data Requirements for Long Distance Road Freight

Data Requirement	Description
Level of activity	Measured on tonnes-lifted, tonne-kilometres, vehicle- kilometres as well as volumetric- and value-based estimates of the quantity of freight movement
Commodity mix	Disaggregation of tonnes-lifted, tonne- kilometres, and vehicle kilometres by commodity type
Vehicle types	Disaggregation of tonnes-lifted, tonne- kilometres, and vehicle- kilometres by type of vehicle
Utilization of transport capacity	Measured by the ratio of actual loading (by weight and volume) to maximum possible loading
Consumption of resources	These resources should be expressed both in physical terms (e.g. litres of fuel, number of drivers) and monetary values (vehicle operating costs and freight rates)
Externalities	Emissions of atmospheric pollutants and GHG, noise levels, accidents, and other impact indicators
Energy use and emission reductions measures	As in Japan, it could be made compulsory for large companies to reduce transport energy use and to report annually on the effects of energy-efficiency measures taken at company level
Scheduling	This would cover average transit times, delivery reliability and time utilization of vehicle equipment
Supply chain structure	This would go further into the chain and indicate how freight journeys were inter-connected into a supply chain from the producer to the final consumer and differentiating them with respect to land uses at origins and destinations
Intermodal & Multimodal links	Where road freight operations interface with other transport modes, these modes would be specified and some indication given of the complete door-to-door movement, permitting analysis of the transport chain. Please refer to the glossary for the differences between inter and multimodal.
Market structure	This would distinguish own-account from hire-and-reward operations, identify cabotage and cross-trade activity, and possibly differentiate carriers into several categories
Infringements	As the long-distance road freight sector has a poor reputation for observing regulations, data on the nature, severity, and frequency of infringements would contribute to a wider understanding of the industry

Source: (McKinnon & Leonardi, The Collection of Long Distance Road Freight Data in Europe, 2008)

The thematic classifications of the international sources are relatively unique compared to the domestic considerations. Primarily in the extent of information being tracked about the transportation vehicles, and for road in the UK, indicators of overall industry performance. Little information of the same type of detail was reviewed or discussed in the sections focusing on domestic frameworks. As well, there are a lack of indicators, being presented in the freight context at least, that are interested in monitoring the condition of infrastructure, the New Zealand example is an exception, and the cost of maintaining the current state of the network. These are key measures within every US State Department of Transportation framework reviewed, likely attributable to a different funding structure in those jurisdictions. Furthermore, it is noted that the European Union appears to maintain a higher degree of interest in the journey and associated goods being moved, what and from where, than the levels of speed, reliability, congestion, or other more 'classic' engineering indicators of transportation performance. It is fairly clear, even from the few reporting mechanisms and frameworks discussed in this section, that internationally, agencies are developing sets of measures that are relevant to their policy objectives and actions. Measurement and data collection frameworks internationally do not represent a panacea or a perfect solution, as with domestic examples, these freight performance measurement systems are being developed with the organizational objectives in mind; a learning that Ontario could follow.

2.4. Chapter Conclusions

Based on the high-level review, to this point, of freight performance measure systems that are in use, or have been proposed, and based on a similar high-level review of data-oriented issues that affect the measurement of freight performance, the following chapter conclusions are offered:

2.4.1. Measurement Conclusions

- Performance measures should be simple, especially those that are more public-facing. It has been argued that the technological/engineering side of organizations can drive the development of performance measures excessively (McMullen & Monsere, 2010) and that measures are too often derived simply because they can be. Considerations of what can be absorbed/utilized by a wide stakeholder audience are very important.
- It is wise to conceptualize FPM from the normative viewpoint; to assess what ought to be measured as opposed to what is easy to measure. Under this approach, regardless of data availability, there will still emerge an understanding of what new data sources might be valuable to collect and what is fundamentally necessary to meet the requirements of the monitoring framework as defined by the strategic goals of the organization.

- One important result highlighted by TRB (2011b) is that the most "mature" freight jurisdictions in the U.S. feature only a handful of measures. There are other jurisdictions which feature the opposite and have a "laundry list" approach. Such jurisdictions generate performance measures and then tend not to be effective in using the measures as actionable information.
- An observation from reviewing the measures and associated frameworks is that there is a degree of jurisdictional, and perhaps geographical, specificity in the measures selected by an implementing authority. Typically, jurisdictions are measuring what is relevant to their specific contexts, as opposed to adhering to a template. As such, not all measures apply well to other jurisdictions. Measures that are identified as being appropriate for Ontario may very well be quite different than a set of measures suggested for British Columbia. There are jurisdictions that have taken very different approaches to performance measurement, and while they are noted as outliers, overwhelmingly measurement frameworks are specific to their jurisdictional goals and objectives.

2.4.2. Data Conclusions

- It is important to note at the outset that a basic lack of freight data in matters as simple as truck counts remains a real problem even as mostly private data are being generated in other contexts. The lack of data on the one hand and difficulties in obtaining it for public use on the other hand both remain as significant problems in Canada for the measurement of freight performance. It is recognized that Ontario has made headway on this front through some of the data tracked / presented through iCorridor.
- Based on precedents seen to this point, the best performance measurement systems will make use of data from multiple jurisdictional levels. A province-oriented system, for example, will be more effective if it leverages municipal, federal, or non-public data sources. Data that can be collected locally and then aggregated into higher-level datasets appears to be preferential, provided that each data collector can maintain and follow a defined methodology.
- The collection and standardization of freight data represents a challenge for performance measurement in Canada. There is a need for a greater federal role to co-ordinate and lead. Recommendations emerging from the recent review of the Canada Transport Act suggest that this need is being acknowledged. Aspects that could be standardized at the federal level, so that municipalities and provinces could execute data collection in a uniform way, seem mostly to be missing. It is not an easy task in Canada, for example, to develop a robust, bottom-up national estimate of truck vehicle kilometres travelled. There is the potential that newer data types, such as GPS, may play a substantial supporting role.

- As an example, the emerging commodity flow survey at the federal level in Canada has the promise to close a significant data gap in Canada and for Ontario. This has been one of the biggest differences between U.S. and Canadian freight data.
- In general, the least development in freight performance measurement and freight data collection appears to be at the municipal level. In Canada, Peel Region is the exception, not the rule, an understanding echoed by many stakeholders. Municipalities in the future will likely represent one of the largest sources of freight data as data capturing expands and becomes more granular in focus.
- The availability of private sector data, from carriers, is limited and restricts the ability for public-private sectors agencies to develop well-defined and mutually beneficial freight mobility plans and measurement systems. The integration of private sector data into public-sector datasets would provide a major benefit to provincial and national economic and transportation planning.
- There is a shift towards using more reliable and advanced sources of data and data collection methods (e.g. ITS related data sources). Many related initiatives are in their infancy but show great promise and could lead to new sources of data that might reduce dependence on expensive surveys. This remains to be seen.
- One important note is that some data are refreshed/updated more frequently than others. Data based on surveys are often updated only every five or more years. Data based on newer technologies such as GPS have the potential to be updated much more frequently. From the point-of-view of capturing shorter-term trends on a dashboard, and frequent updating, more traditional survey data may be less effective.
- A major component of the proposed TRB report card was in simplifying the breadth of their project by delineating what parts of the freight system to evaluate. They determined to evaluate the key highway systems, the US Interstate System, Class 1 Railways, and the top 20 ports across the country. (Transportation Research Board, 2011b). Related to this is the observation that since efficient freight movements are linked to consolidation of goods flows, that something analogous to the 80/20 rule is helpful for understanding what components of the infrastructure need to be monitored. Chances are, 80% of the cargo flows are on 20% of the infrastructure. Potentially, this reduces the scope of what needs to be monitored.
- Internationally, the EU reporting structure provides an overview of a data collection scheme unparalleled in size and complexity. Presenting a template that could be followed in Canada to address data collection at each level of government to produce a national freight database.

3.0 Road

Road

3.1. Background

Movement of goods by road is of enormous importance for Ontario and its economy. With few exceptions, roads provide the only means to address the first and last kilometre delivery requirements of freight. Consequently, goods movements of any mode are inherently dependent on the road network; almost every freight-supported supply chain within Ontario is reliant on the efficiency and the reliability of commercial movements. Any improvement in the fluidity of the road network benefits, virtually, the entire transportation system.

A 2014 report by (Ferguson et al.) produced a detailed review of the road freight context in Ontario based on an analysis of the highest-quality survery data available at the time. From the report, it emerged that the GTHA is by and far the foremost trucking hub for Ontario and much of Canada. McMullen and Monsere (2010) meanwhile, note that for many states in the U.S., the trucking mode is essentially the *only* mode available to accommodate freight movements. This observation also applies to large areas of Ontario and some urban centres, which lack rail, marine and air related infrastructure and are thus dependent on trucks for goods movement.

From stakeholder discussions, it was observed that the road and rail modes only compete for approximately 5%-10% of goods and between road and marine, direct competition is virtually non-existent, within Ontario and Canada.

At a high level, two initial aspects about Ontario stand out and merit consideration for the ultimate selection of road-based freight measures. One is that the metropolitan freight context is a very important one for Ontario; the GTHA is a large and significant metropolitan ecosystem in North America. The second aspect is the importance of the border and freight flows to and from the United States and beyond (Taylor et al., 2003; KPMG, 2002; Anderson, 2012; Anderson & Coates, 2010). It has been said that if Ontario were a nation, it would have one of the most open, trade-dependent economies in the world (Anderson et al., 2013). In considering all U.S.-Canadian road crossings, Ontario hosts the three busiest for truck traffic. These represent over 60% of the value of Canada-U.S. cross-border truck flow of goods, moving hundreds of billions of dollars of goods yearly (Transport Canada, 2016).

The movement of goods by truck and other commercial vehicles in Ontario relies heavily on the availability of the extensive and well-maintained network of King’s Highways, including the 400-Series controlled-access highways, regional roads, municipal expressways/parkways, urban arterials, and local streets. Having such an extensive network means that a wide range of municipal and regional governments are involved and several political boundaries are likely to be crossed even in the context of a single freight movement by truck or commercial vehicle. There may be issues of truck routes not aligning between municipalities and certainly stakeholders indicate that there are issues of non-uniform co-ordination between municipalities and the provincial government, representing an issue for the seamless movement of goods within and through the region. There are apparent variations in the importance placed on freight movements by municipalities and largely this is attributed to the relative prominence of other pressing municipal/political issues; within the GTHA the differences in freight planning between the Region of Peel and the other regions and cities in the assemblage are surprising given the importance of freight in supporting local economic activity and municipal coffers.

One of the truly major aspects that differentiates the use of roads for freight movements compared to rail, water or air in Ontario is that the road mode suffers from severe traffic congestion in locations that are strategically very important for truck movements in the province. As Peel Region (WSP Canada Inc, 2015) notes: “The effects of congestion, networks that are not resilient to traffic incidents or inclement weather, and poorly planned links within road networks can, and do, cost the public and private sectors hundreds of billions of dollars globally each year in lost productivity, wasted fuel, and emissions.” No other freight transportation mode shares infrastructure to the same extent as commercial road freight does with the general public, resulting in a plethora of difficulties as described by stakeholders (Wheeler & Figliozzi, 2011).

There is structuralized congestion caused by overwhelming demand, highway interchanges, steep grades and other aspects and there is non-structural congestion caused by aspects such as collisions, inclement weather, and construction. For the latter, feedback indicated that multiple construction projects are often negatively impacting the same freight movement; the issue of construction appears to be epitomized by the experiences of movements through Montreal but also the extensive and reoccurring construction through the non-winter months across Ontario – construction bottlenecks are a major consideration for the planning of truck movements.

The overall freight congestion situation is most acute in the GTHA including: major highway interchanges; throughways; and, in the metropolitan core, which is quite dependent on arterial movements. Within the metropolitan core, the issues of commercial short-term parking, local pickups and deliveries, especially of time-sensitive goods, are an area of major concern for shippers and carriers. The rise of e-commerce has been repeatedly noted in consultations as just adding to congestion problems. The increased pressure being caused by the rise of e-commerce is related to the dramatic increase in small, lightweight packages being demanded by consumers in increasingly short spans of time, as quickly as same-day delivery, for to the home delivery. These packages are typically being shipped by plane to the local airport or being shipped from a major distribution centre and moved by delivery van to the destination, as opposed to large trucks delivering consolidated loads to storefronts.

The traffic situation in the GTHA is generally seen by those consulted as difficult and a pressing problem. There has been feedback from carriers that road congestion leads to a more challenging planning environment that encourages: short-term thinking; inefficient use of physical assets; the need for more trucks and drivers; considerable driver stress; increased costs; and, unreliable service where time buffers fail a noteworthy percentage of the time (i.e. from 5% to 20% based on feedback). Moreover, there is concern about congestion levels further increasing and approaching the point where it will be difficult for the system to function; already multiple trucks are being used to complete delivery trips that used to be completed by a single driver.

The issue of the driver is one that comes up repeatedly. Drivers are focusing increasingly on quality-of-life issues and may be reluctant to service off-peak deliveries and many are pushing to long-haul runs to avoid the congestion and stress of metropolitan areas. Especially when getting paid a rate per mile or a flat rate per delivery, there is considerable stress on the driver and financially on his firm due to road congestion and the sense of needing to finish deliveries and move on to the next; each hour a truck sits in traffic can cost a firm up to a $100 – a significant value considering the number of trucks and the extent of traffic congestion that occurs within the GTHA.

3.2. Suggested Road Measures and Rationale

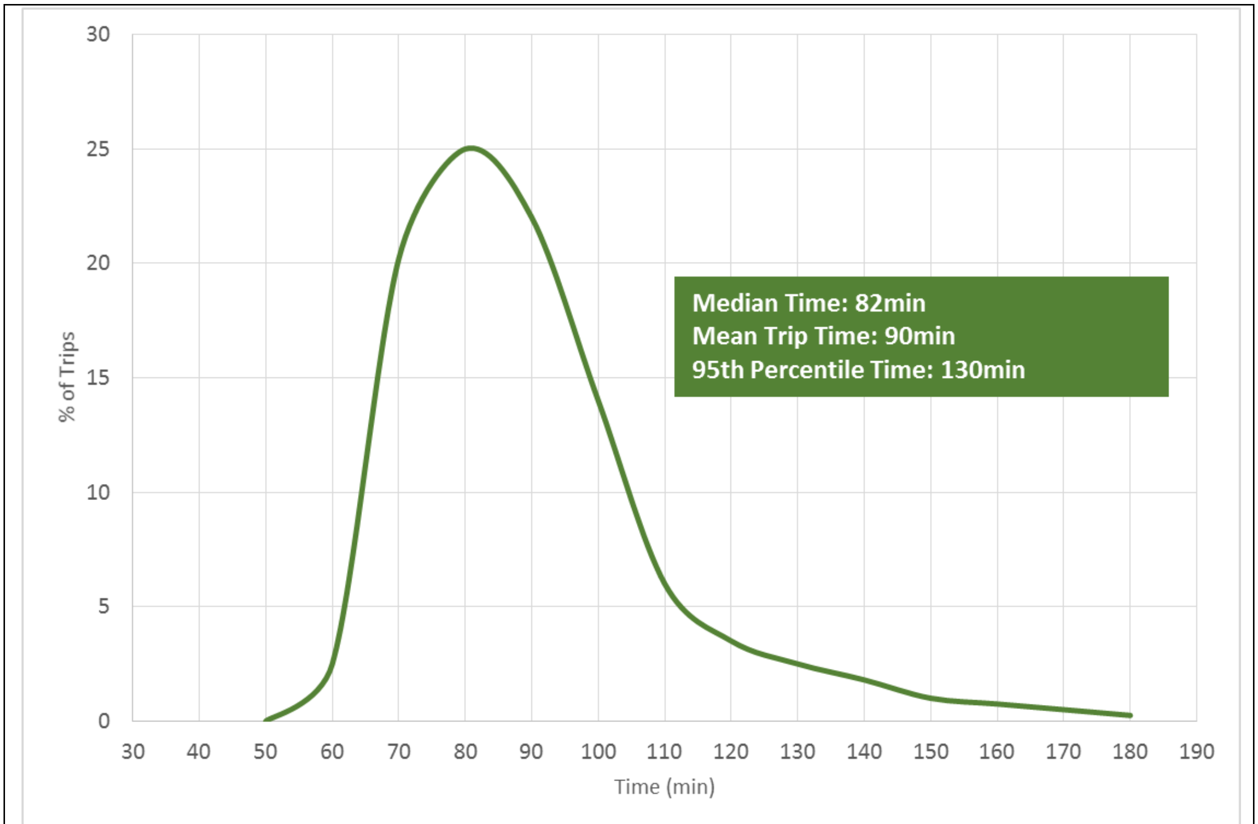
The suggested list of freight performance measures relating to road freight are outlined in Table 3-1. For each measure, there is a brief statement which gives a sense of why the measure is considered important. For many of the measures, more detailed measure-specific tables are included in the Chapter Appendix, Section 3.4.1. These tables offer further insight on the rationale, salient aspects, and data requirements for the specific measures. On a dashboard that might visually capture these measures for Ontario, there could be various segmentation options that offer potential for a theme-specific deeper understanding of performance improvement or deterioration over time. Also in the Chapter Appendix in Section 3.4.2, is fairly lengthy table that offers a summary of the primary measures that have been observed in the literature. At a broad level, the measures suggested in Table 3-1 offer strong emphasis on mobility, efficiency and reliability themes that have been stressed in the literature and most certainly in recent consultations carried out by MITL. There is also a strong emphasis on environmental measures since there certainly needs to be a keen understanding of the role of the road freight sector in impacting GHG emissions and air quality.

One measure to stress is the travel time distribution on significant freight corridors. The Ambassador Bridge, for example, is a very significant freight “corridor” for Ontario. Movements across this bridge are studied in detail and, in fact, specific tracking is suggested in Table 3-1 for Truck Border Crossing Times. It can be argued, that there are other very significant corridors, not related to the border, that are of equal or larger importance for Ontario. One example would be the Hwy 401 corridor that traverses the built-up area of the Census Metropolitan Area of Toronto. In the same way that travel times are tracked in detail for crossing the international bridges, it could be tracked for such strategic corridors based on observed traverses. Intermodal movements, associated with containers and the transition from rail-to-truck, can also be tracked through the delineation of an appropriate road corridor. One example could be the travel time distribution from the CP Vaughan Intermodal terminal to the junction of Hwy 427 and Hwy 401 and the reverse trip. The fact that freight movements have been noted, in the previous chapter, to be “concentrated” in their movements is another argument in favour of a strategic corridor approach.

Table 3-1: Suggested Freight Performance Measures for Road

Strategic Corridor Truck Travel Times and their Distributions (See Table 3-3)
Ultimately, time is a very important currency for a wide range of stakeholders involved with the road freight sector and there are certain specific corridors that are of great strategic performance for Ontario. End-to-end performance on these corridors ought to be captured and presented. An illustration of this measure that simultaneously highlights central tendency and variability (reliability) is recommended.
Percentage of Commercial Vehicle Registrations that are Low/Zero Emission (See Table 3-4)
It is desirable to have a measure for likely the most important mechanism of how emissions from the road freight sector will be reduced over time in absolute terms or at least in relative terms on a per registered commercial vehicle basis.
Composite Travel Delay (See Table 3-5)
Travel Delay is a critical measure to help quantify the magnitude of the congestion problem and to help prioritize infrastructure investments. While it is true that such investments in denser urban areas may be exponentially more expensive than in outlying areas, delay measures will help to show that such investments may nevertheless be very justified. Table 3-8 offers segmentation options for delay and highlights the importance of interchanges in generating delay.
Border Crossing Travel Times and their Distribution (see Appendix 9.3)
The handful of road border crossings between Ontario and the U.S. are of enormous strategic importance to Ontario's economy and their performance over time is thus a very useful aspect to highlight. A presentation of this measure that simultaneously highlights central tendency and variability (reliability) of crossing times is recommended. An in-depth discussion on border performance measurement is provided in Appendix 9.3.
GHG and NO_x Emissions from the Road Freight Sector
Diesel Fuel is the dominant fuel for especially the larger vehicles in the road freight sector and NO_x levels, which have negative impacts on health are elevated through the burning of diesel. As such, this is an important pollutant to monitor. The contribution of the Road Freight Sector in Ontario to the emissions of greenhouse gases and potentially climate change is essential to openly track. There is potential to seamlessly display other pollutants in a dashboard context.
Percentage of Road Pavement that is in Good Condition (see Appendix 9.2)
Top-quality road surfaces are important for the freight sector and for the smooth and more fuel-efficient handling of its cargo and it is important that this indicator be closely monitored for potential deterioration in pavement infrastructure.
Truck-Related Injury Collisions and Fatalities
By maintaining information on the number of freight-related collisions resulting in at least some injury to a party a good understanding is gained of the scale of the problem in terms of frequency and the associated count of fatalities offers an indication of the human toll. Most stakeholders consulted consider safety to be the most important theme of all.
Truck Tonne-Kilometres and Vehicle Kilometres Travelled (See Table 3-7)
These measures are very much intertwined and are included because they do the best job to illustrate the demand for movement of goods by truck in Ontario and associated component data are also fundamental building blocks for other measures that can be developed such as those relating to emissions. Useful measures, for example, such as tonne-km moved per litre of fuel consumed are fairly easily derived once these basics are in place.

Figure 3-1: Corridor Trip Time Distributions by Truck: Peak and Non-Peak Departure



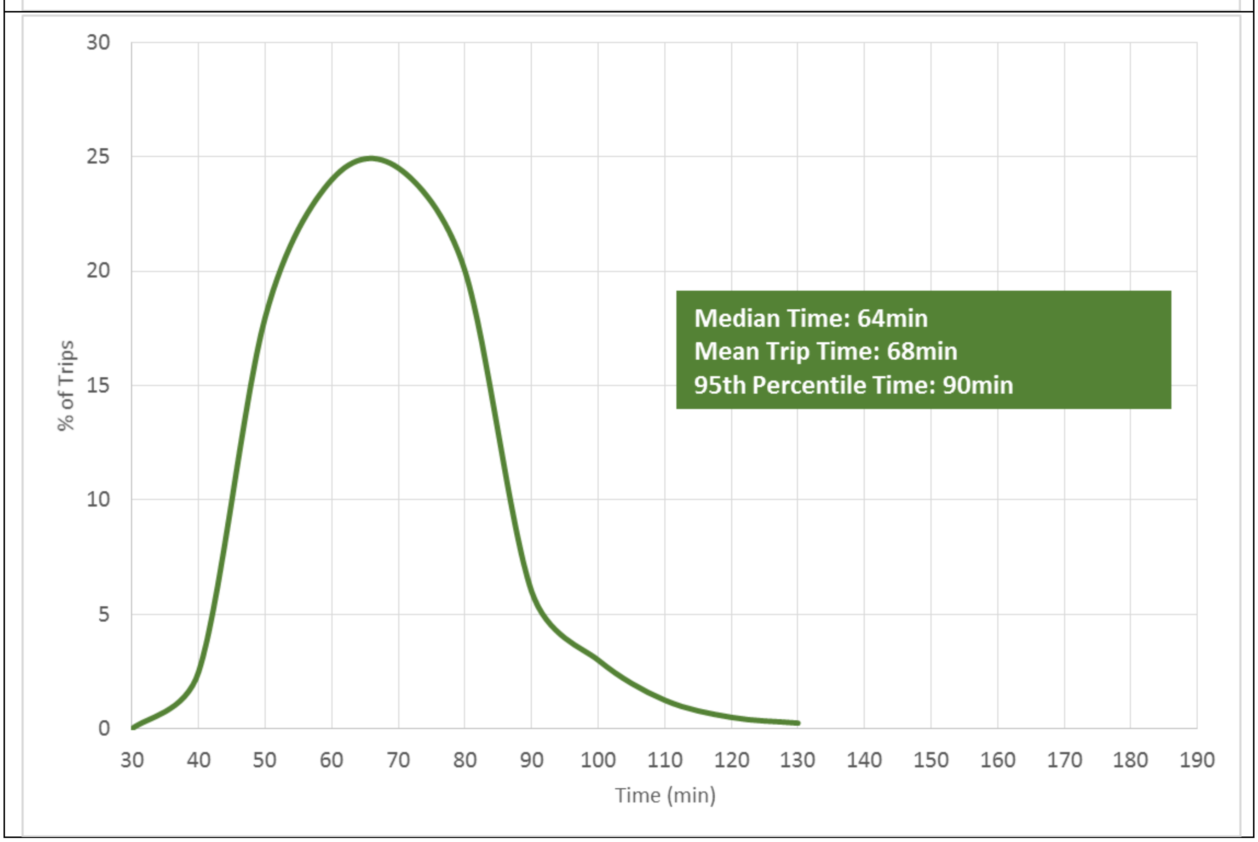


Figure 3-1 is included to highlight an important aspect of the suggested suite of measures and the visual nature of the dashboard. It can be argued that there is a false dichotomy between speed/efficiency and reliability as both aspects are simply attributes of the same distribution. In a dashboard, there is the capability to show the distribution and identify any key quantitative attributes of that distribution in an integrated fashion. In Figure 3-1, the trip time distribution to traverse a fictitious corridor by truck for a peak (top graph) and non-peak (bottom graph) departure time is provided. From this schematic, the user can get a real sense of what to expect from making that trip and meanwhile, the basic characteristics that would normally be provided: mean and median travel times and the 95th percentile "very conservative" time are captured. Given some budgeted time, these charts provide the probability that an actual outcome could be worse than the budgeted time. Sometimes, standard deviation is captured and reported on in isolation as a measure of reliability but Figure 3-1 makes clear that this is a dangerous practice as trip time distributions can be heavily positively-skewed with a long tail to the right. The standard deviation is therefore less meaningful in the context of a symmetric distribution.

As was already mentioned, the distribution of border crossing times is already captured as a suggested performance measure for Table 3-1. In Appendix 9-4, an essay by Charles Burke is attached which shows there is considerable in-depth analysis of performance at Canada-U.S. borders. For a general FPM system, the suggested measure is likely sufficient; this should not be taken as an indication that other measures and metrics on border performance are not available.

With regard to road pavement condition, consider that the Province already has elaborate processes in place to monitor this aspect and there are databases that are generated as a result of these efforts. There are a lot of detailed aspects that relate to these processes and there is more discussion along these lines in Appendix 9-3 which focuses on aspects of measuring the condition of Pavement, Bridge and Tunnel Infrastructure. It is noted that road conditions do directly impact the rate at which trucks and heavy goods vehicles are able to navigate roadways.

Vehicle emissions represent one of the most exhaustively regulated segments of the entire transportation system, for all modes. These measures focus on the level of environmental impact in terms of: carbon dioxide; nitrogen oxides; volatile organic compounds; particulate matter; and, other greenhouse gas emissions. An important side effect of reducing traffic congestion and improving freight system and vehicle performance is a reduction in emissions (Piecyk & McKinnon, 2010). Some jurisdictions offer vehicle retrofitting and clean engine programs and will track such measures under their environmental impacts section, such programs are discussed in the (Decarbonizing Transportation in Canada, 2017) report by a

Canadian Senate committee. In Arvidsson (2013) it was reported that eco-driving, including the minimization of idling, was found to be a very effective approach in Sweden. Time lost by driving more carefully was judged as being a small cost relative to savings from reduced emissions and better fuel economy.

Some measurement themes are not highlighted in Table 3-1 and it is worth explaining why. No indicators have been included that measure aspects such as impacts of the goods movement sector on GDP. The analysis and estimation of economic impacts are complex areas of inquiry and require advanced modelling techniques as there are direct, indirect, and induced economic impacts. It is a sounder strategy to have freight performance measurement rely on empirical data rather than modelling to the extent possible. Also, it is universally recognized that road transportation infrastructure is a critical enabler of economic activity; many stakeholders have noted that the level of truck movements in an area is a representation of the level of consumer economic activity happening within a geographic area. Monitoring performance on the measures that are captured in Table 3-1 will go a long way to ensuring that road infrastructure continues to effectively support the economy. Furthermore, if necessary the Truck Tonne-kilometre metric could be revised to include the estimated value of goods that are moving at the level of geographic specificity such data could be collected at allowing for economic statements about the value of goods moving across a region or corridor per unit of time.

Table 3-1 avoids ratio type measures such as travel time index or planning index. It is argued that these “unit-less” indices are somewhat abstract for wide dissemination and that a performance dashboard would be better off highlighting indicators that have units such as hours, percentages, or tonne-kilometres to which more people can relate. The conversion of absolute data quantities to ratios is almost always associated with some trade-off, distortion (e.g. inflated ratios when dividing by a small number) or loss of information and results often need to be interpreted with care.

Another principle in the selection of measures, as previously discussed, is that a change in an indicator ideally should be unambiguously good or bad. In the case of truck utilization, for example, there are often very good reasons why trucks are not running full; it may place an unfair burden on the trucking industry to insinuate that flat or declining truck utilizations over time suggest that participants are not doing their part. The same point applies for trucks running empty. This aspect, along with considerable challenges, associated with collecting appropriate data, argue against inclusion of a measure such as this. In Appendix 9-2, a more detailed discussion of truck utilization is offered which also discusses some important academic sources.

Courier stakeholders are particularly focused on parking their vehicles in dense urban contexts and in fact incur substantial extra costs as their vehicles park illegally to carry out pickups or deliveries. It was suggested that in the same way that large parking lot and garage operations can offer real time information on the number of parking spots that are available at a location that municipalities might investigate doing something similar for street parking – as discussed in Chapter 2. While highly urbanized contexts are important considerations for the overall freight system, measurement of aspects related to street parking are considered speculative at this stage and perhaps not relevant for an overall freight performance system. Nevertheless, measures of urban mobility already included are capable to do a good job in capturing traffic problems induced by the "cruising for parking" phenomenon which has been studied by Shoup (2011) in the High Cost of Free Parking.

3.3. Gaps

The list of suggested performance measures outlined in the previous section has an "aspirational" aspect in that all the required data to develop them may not, as of yet, be in place. The purpose of this section is to explore what data elements might be lacking. Table 3-2, highlights the range of road-oriented data that are relevant for Ontario from both sides of the border and highlights the jurisdiction or organization that maintains and collects the associated data.

For the road sector, the data that has become available is higher quality and more extensive than it ever has been. Much of this improvement is due to the rise of GPS sources which are able to provide rich information for road segments. As such, the extent to which gaps exist are shrinking considerably and fairly quickly. Government has recently mandated the use of electronic logs to replace paper logs in the trucking sector and this is also likely to lead to new tracking capabilities.

Of the measures suggested in Table 3-1, several have the required data at this point. There are good data available on the nature of commercial vehicle registrations to assess whether a vehicle is low or zero emission; the province maintains an extensive inventory of information on pavement condition; comprehensive data on police-reported vehicle collisions are available; and the Province monitors the performance of highways through traffic counts, travel time indices, and buffer indices, among other elements available through the iCorridor portal.

With regard to data for end-to-end travel times on strategic corridors, it is recognized that MTO is rapidly improving its capabilities with GPS-oriented data to make such a capability a reality. MTO also targets its Commercial Vehicle Survey at intermodal rail terminals and airport cargo terminals to make estimates possible for some of these strategic "door-to-door" movements. Alternatively, MITL has confirmed with private data collection firms that end-to-end travel times for trucks are available. To the extent that strategic corridors are identified on major arterials, opposed to provincial highways, reasonable data should be available, though perhaps in a lesser quantity and quality.

Table 3-2: Road-Oriented Data Sources Relevant for Ontario

Data Source	Jurisdiction/Organization
Vehicle Flows	
Traffic Volumes & Traffic Counts	Cities of Toronto; Montreal; Vancouver; Calgary; Edmonton; London; Hamilton Provinces of Ontario; British Columbia;
Commercial Vehicle Flows by Road Type	Province of Ontario;
Average Car and Truck Travel Speeds	Province of Ontario, INRIX Corporation
Traffic Bottlenecks	Canadian Automobile Association
Vehicle Use	
Commercial Vehicle Registrations	HIS; Province of Ontario
Canadian Vehicle Use Study – Heavy Trucks	Transport Canada
Safety	
National Collision Database	Transport Canada / Statistics Canada
Canadian Motor Vehicle Traffic Collision Statistics	Transport Canada/ Statistics Canada
CANUTEC Statistics (Hazardous Materials)	Transport Canada
CANSIM	Statistics Canada
Database of Motor Carrier Crash Costs	ATRI; Ontario Trucking Association (OTA)
Commercial Vehicle Safety and Enforcement	Province of British Columbia
Border Crossing	
Border Crossing/Entry Data	Statistics Canada; US DOT Bureau of Transportation Statistics (BoS)
Border Wait Times	Canada Border Services Agency
Trans Border Freight Data	US DOT BOS; TransCore Link Logistics
Infrastructure	
Road / Pavement / Bridge Condition Data	Cities of Toronto; Calgary; Provinces of Ontario; British Columbia;
Truck Routes	Cities of Vancouver; Calgary; Ottawa
Data on Truck Parking Challenges	ATRI/OTA
Environmental	
Air Pollutant Emissions Inventory	Environment and Climate Change Canada
Fleet Fuel Datasets	N.A. Council for Freight Efficiency
Freight Movements	
Canadian General Freight Index	Nulogx Inc;
Freight Load Volumes	TransCore Link Logistics; DAT Solutions;
AccuFreight Index (Rate Benchmarking)	Trans-Lucent Markets
Trucking Commodity Origin-Destination Survey	Statistics Canada
Intelligent Transportation Systems	
Traffic Reporting Information System	Province of Ontario
Traffic Management Systems	Several Canadian Metros
Road Observation Camera Network	City of Toronto; City of Montreal

To the extent that there are gaps that remain in the estimation of composite travel delay, it likely relates to arterials in certain municipalities where estimated truck volumes are missing or not shared. Ideally, it should be possible to build a good estimate of provincial aggregate travel delay from the ground up on a link-by-link basis (at least for the regions in the province where delay is seen as a problem), as is done in the EU at the national level (Chapter 2). The speed data to do this for trucks is available but the volume data appear to be more of a problem. There is uncertainty at this point as to whether electronic log data, which will soon be comprehensively collected, could be used as a basis to estimate truck volumes on significant links. In the absence of this possibility, there seems little choice but to rely on conventional means for truck volumes and the municipalities that may or may not collect these data.

With regard to emissions, there appear to be established methodologies in place to provide estimates for a wide range of sectors including the transportation sector (Environment Canada, 2010). One possible gap is the level of accuracy that is desired in the emissions estimates. In MITL's experience (see Ferguson et al., 2014), the most accurate way to estimate emissions is on a link-by-link basis; ideally in a manner that would take driving conditions, traffic volumes and traffic congestion into account. Within the driving cycle, emissions are greatest as vehicles accelerate from a standing start and of course, idling is associated with emissions simultaneous with no forward progress in movement (Wheeler & Figliozzi, 2011). Traffic congestion therefore increases emissions. Despite best efforts, there are numerous sources of error with a detailed approach as well. On this basis, more aggregate approaches which may take account of aspects like aggregate vehicle kilometres travelled and sales of fuel may be adequate for a provincial level dashboard. Estimates of emissions should ideally take account of all truck movements, including when a truck is empty.

Perhaps the greatest gaps relate to what would seem to be fairly basic statistics on truck movements. It would not be simple to generate a comprehensive estimate of truck tonne-kilometres over the various road contexts in Ontario. One reason for this is that the Federal Trucking Commodity Origin Destination (TCOD) Survey focuses only on for-hire trucking and excludes private fleets. It also excludes many owner-operators that would be below the survey's revenue threshold for inclusion. Results from the U.S. Commodity Flow Survey suggest that private fleets are quite comparable with for-hire trucks in terms of shipment value and tonnage, though less significant on a ton-mile basis because private fleets are more locally oriented. This is a significant gap in Canada and for Ontario.

One of the strengths of a shipper-based Commodity Flow Survey is that it seamlessly captures how the different modes function in the overall system. Private and for-hire movements are captured equally as well, truck movements that are part of intermodal shipments are identifiable and the totality of movement in the overall system is well-characterized. The MTO

Commercial Vehicle Survey, as an intercept survey, is hard-pressed to accurately capture this picture though it is useful for a whole host of aspects.

Even with a commodity-flow survey in place in Canada, there would be problems in showing temporal patterns on a dashboard since such a survey would not be frequently carried out, the more routine collection methodologies employed by Eurostat and EU member countries may provide an interesting model for future iterations or versions of the survey (Chapter 2).

Another gap relates to the estimation of the basic quantity of truck vehicle kilometres travelled and related segmentations. Ideally, such quantities would be estimated in Ontario using a bottom-up philosophy that might imitate aspects of the HPMS system in the United States. The key aspect leveraged in the HPMS for this is the detailed and continual collection of volume data. Considerable co-operation from municipalities would be required to execute something like this in Ontario. Failing that, it is possible that adequate data on VKT to support a dashboard could be derived from the Federal Canadian Vehicle Use Survey which replaced the defunct Canadian Vehicle Survey (last carried out for the year 2009), there is a possibility to leverage data from GPS sources, and if applicable, the electronic truck logs when they become law in 2019.

The Ontario Ministry of Transportation is an important source of road freight data and prominent in this regard is the commercial vehicle survey. Through consultations, some feedback suggests that the system could benefit from improved access to this important data source. The current process of making requests and receiving a deliverable at a later date is considered cumbersome in some quarters. It was noted that a more open approach could increase the potential for 3rd party solutions to add value to the data in the ways it could be leveraged.

3.4. Chapter Appendix

3.4.1. Detail on Suggested Road Measures

Table 3-3: Strategic Corridor Travel Times and Their Distribution

Rationale

- Travel times over certain geographies (corridors) is a concept that a wide-range of parties will find easy to relate to and histograms are not a complicated means of data display.
- The times for trucks to traverse strategic corridors should be well-understood and monitored.
- Durations by time-of-day of departure should be well-understood as well; an understanding of optimal and non-optimal times to travel would be welcome by freight stakeholders.
- The probability distribution for the range of travel times is very important to understand from the perspective of informing reliability; the distributions should be displayed.
- Enhanced knowledge and understanding for key corridors can be taken as a good representation of the overall picture and will work in concert with other measures.

Remarks

- For a given corridor and departure time, it will be important to assess the duration of the trip in both directions.
- Planning times, for example, to be 50% sure or 95% sure of arriving at a certain time for the traverse of a given corridor are easily captured with the distributions.
- Mean and median travel times by time-of-day are easily captured as simple attributes of probability distributions. Standard deviation can be shown; less effective for skewed distributions.
- The evolution of these corridor travel time distributions will be very useful to monitor over time.
- Suggested Corridors (there are other possibilities):
    - Highway 401 from its intersection with Highway 407 west of Toronto to its intersection with Highway 412 east of Toronto;
    - Highway 401 from U.S. border at Windsor to border with Province of Quebec;
    - Hamilton International Airport to Oshawa; and,
    - CP Vaughan to junction of Highway 401 and Highway 427 – note that this would be an "intermodal" measure.

Data Requirements

- Ideally, these will be based on sampled observed trips of each entire corridor, possibly with data from a private vendor; a less preferred approach might piece together detailed data from component links.
- It is important to base times on actual truck travel. As McCormack et al. (2010) note, trucks are liable to experience slower accelerations and frequent decelerations in having to adjust for faster moving vehicles on the road – resulting average speeds are slower than for other vehicles.

Table 3-4: Percentage of Commercial Vehicle Registrations that are Low/Zero Emission

Rationale
• Emissions measures fail to recognize how freight emissions could be fundamentally reduced. Aside from an overall decrease in movements or fleet reductions (both unquestionably unlikely), is by employing, encouraging, and possibly incentivising freight vehicles with zero or low tailpipe emissions (battery electric, plug-in hybrids, fuel cell, hybrids). • This measure speaks directly to leveraging the clean electrical generation profile in Ontario. • The fact that zero emission Class 8 size trucks are becoming available through the “Tesla-Semi” and the “Nikola One” programs indicates potential for these technologies in the most testing of circumstances. Feedback has been received that these new entrants to the marketplace are seen as quite disruptive to the existing order.
Remarks
• In order to reduce emissions, it will be helpful for this indicator to increase over time. • Possibility of increased ambiguity in the case of light commercial vehicles and small enterprises. • Anti-idling technologies (e.g. cab heaters and coolers) will also reduce emissions but less effectively than clean vehicles. • There is a possibility to segment this curve by vehicle size classes and/or the industry type the vehicles are registered to, to provide further detail.
Data Requirements
• Required registration data should be readily available from the provincial vehicle register.

Table 3-5: Composite Travel Delay

Rationale
• It is important to understand aggregate delay (for weekday peak periods and weekend days) to appreciate the magnitude of the freight congestion problem and to help guide investment decisions. • Two road links may experience the same slow speeds at a certain time but aggregate delay could be larger on one of the links due to different link capacities; a delay measure helps to differentiate.
Remarks
• Delay is arbitrary in nature as it depends on defining a benchmark travel speed; often the 85th percentile of free flow speed is used. • Aggregate travel delay accumulates quickly when traffic volumes are high, speeds are slow, and as the benchmark speed is high. • If the benchmark speed is too high, delay totals may be seriously overestimated in terms of having any realistic chance to eliminate such delay through policy interventions. • Could be segmented in interesting ways: interchanges, arterials, highways, core downtown, etc. • Delay results are typically presented in hours or are monetized for more dramatic effect. (Weisbrod et al., 2007)
Data Requirements
• Accurate calculation of delay across road links depends heavily on having accurate data on the associated freight traffic volumes.

Table 3-6: Injury Collisions and Fatalities Due to the Operation of the Road Freight Sector

Rationale

- A straightforward indicator of collisions and the human toll from road freight movements.

Remarks

- There may be a need to focus on collisions where the trucks are at fault since many collisions involving trucks were not caused by trucks or to segment based on this criterion
- There may be a need to segment by truck size.
- There is a case to report on major injuries since these can often be life-changing events.
- Standardizing by vehicle kilometers travelled to make a rate could be considered misleading when considered that 23 pedestrians were killed from 2001-2005 by reversing trucks (Transport Canada, 2010).
- This measure can be compared with trucking demand measures elsewhere in a dashboard or standardized quantities can be provided.
- Collisions can be segmented by posted speed limit (3/4 of fatal trucking collisions in Canada are with posted speed limits of 80 km/h or above).

Data Requirements

- Required data are available: nationally compiled in Transport Canada's National Collision Database (NCDB) from police-reported collisions. Collisions compiled are from police-reported motor vehicle collisions in Canada and the data are provided to Transport Canada by the individual provinces and territories.

Table 3-7: Trucking Demand (Tonne-km, Trips, Vehicle Kilometres Travelled)

Rationale

- Truck tonne-km and VKT are two fundamental measures of demand that should be accurately captured.
- Identifying these measures as a basic priority would provide impetus to improved forms of new data.

Remarks

- There is an opportunity to segment by vehicle size, road type, geography, and potentially by commodities and there is an opportunity to highlight demand for border crossings
- Tonne-km would be associated with actual transport of goods while VKT should be geared to capturing all movement including when truck is empty.
- The Trucking Commodity Origin Destination Survey is arguably closest to fulfilling requirements for these data but has gaps – particularly with private fleets.
- The Ontario Commercial Vehicle Survey is a valuable source for understanding spatial and temporal variations in demand.

Data Requirements

- If basing on the HPMS experience in the U.S., then detailed truck volume data at a very large number of locations would be ideal for the calculation of VKT.
- A shipper-based perspective is necessary for the greatest likelihood of an unbiased representation of generated tonne-km and would be best served by a commodity-flow survey.
- GPS and electronic log data may lead to alternative means to derive unbiased representations of these quantities.

Table 3-8: Delay Quantification by Type of Truck Bottleneck in the United States

Bottleneck Type			National Annual Truck Hours of Delay, 2004 (Estimated)
Constraint	**Roadway**	**Freight Route**	
Interchange	Freeway	Urban Freight Corridor	123,895,000
			Subtotal: 123,895,000
Steep Grade	Arterial	Intercity Freight Corridor	40,647,000
	Freeway	Intercity Freight Corridor	23,260,000
	Arterial	Urban Freight Corridor	1,509,000
	Arterial	Truck Access Route	303,000
			Subtotal: 65,718,000
Signalized Intersection	Arterial	Urban Freight Corridor	24,977,000
	Arterial	Intercity Freight Corridor	11,148,000
	Arterial	Truck Access Route	6,521,000
	Arterial	Intermodal Connector	468,000
			Subtotal: 43,113,000
Lane Drop	Freeway	Intercity Freight Corridor	5,221,000
	Arterial	Intercity Freight Corridor	3,694,000
	Arterial	Urban Freight Corridor	1,665,000
	Arterial	Truck Access Route	41,000
	Arterial	Intermodal Connector	3,000
			Subtotal: 10,622,000
			Total: 243,032,000

Source: (FHWA Office of Transportation Policy Studies, 2005)

3.4.2. Literature-Based Short List of Road Freight Performance Measures

Table 3-9: "Short List" of Road-Oriented Performance Measures

Theme	Measure	Description	Jurisdiction / Source
Delay	Border Crossing Delay	Time to cross border above a set threshold (by time of day)	AASHTO; FHWA
	Hours of Delay	On freight-significant travel links operating at speeds below set thresholds, for peak periods	California DOT; Michigan DOT, Minnesota DOT; Missouri DOT;
	Cost of Delay	Including lost productivity time, fuel, vehicle and maintenance	Michigan DOT; Missouri DOT; Virginia DOT; FHWA; AASHTO
Speed	Travel Speed	Mean speed and 85th percentile speed (km/hr.)	California DOT; NJ DOT; TAC
	Travel Speed across top Bottlenecks	Reported as the change of speed through bottlenecks	Transportation Research Board; Virginia DOT
	Level of Service	Assessment of the "normal" service level of a road link	Region of Peel; TAC
Mobility	Congestion Indicator	[actual travel time – base travel time] / distance travelled	Austroads (Australia & New Zealand)
	Recurring Highway Bottlenecks	Relevance of bottleneck to key access points of corridors	California DOT; Virginia DOT; MLIT (Japan)
	Percentage of Congested Highway VMT	Based on amount of travel on links where vehicle counts are above the set threshold level	California DOT; NJ DOT; MLIT (Japan)
	Freight Congestion Index	Utilized capacity over available capacity for truck movement	Virginia DOT; NJ DOT; TAC
	Travel Time Index	Uses FHWA TTI as indicator, can be reported at the link level	Arizona DOT; Oregon DOT; Virginia DOT; FHWA; AASHTO
Reliability	Travel Time Reliability/Variability	Percentage variability in travel times	MLIT (Japan); Queensland (Australia)
	Reliability of Freight Significant Routes	FHWA Buffer Index (reliability index based on 80th percentile)	California, Oregon, Minnesota & Missouri DOTs; Region of Peel
	Buffer Index	Planning time & 95th percentile; FHWA and TRB buffer indices	AASHTO; MLIT (Japan)
Infrastructure Condition	Pavement Condition	Condition of lanes on freight significant routes	Arizona, Oregon, California, Iowa, Michigan, Minnesota DOTs
	Bridge Condition	Condition of deck on freight significant bridges	Arizona, Oregon, Minnesota, California, Iowa, Michigan DOTs
	Investment Needed to Sustain Infrastructure	Dollars per year required to keep infrastructure in good condition	TRB; Queensland (Australia); TAC
	Truck Parking Availability	Freight parking spaces available in freight significant corridors	Virginia DOT; TRB; Arizona DOT; ATRI
	Roads returned to normal conditions after severe events	Average time to recover system. Conditions may be any emergency events	IOWA DOT; Missouri DOT; MLIT (Japan); New Zealand

Emissions / Environment	Mobile Source CO_2/ GHG/NO_X/NH_3/VOC/ SO_X emissions	Measured as estimated kilograms of CO_2 emissions produced by freight related vehicles per year	Oregon DOT; TRB; Transportation Association of Canada; MLIT (Japan)
	Ton-miles (km's) of hazardous materials	Volume of hazardous materials transported by truck	Melo & Costa (2011)
	Noise Emissions	Decibels of noise generated by traffic flow against noise level threshold	MLIT (Japan); New York City (USA); Transportation Association of Canada
	Use of load capacity / load factor	Percentage of trucks running at near or full load capacity vs. trucks running empty	BESTUFS (Europe); Melo & Costa (2011); New Zealand
Demand	Freight by Truck	Tons, value, ton miles, VMT	Minnesota & Missouri DOTs; Region of Peel
	Freight Type	Distribution of freight by task: bulk, non-bulk, light commercial	Australia
	Heavy Commercial VMT (VKT)	Total VKT of heavy-duty and large bulk movement vehicles	Minnesota DOT; NJ DOT
	Freight Volume Traffic on Roads	By day and time through major freight significant corridors	Missouri DOT; TRB; Virginia DOT; NJ DOT
	Triple Trailer VMT as a percentage of total freight VMT	Percentage of long-combination vehicles as a percentage of total freight movements	Oregon DOT
	Estimated truck tonnage transported into urban areas	Percentage of freight vehicles road-ton km's travelled, controlled for economic activity	BESTUFS (Europe); NJ DOT; Austroads (Australia/New Zealand)
Safety	Number of fatalities	Due to freight vehicle collision, on freight significant routes	Oregon, Missouri, Minnesota, and Iowa DOT; TRB
	Number of injuries	Due to freight vehicle collision, on freight significant routes	Missouri DOT; TRB; TAC
	Crash rates	Minor, severe non-fatal, and fatal crashes,	Arizona, Virginia, Iowa, Michigan, and California DOT
	Cost of incidents	As a function of traffic delay caused by incident	Michigan DOT; Transit New Zealand
	Commercial Vehicle Hazmat Incidents	Incidents per year; class & type of spill may be included	Melo & Costa (2011)
Technology	Estimated time savings from ITS investments	Temporal comparison of travel times before and after install of an ITS-related traffic measure	Arizona DOT; MLIT (Japan); Tokyo, Japan; New Zealand; Australia
	Usage of ITS on Significant Corridors	Percentage of system/corridor covered by ITS	Arizona DOT; MLIT (Japan); New Zealand; Australia
	Percent of trucks using advanced ITS	Percentage of vehicles using ITS at weigh-in/ inspection stations.	Missouri DOT
	Percentage of Electronic Tolling	Percentage of traffic on toll roads using electronic tags.	MLIT (Japan); Tokyo; New Zealand; Austroads

4.0 Rail

Rail

4.1. Background

The movement of goods by rail is of great importance for Ontario and the Canadian economy. The Class 1 railways connect Ontario with the rest of Canada and into the United States. Ontario is also home to a handful of the 53 Shortline railways that feed and deliver nearly twenty-percent of carload traffic to and from the Class 1 railway system in Canada (Roy & Ludlow, 2015). Rail operates over two primary lines of business which are referred to as 'carload' and 'intermodal.' Intermodal includes containers and trailers, while carloads include everything else. It is useful to consider the geographic scope of the Class 1 railways in terms of how they think about their operations. It is clear from consultations that they operate with a North American perspective as opposed to a local or provincial concept.

In the Canadian context, the Class 1 companies are federally regulated but are responsible for running and maintaining their own networks (Transport Canada, 2016). These are large, sophisticated private enterprises that track a multitude of indicators to ensure their operations run smoothly. They have expansive capital spending programs in place to make investments to ensure their system runs safely, fluidly, and efficiently. On average, the Class 1 railways invest twenty-percent of revenues into capital spending projects and maintenance, which can bring the value of these programs to in excess of $2.5 billion (Roy & Ludlow, 2015). Early in the research, it was considered that congestion issues may exist across the rail networks, especially given the problems in the Chicago interchange (Beyer, 2016; Grey, 2016; Hutchins, 2015). As learned from consultations, the railways generally have the means to upgrade, adjust, or otherwise solve track congestion. Any issues that the railways do identify are typically addressed: CP undertook a major reconfiguration of its yards to optimize efficiency; and, CN continually upgrades the Toronto-Montreal corridor (MM&D, 2011). Few issues exist on the railway right-of-way's; instead, it is at the yards where delays and fluidity "hiccups" occur, especially at intermodal transitions. Improvements in the road connections to these yards may increase the truck throughput, improving capacity and reliability. Overall, congestion and capacity management is a continual process which the private sector, out of necessity, largely addresses quite well.

Shortline railways are generally provincially regulated; in Ontario by the Shortline Railways Act, (Shortline Railways Act, 1995, S.O. 1995, c. 2, 2010). Shortlines are also responsible for running and maintaining their own networks and are required to follow both provincial law and the federal regulations set out by Transport Canada; in Ontario, the Federal and Provincial regulations are nearly identical (Transport Canada, 2017). These regulations, including new grade crossing and safety management systems, while imperative, represent major economic burdens for Shortlines as they operate with less traffic, lower margins, and higher operating ratios. With an average reinvestment of only 12% of revenues into capital spending, these small railways can struggle to maintain their infrastructure. There is a need for their tracks to be upgraded to the Class 1 286,000-pound standard, to expand lines, and to boost network performance to stay competitive (Roy & Ludlow, 2015). In the United States, there are several programs aimed at providing grants, low-interest loans, and reduced taxes to Shortline Railways to assist in their track improvements and line expansions (Office of the U.S. Secretary of Transportation, 2017).

From the perspective of overall freight performance, a very significant percentage of the tonnage moved by the Canadian railways is based on direct connections where cargo is picked up or dropped off at the ultimate origins and destinations. In these cases, the last kilometre problem is eliminated and this tonnage is kept off the roads. Bulk commodities are especially prominent in this regard; as well as some finished products, including autos and auto parts where the industries have spur lines leading onto their properties. The intermodal business, which moves containers over rail, represents roughly 20% of the railways' business and makes significant use of trucks to get goods to and from their ultimate origins and destinations. This generates extra localized road traffic (Transport Canada, 2016). Even so, intermodal movements remove much of the associated long-haul, total-trip kilometres off the roads and onto rails (Guoet al., 2014). As per claims in consultations with the Class 1 railways, each intermodal train can remove up to 280 long-haul trucks from the road, diminishing both road traffic congestion and emissions.

Even within metropolitan areas, which are problematic for road travel, the railways have a great deal of fluidity across their infrastructure. Yet, road traffic congestion near intermodal terminals can affect overall performance. In the GTHA, there is a focus on localized congestion between terminals and the 400-Series highways. It is noted that improving road fluidity would increase intermodal rail capacity and throughput as more trucks could be processed, cycling the yard and rolling stock faster. The upcoming Milton rail terminal is keeping up with the sprawl of distribution centres and is intended to reduce truck trips on the 400-Series highways. However, the result could be longer trips to delivery locations since fewer destinations will be nearby.

4.2. Suggested Rail Measures and Rationale

There is a long list of performance metrics that are important for the rail companies to collect and monitor for efficient operations but the issue here is to determine whether these are appropriate, or available, for provincial reporting to a range of stakeholders.

Much of this section focuses on what is important from the perspective of the railways and from that longer list a small subset of measures which may be relevant for an Ontario audience. Indeed, many of the measures found in Table 4-1 are indicators that the railways actively report on at present. Many of these rail measures are straight-forward and intuitive. Many of the aspects that would ideally be tracked for road vehicles (the speed and destination of each vehicle) are tracked by the private rail operators of their systems. As with any road based carrier, the goal of the railway is to maximize the profitability of the firm, which requires extensive monitoring and data collection for the railways.

The recommended list of freight performance measures relating to the rail mode is outlined in Table 4-1. For each measure, there is a brief statement which gives a sense of why the measure is considered important. For a few of the measures, a more detailed table which is specific to selected measures is included in the Chapter Appendix in Section 4.4. These additional tables offer further insight on rationale and data requirements for the specific measures. On a dashboard, there could be various segmentation options that offer potential for a theme-specific deeper understanding of performance improvement or deterioration over time.

At a broad level, the measures suggested in Table 4-1 offer a strong emphasis on representing rail movements, demand, efficiency, and safety. The theme of safety has been stressed heavily in the literature and in MITL consultations. As with the road sector, there is a strong emphasis on environmental indicators, since railways are noted for being a fuel-efficient method of transportation, there is a demand to understand the role of the rail-sector in impacting GHG emissions and air quality, especially around terminals and marshalling yards (The Standing Senate Committee on Energy, the Environment and Natural Resources, 2017). Demand and movement efficiency are perhaps the most pertinent measures for the railways and the Province after safety.

Table 4-1: Suggested Freight Performance Measures for Rail

Revenue Tonne-Kilometres (See Table 4-3)
Basic indicator representative of the demand on the railways to move goods. Presented with train and gross-tonne kilometers to account for non-revenue generating movements.
Carloads (See Table 4-4)
Carloads is representative of the demand to move goods; the greater the number of carloads, the more firms there are demanding the services of the railways and having their goods moved. Carloads includes four separate sub-measures: originating and terminating in Ontario; originating in Ontario; terminating in Ontario; neither originating nor terminating in Ontario. The additional benefit of tracking carloads is the ability to track the value of carloads and generate an indicator of the value of goods being moved.
Train Velocity
Represents the average speed of a train across a line-haul movement for the entirety of origin-destination trip. Important for estimating fluidity which may be of interest for some stakeholders. Higher train speeds also correlate to a higher usage efficiency of the network.
Terminal Dwell Time
Terminal Dwell is the average time a car resides at a specified terminal location expressed in hours. Longer dwell times negatively affect fluidity, yard/terminal capacity, and customer turnaround.
Fatal and Non-Fatal Rail Accidents (See Table 4-5)
The primary focus is on accidents causing death or injury to persons with the indicators segmented into the accident types and relative incidence values. By maintaining information on the number and severity of rail incidents and accidents, an understanding of the scale of the issue developed.
Dangerous Goods Accidents
Dangerous goods accidents are tracked by the event type and incidence rate.
Emissions: GHG, NOx, $PM_{2.5}$
The burning of diesel fuels releases emissions and pollutants which negatively affect health and are important to track. The contribution of the freight rail sector in Ontario to the emission of greenhouse gases and climate change is essential to openly track.

Of particular interest are the surrogate measures relating to demand and movement of rail freight. A reoccurring theme throughout the literature was to identify measures which would indicate the level of and extent of volumes moved by the railways and the efficiency at which they accomplished this. In the United Kingdom, such a practice is more amenable to a public-sector reporting scheme as the Network Rail system is owned and maintained by a state-owned company (Woodburn, 2007; Office of Rail and Road, 2015). In Canada, the rails are privately owned with few exceptions, and the government is limited in its ability to compel the companies to divulge corporate secrets. The Railway Association of Canada and the Class 1 railway's relationship with Transport Canada both serve to remedy this concern as data is provided to both, whom then aggregate the information for reporting purposes, as further discussed in section 4.3. Though, much of the data required for the suggested measures is currently available and tracked by either the railways or the Federal Government via Transport Canada or Environment Canada.

Revenue Tonne-Kilometres (RTK) is representative of the demand on the railways to move goods; the greater the value, the more firms there are demanding the services of the railways and having their goods moved. RTK is one of the four main measures that Class 1 railways report on a weekly basis to assess railway performance against themselves and in comparison, with competitors. This information is readily, and publicly, available.

Carloads represents the number of unique carloads that the railway has carried over a period. Three separate indicators are included in this measure: gross carloads; net tonnage carried (less the mass of the rail car); and average tonnage per carload carried (Transport Canada, 2016; Railway Association of Canada, 2017). Carloads originated refers to unique carloads and does not double count cars that have been marshalled onto a new locomotive at a terminal without being delivered. Intermodal trailers and containers carried can be viewed as a subset of carload data in the context of evaluating the types of commodities carried by carload rolling stock. Elsewise, Intermodal and carload units are different in their operational requirements.

Carloads itself breaks out into four segments: originating; terminating; originating and terminating; or, passing through a geography. All four are important to generate an understanding of how RTK's are actually being moved across the network and where the supply and demand of economic activity is flowing to and from. Carloads is one of the four main measures that Class 1 railways report on a weekly basis to assess railway performance against themselves and in comparison, with competitors. Much of this information is readily, and publicly, made available.

Train velocity is a highly intuitive indicator that simply represents the average speed a train hauling a load is moving at, including any stops made by the train between its origin and destination. From stakeholder consultations, it was made clear that train speeds are important because faster moving trains result in more goods being moved, with fewer trains, and better margins. Average train velocity is one of the four main measures that Class 1 railways report on a weekly basis to assess railway performance against themselves and in comparison, with competitors. Some railways will report train speed as between terminals instead of between the origin and destination; CN and CP use different definitions which presents integration and comparability issues as discussed in Chapter 2 with reference to Caplice and Sheffi (Canadian National Railway Co., 2017; Canadian Pacific, 2017). The Railway Association of Canada presents a metric for train speeds; the method used to account for the varying definitions is unknown.

Terminal Dwell Time is the average time rolling stock resides at a terminal. Measured in hours, railways are consistently trying to minimize dwell time as it increases overall capacity. High dwell times can result in delays for other rolling stock, which is bad for fluidity, productivity, and business. In a simplified scenario, the timer begins when a train arrives and stops when the loads are delivered (Canadian National Railway Co., 2017). Rolling stock passing through a terminal or yard are not included in the proposed metric, as this is captured by train velocity. Some railways will report terminal dwell time for any cars that are stopped at the terminal, including those passing through. The value of the opposing measurement approaches can be assessed in the context of a point-to-point railway focus, or from an origin-to-destination supply chain focus. CN and CP for instance have varying definitions causing issues of comparability (Canadian Pacific, 2017; Canadian National Railway Co., 2017). This information is available for the Class 1 railways.

Based on stakeholder consultations, safety measures are of the highest importance to the railway companies. Due to the potentially significant consequences of accidents, the Class 1 railways are exceptional at policing themselves to ensure their equipment and protocols are safe. Meaningful improvements in the detection of problems like hairline fractures in tracks, over-heating car wheels, and other issues allow for quick remediation, increasing railway safety. Accidents still occur and it is critical to track these events, especially those resulting in death, and use the accident data to inform new safety policies to further reduce the rate of accidents and rail fatalities (Transport Canada, 2016). Measure details are further discussed in Table 4-4. Accident injury and fatality information is reported / tracked by the Transportation Safety Board.

The safe movement of dangerous goods is important for everyone. This indicator tracks the number of accidents that involve railcars carrying dangerous goods. It is important to note that an accident involving a hazardous material does not necessitate that there was a release of that/those materials, but that a railcar carrying dangerous goods was involved (Railway Association of Canada, 2017; Transport Canada, 2016). Any events involving railcars carrying dangerous goods is of deep concern to all parties involved and such an indicator should be well understood and openly tracked. These events are tracked by the Transportation Safety Board.

Emissions represent one of the most systematically regulated segments of the transportation system. These measures focus on the level of environmental impact in terms of carbon dioxide, nitrogen oxides, volatile organic compounds, particulate matter and other pollutants. While it is noted that rail is a fuel-efficient method of moving goods, it is still important to monitor and reduce emissions (Transport Canada, 2016). Fewer emissions result in less spent fuel lowering operating costs and, of course, environmental benefits. Through the Locomotive Emissions Monitoring program with Transport Canada, the railways are reducing GHG emissions from locomotives (2016). Over the long term, there is an expectation that emissions will decrease as pilot projects are being undertaken to transition away from diesel-electric locomotives (The Standing Senate Committee on Energy, the Environment and Natural Resources, 2017). Emissions information is estimated by the railways, Transport Canada, and Environment Canada.

Of some interest are important measures or concerns that were not included in the suggested measures. Measures were excluded on the basis that they were not conducive, or appropriate, for a public-sector reporting and monitoring mechanism. The foremost excluded measures include: border crossing times and delays; rail capacities; encroachment; and adverse weather.

No measures for rail border crossings and delays are included, despite extensive international movements. Crossings are generally considered to work well for rail and from consultations with CN and CP, delays from border crossings were not considered to be a major issue. Similarly, no measures relating to rail bottlenecks were included as the railways address these internally. In addition to bottlenecks, no rail capacity measures were included. Though such measures are widely found throughout the literature, they have little relevance to provincial-level performance and capacity fluctuates in tune with train velocities, temperatures, and overall system demand.

No measures for the impacts of adverse weather were included, though they are noted from both the literature reviewed and stakeholder consultations. Rail operations are susceptible to weather events including: floods, as evidenced by the GO Train incident in Toronto of 2013 (Alamenciak, 2013); snow and ice, can slow or stop rail movements (Ludvigsen & Klæboe, 2013); extreme temperatures reduce train speeds; and extreme weather makes completing simple tasks arduous (Pulling, 2008). Such events are difficult to empirically and consistently track; weather effects are reflected in measures such as train speeds.

A major area of concern identified through stakeholder consultations is the effects of residential encroachment towards railway tracks, terminals, and yards. Despite the historic nature of some of the railway infrastructure, noise complaints have noticeably increased about railway and other transportation operations (CTA, 2016; CN, 2017; CP, 2017; Cairns, 2015; Oiamo, 2015). Another concern with encroachment towards railway tracks is the ability for future expansion of those corridors (City of Toronto, 2007; Transport Canada, 2017; Tulloch, 2015). These concerns are addressed in Chapter 7, the Multimodal system.

4.3. Gaps

The most pressing gaps as they relate to rail freight performance monitoring in Ontario:

- Geographic level of specificity available in data, due to business confidentiality concerns;
- Ability to monitor specific corridors that are wholly operated by a single railway; and,
- Valid integration of data collected using different, or opposing, reporting methodologies.

Class 1 rail is unique in the amount of information it is obligated to report and the amount of data that is makes available for analysis and measurement. Available data includes information on carloads carried and commodity type, dwell times, train speeds, train lengths, and extensive safety data (Transport Canada, 2016). More sensitive and commercially-confidential data is shared with Transport Canada who aggregates and removes potentially sensitive or identifying information. Non-federally regulated railways are not required to share the same degree of data. To an extent, there is an element of concern given the amount of data the railways are obligated to provide compared to other participants, especially road operators, in the supply chain.

While the railways do provide the provinces with data, there is a preference for the data request and scrubbing to go through Transport Canada due to their good working relationship. Processing data requests through Transport Canada provides the additional benefit of Transport Canada dealing with the issue of aggregating the data in a consistent and accurate manner making note of the varying definitions used by the Canadian railways to record and report data. Such variances can create flawed analyses, as with the variances between terminal dwell and train velocity. There is a lack of municipal and regional-level data readily available for analysis and measurement, likely due to issues of competition. Accessing data at a local scale may prove to be difficult or impossible for regions where only a single railway operates or where it would be easy to attribute the data to a certain firm. Of the data readily available (Table 4-2), nearly all of the information is aggregated to the national scale or an eastern/western Canada dichotomy.

In Canada, the necessary data to fulfil a national-level freight reporting dashboard for the railway system is available. Scaling that information to the provincial level currently represents the largest gap related to railway performance and the suggested list of measures.

Table 4-2: Rail Data Sources

Organization	Title / Description
Transport Canada	Transportation in Canada annual reports and statistical addendum
Railway Association of Canada:	Rail Trends: Provides a rolling ten-year review of statistical and financial results of Canadian railways.
Transportation Safety Board: Rail Occurrence Database System	Federally collected data. Publicly available information includes information on accidents and reportable incidents.
Statistics Canada	Railway Carriers, Operating Statistics.
Statistics Canada	Railway Car-loadings by Commodity Group
Statistics Canada	Monthly Railway Car-Loadings Survey
Statistics Canada	Federally Regulated Railway Accidents and Incidents,
Association of American Railroads	Freight Rail Traffic Data. Includes weekly freight traffic data for railways and includes the US operations of CP and CN.
Canadian National Railway	Rail Capacity Map, by weight class and car length
Canadian National Railway	Key Weekly Metrics. Including train speed, dwell times, and cars.
Canadian Pacific Railway	Weekly Key Metrics
Statistics Canada	Dangerous Goods Accident Information System: CANSIM Table 409-0003.

4.4. Chapter Appendix

4.4.1. Detail on Suggested Rail Measures

Table 4-3: Revenue Tonne-Kilometres

Rationale
• Revenue Tonne-Kilometers (RTK) is a simple measure of railway performance that is easily tracked and understood. It is an assessment of the freight tonnage carried over one kilometer that is generating railway revenue and excludes any non-revenue generating movements, referred to as Gross Tonne Kilometres. • RTK should be well understood as a key indicator of freight volumes in tandem with Carload and Intermodal Units. • RTK is one of the primary measures used by industry to report freight volumes of traffic and one of several surrogate indicators of rail freight demand. • Can be presented as a dual-axis line graph with historical values, with gross-tonne and train kilometers.
Remarks
• RTK is the industry standard for reporting freight performance in conjunction with gross tonne-kilometers and train kilometers. RTK and GTK are presented in billions and Train Km in millions. • RTK measures the relative weight and distance of freight transported. The greater the value, the greater mass of commodities moved. Important given rail's bulk commodity focus. • A lower value does not necessitate poor performance, a shift from bulk to intermodal movements would represent a lower weight, but generally a higher number of carloads carried. • For a given scale, it may be important to assess the direction of RTK. Understanding the flows of rail commodities may be useful for future freight planning and policy development. • Given extensive historic data availability, wide-ranging segmentation is possible to assess seasonal variabilities, jurisdictional profiles, and environmental or economic events. Steep changes in RTK can typically be easily connected to major economic events– e.g., the recession of 2008 is a noted trough for RTK over the past 15 years.
Data Requirements
• RTK is readily reported by the Canadian and American Class 1 railways on a weekly basis and is currently accessible for a national scale assessment. RTK would need to be calculated for Ontario, delineating tracks at the provincial borders to measure intra-provincial movements. • Data would need to be collected from the Class 1 railways, likely through Transport Canada, and from the Shortline railways to report at the Ontario scale. • Due to business confidentiality concerns, it is likely impossible to attain individual track-level reporting data, which will make certain scales impossible to report on.

Table 4-4: Carloads

Rationale
• Carloads in Canada is a simple indicator of performance that is easily tracked and understood. It is a count of carloads, car type, commodity carried, and tonnage per car. • Carloads, presented as the number of carloads carried and the weight of those carloads, provides an indicator of demand on the railways and the level of goods being moved. • Carloads carried should be well understood as a key indicator, used by industry, of rail freight volumes in conjunction with RTK, and as a surrogate indicator of rail freight demand. • Carloads terminating in Ontario similarly tracks the types of commodities or goods being brought into Ontarian terminals or yards and unloaded. Also need to consider carloads that are only passing through and carloads that are originating and terminating within Ontario. • The value of carloads, being moved between a pair of OD points, is tracked by the reported value of the commodities carried and provides an economic indicator of freight demanded.
Remarks
• Tonnes per carload is an important consideration as low weight commodities will decrease tonnes per carload, but this does not necessitate that fewer goods were transported, or less revenue generated as more cars may have been required to complete the move. • Includes Intermodal commodity movements; intermodal container movements will be of especial interest for stakeholders focusing on effects of multimodal movements. • Given extensive historic data, expansive segmentation is possible for analysis.
Data Requirements
• Data would need to be assessed to identify carloads originating in Ontario and other sub-boundaries such as the GTHA. • Data is reported by industry on the gross number of carloads carried, the total number of tonnes originated from those carloads, and the average number of tonnes per carload. • Statistics Canada reports carload movements monthly on a Western or Eastern Canada basis. • Accessing data for a specific corridor would be very difficult due to privacy concerns.

Table 4-5: Fatal and Non-Fatal Rail Accidents

Rationale
• This simple set of measures looks at the number of accidents freight trains are involved in by accident type and by accidents resulting in a fatality by type (rail crossing, trespassing, other). • There is no denial, by the railways or any stakeholder consulted, of the need to track and assess events causing accidents and injury to persons, equipment, and/or the environment.
Remarks
• Standardized as accidents per million train kilometers (miles) with a rolling five- or ten-year average, as opposed to revenue tonne-kilometers. • There may be a need to segment based on at-fault accidents as approximately one-third of fatal accidents occur at at-grade crossings, one-third due to trespassers, and one-third due to miscellaneous events including collisions and derailments of rolling stock. • Accidents should be segmented by main-line and non-main line track events. • Half of accidents are noted to be caused by human error and these aspects are more challenging to remove – locomotive black boxes are not currently required.
Data Requirements
• Transportation Safety Board Statistics in the U.S. and Canada are very detailed in terms of incidents/accidents that take place and where they take place and what caused them.

4.4.2. Literature-Based Short List of Rail Freight Performance Measures

Table 4-6: Short List of Rail Performance Measures

Theme	Measure	Description	Jurisdiction / Source
Safety	Rail Freight Accidents and Incidents, number of	Total number of accidents and incidents involving rail vehicles.	Virginia DOT; RAC (2014); TC; TSB
	Accidents per billion gross ton-miles	Accidents include: collisions; derailments; and other events	RAC (2014); TSB
	At-Grade Railway Crossing Accidents	Total number of at-grade incidents involving rail freight vehicles.	Iowa, Minnesota, Michigan, Virginia DOTs; TRB; TSB; MLIT; TC; Etc.
	Train derailments per million tonne-kilometres	Number of main and non-main track car derailments, standardized	Oregon DOT; Iowa DOT; TSB
Dangerous Goods Movement	Total Accidents involving Dangerous Goods, per million km, or per billion gross tonne-Kilometers	Considered if any railcar carrying dangerous goods derails, strikes or is struck by any other object. Included are crossing accidents in which the vehicle involved is carrying a dangerous good.	RAC (2014); MITL (2011)
	Accidents involving dangerous goods per 1 000 originated Hazmat carloads	Does not necessitate any hazmat release	RAC (2014)
	Hazmat Incidents, at terminal	Total number of loading & unloading incidents w/ Hazmat	Adapted from MITL (2011)
Demand, Efficiency & Mobility	Rail Freight Volumes: Carload traffic & Tonnage per carload	Total carloads, TEUs or tonnage, moved through or about a jurisdiction.	TRB; Region of Peel; New Jersey DOT
	Revenue Ton-Miles, Tonne-kilometers Carried, Yearly	Overall indicator of performance. Measured in billions. Excludes the movements of non-revenue generating movements	Transport New Zealand (2016); Washington DOT; TSB; RAC; Etc.
	Number, and percentage of total carloads, of double-stacked containers moved	Movement of double-stack containers within a jurisdiction.	US DOT (2015) BT; MLIT; Transport New Zealand; Etc.
	Number, and percentage of total carloads, of bulk-commodity movements	Movement of bulk-commodity cars within a jurisdiction.	US DOT (2015) BT; MLIT; Transport New Zealand; Etc.
	Intermodal Traffic Volume, by Domestic; International; and Total Containers	Count the number of domestic containers, trailers, and international containers,	DIOMIS c/o UIC (2009); US DOT (2015) BT; RAC

	Freight rail throughput (tonnes) on shared corridors	Rank shared rail corridors by freight and passenger volumes	TRB; New Jersey, Oregon, US DOTs; Transport New Zealand
	Length of Haul	Average Kilometers hauled by trans-continental; regional and local railways. Revenue ton-miles / revenue tons.	RAC (2014)
	Average Train Length and Loading Capacity.	Train length is the number of cars per train or foot length. Capacity is specifically for intermodal trains and counts the number of TEUs the average intermodal freight train moves.	RAC; Adapted from TC; DIOMIS c/o UIC (2009)
	Throughput capacity of rail corridors and level of service	Designed volume to capacity, and actual volume.	New Jersey DOT; Oregon DOT
	Percent of corridors congested	Percentage of rail corridors that operate over capacity, regularly	US DOT (2015) Beyond Traffic
	Rail bottlenecks/chokepoints	Number of, and specific areas, that experience reduced travel speeds, incidents, or phenomena that reduce reliability of service.	California DOT
	Average Train Speed. By train type and car. Typically reported weekly	Average velocity achieved for line-haul movement excluding terminal time.	DIOMIS c/o UIC (2009); Cottrell (2008); CN; CPR;
	Average Terminal Dwell Time in Hours; aggregated weekly	Average time a wagon spends at a specified terminal location	Iowa DOT; Oregon DOT; CPR; CN (2017)
Infrastructure Capacity	Number and percentage of bridges and/or tunnels allowing double stack cars	Restrictions on rail routes to allow for maximum freight movements on rail cars.	AASHTO (2009)
	Percentage of track capable of 286k lbs railcar operation	Restrictions on rail infrastructure to allow high-weight rail cars.	AASHTO (2009); Iowa DOT
	Number, and capacity, of intermodal facilities	Number, and capacity in TEU's, of intermodal within a jurisdiction.	Oregon DOT
	Percent of shippers within 80 kilometers of an intermodal trailer-on-freight-car facility	Counts of freight shippers within a set distance of an intermodal facility.	Oregon DOT
Environment	Fuel Consumed	Average litres of fuel consumed	RAC (2014); TC
	GHG Emissions	Mega tonnes of Carbon Dioxide Equivalent emitted	Adapted from TC; Oregon DOT
	NOx & PM 2.5 Emissions	Nitrous Oxides and Particulate Matter Emissions	Adapted from TC; Etc.

5.0 Marine

Marine

5.1. Background

One of the distinguishing features of the marine mode in Ontario is that the service it offers is generally seasonal. The winter closure of the St. Lawrence Seaway appears to disqualify marine as a viable choice in Ontario in the eyes of many shippers even if they might like the general concept of shipping by water. For them, the trucking and rail carriers offer more viable options that can be counted on all year round. An option that cannot offer service for 12 months is not given business for even one month. Moreover, the rail and trucking modes offer formidable competition in many freight contexts. As it stands, there is ample capacity at Ontario Ports and no significant recurring bottlenecks on the systems of locks that make up the Welland Canal and ultimately the Great Lakes - St. Lawrence Seaway.

Based on the winter closure and other issues, the marine mode in Ontario is focused almost entirely on bulk commodities and project cargo but in aggregate is responsible for moving a significant share of provincial goods movement tonne-km (Ferguson and Lavery, 2012, p. 37). By their nature, most cargo that is moved is substantially less time-sensitive than cargo moved by rail or especially by truck.

In terms of important marine infrastructure in Ontario, the Welland Canal is most prominent. It joins Lake Ontario to Lake Erie over 43 kilometres and navigates a change in elevation of 326.5 feet via a system of seven locks. On average, it will take a vessel about 11 hours to traverse the canal (Ferguson, 2010). According to data provided by the St. Lawrence Seaway Management Corporation there were 24,531 transits of the Welland Canal in the period 2003-2010 with about 79% of these being carried out by inland vessels and the remainder by ocean vessels. Other important pieces of marine infrastructure include the locks through Sault Ste. Marie and the five seaway locks along the St. Lawrence River, one of which resides in Ontario.

Another significant facility in the Ontario marine system is the Port of Hamilton. This is the largest Canadian Port on the Great Lakes; in 2015, the Port handled approximately 9 million tonnes of cargo (Transport Canada, 2016). The majority of this is in the form of raw material inputs for the steel industry but in recent years there has been a rapid increase in the flow of agricultural commodities. Two other significant Ports are in Windsor and Thunder Bay (Transport Canada, 2016). The former specializes in cement, fuel, grain, salt, aggregates, and general cargo while the latter emphasizes grain, coal, and potash. Ports in Toronto and Oshawa are much smaller in terms of tonnages. Superior access to the 400-Series highways is considered one of the significant advantages of the Port of Hamilton. The ports mentioned above are all Canadian Port Authorities, meaning they are Federal ports operating on a shared governance structure, as discussed in Chapter 1. There are about 25 other Ontario ports including private and municipally owned and administered ports.

For marine, road traffic congestion is seen as a double-edged sword. On the one hand if congestion delays became sufficiently severe, marine carriers could offer a timely and cost-effective alternative to land-based travel. To some extent this happens already with agricultural products. Farmers truck goods to the Port of Hamilton, for example, which is shipped along the St. Lawrence Seaway to Quebec, sparing the possibility of a long truck trip and a transit through the congested GTHA. On the other hand, traffic congestion hurts marine in that the truck legs of transloaded marine cargo can be slowed.

Performance measurement of the marine sector takes on two distinct meanings when trying to assess the system. Foremost is the measurement of vessel performance and secondly is the performance of the ports and associated terminals (Vitsounis, 2011; Holguín-Veras & Walton, 1998). The focus in this report is generally on the performance of port performance as an indicator of the marine sector's ability to transport freight. Bottlenecks and congestion issues do not typically arise at sea, or on the Great Lakes, they surface in general at chokepoints such as canals, lock systems, and ports (U.S. Committee on the Marine Transportation System, 2015). This reality is reflected in the available literature and data, which focus on major container terminals and efficient intra-port operations, especially at the terminal and yard levels (Feng et al., 2012; Konsta & Plomaritou, 2012; Sarwar, 2013). Container movements are more likely to land on the East or West coasts of Canada or the United States and make their way into Ontario by way of rail and truck (Transport Canada, 2016). The Ontario situation is quite different with a focus on bulk movements across in-land waterways with limited ocean access.

5.2. Suggested Marine Measures and Rationale

In terms of giving rise to the short list of measures that appear in the Chapter Appendix, a total of 127 unique performance indicators for the marine mode were identified, including 14 from the European Commission's *Port Performance Indicators: Selection and Measurement* Port Performance Dashboard ("PPRISM") and 16 from the Transportation Research Board, focused specifically on marine freight movements (2011b; ESPO, 2012). A suggested set of seven marine based measures, Table 5-1, was decided upon considering the criterion elements as discussed by Caplice and Sheffi (1994), a review of the literature, and across consultations.

The reality of marine and port performance measurement is that ports internally monitor their performance to varying degrees (U.S. Committee on the Marine Transportation System, 2015). The Ports of Montreal and Vancouver are exceptional at tracking and collecting data from their tenants and the truck-carriers that move through the port. Extensive licensing and GPS systems are implemented to achieve this level of operational specificity; in which, if a carrier or operator refuses to participate, they are not allowed to service the ports (Port of Vancouver, 2016).

While various pieces of reviewed literature made mention of the accessibility of ports and distances to various other ports (Bichou & Gray, 2004; Kress, et al., 2016), there was limited mention of average vessel travel times (Kress & DiJoseph, 2015). These are less of a concern in Great Lake shipping as the transit times are typically less important with bulk cargos. More important is port arrival and departure times which can be dynamically managed by the ports and terminals. There is mention made of on-time reliability of marine vessels, but it was noted across the literature that due to the extent of the trips, there is a higher likelihood for delays to be incurred, whether at port (queuing or loading/unloading), at sea, or at other chokepoints. As such, the on-time performance of marine vessels has a significantly larger window than road, rail, or air. For ports and carriers that do report on-time performance, a container vessel that arrives within 24-hours of its docking time is considered to be on-time (Port of Vancouver, 2016).

There is a long list of metrics that are important for the ports, vessel-operators, and stevedoring companies to track and monitor for efficient marine operations, some of which are listed in Table 5-3, in the chapter appendix. The issue here is to determine whether these metrics are appropriate for a provincial-level reporting dashboard. Most of the measures identified from the literature are highly specific indicators of a specifics port's ability to process vessels or specific to vessel operations. It is considered that many of these indicators would be too specific in nature and of little overall value to an Ontario-centric dashboard.

Table 5-1: Suggested Freight Performance Measures for Marine

Vessel Volumes
The number of vessels traversing Ontario waters is a simple indicator of the level of demand for marine freight and its relative important to the Ontario economy. The greater the vessel traffic bound for, or departing from, Ontario ports, the greater the demand for marine cargo.
Origin-Destination Tonnage, Commodity and Value Matrix
It is desirable to understand not only the movements of marine vessels but also the relative flows of the goods carried and their respective origins and destinations. Flows include the mass, value, and commodity type of cargo, by select port combinations; including domestic and international.
Strategic Origin-Destination Trip Travel Times and Distribution
While marine movements are the slowest of the modes reviewed, understanding total travel times and their distributions are important for assessing the fluidity of bulk marine cargo into and out of Ontario.
Annual Transits and Trip Time Distributions of Lock Systems
The travel times to navigate the Welland Canal, St. Lawrence River, and Sault Ste. Marie locks are significant given their important roles in Ontario. Times and distributions provide stakeholders a concise and relevant understanding of the time to navigate the passages as well as the variations.
Average Terminal Dwell Time
Terminal/Yard dwell time is the duration goods are waiting to be loaded onto a vessel or transloaded to rail or trucks. A lower dwell time reflects a higher-level of port-vessel activity and yard operations.
Marine Accidents and Fatalities
The primary focus is on accidents causing death or injury to persons with the indicators segmented into the accident types and relative incidence values. By maintaining information on the number and severity of marine related accidents, an understanding of the scale of the issue developed. A non-fatality specific indicator presents all recorded accidents related to marine operations and their type.
Emissions: GHG, NO_X, SO_X, $PM_{2.5}$
The burning of heavy marine fuels releases emissions and pollutants which negatively affect health and are important to track. Sulfur dioxide emissions are a major concern. The marine sector is noted as one of the largest generators, by share, of SO_X, NO_X, and $PM_{2.5}$ emissions from the burning of heavy fuels.

Many of these marine measures are reflective of and similar to the measures identified in the Rail chapter. The marine and rail modes share many similarities including that there is little to no congestion between terminals. Bottlenecks are encountered at ports for a variety of reasons including: vessel traffic, late-arrivals, slow cranes, low truck throughput, and otherwise inefficient port operations (U.S. Committee on the Marine Transportation System, 2015). Many of the aspects that would ideally be tracked of the marine freight network (tonnages, commodities, speeds, trip times, port throughput, crane throughput, etc.) are, to an extent, tracked by the numerous private operators of the expansive system and less so by public organizations.

Vessel Volumes is a basic measure that tracks the number of vessels calling on, or departing from, Ontario ports. This is tracked at the port level and is segmented by the vessel flag (domestic, trans-border, or international) and the number of ships entering and leaving Ontario ports. This represents a basic indicator of the demand for bulk, or other, goods to be moved by marine vessels. It also provides an indicator of which port facilities in the Province are preferred, and when coupled with the OD Matrix, provides insights into how commodities are flowing through the Province via marine movements. In terms of data availability, traffic volume data is typically made available by the individual ports, especially so for CPA's, and should otherwise be available through Transport Canada. Data from private ports is less likely to be made readily available.

An origin-destination tonnage, commodity, and value matrix is a good representation of the demands placed on the marine freight system by global and regional supply chains. Monitoring the types, extents, and values of goods flowing into Ontario ports provides an understanding of their importance to the local and regional economies they are attached. The matrix presents the ability to understand which ports vessels are coming from and where they are calling upon in Ontario, and vice-versa. This presents detailed commodity flow information which could be of value for a variety of stakeholders and end-users (Pisarski, 2016). Additionally, vessel counts and tonnages are an important aspect in evaluating port performance to assess the utilization of port facilities, including the ability to accept, process, and distribute goods. Data availability to fulfill the requirements of an OD matrix are currently lacking. While aggregate port data is available, and could be used to inform an early version, detailed trip information for vessels arriving at each port is not readily available and would need to be procured. Once bill of lading and other ship manifest documentation is sourced, a detailed matrix could be developed showing changes in flows over time. It is important to note that when aggregating port tonnages, data should be derived from the individual shipment bills of lading, as opposed to total tonnages handled by the port which can include intra-port movements, which effectively double-count cargo volumes.

Marine movements in the freight context are unique in that it is a particularly slow method to transport goods. Concerns regarding total travel time are not as intense as with the other modes. Travel times are still crucial to understanding overall freight fluidity and remain of interest in the marine context. A distribution showcasing travel times, and their variability, of vessels sailing between specific port combinations may be of value, especially as seasonal variations in climate affect the efficiency of movement. Coupled with the aforementioned matrix, the measures in combination provide an expansive understanding of the dynamics of marine freight movements in Ontario. Concerning data, real-time vessel tracking is available through automated identification systems and GPS tracking. GPS logs also make it is possible to calculate statistics for specific routes that vessels are traversing (U.S. Committee on the Marine

Transportation System, 2015). Procuring logs with the level of detail required for marine movements, (e.g., individual-vessel-level data) would likely be challenging as such information would either need to come directly from the firm operating the vessel(s), third party data firms, or potentially the ports.

The lock systems within Ontario represent some of the single most critical pieces of marine-navigation infrastructure in the region. Tracking both the number of vessels that transit the lock system as well as their travel times and the trip-time distribution for all vessels is considered important given the critical role of the lock systems. Any improvements to the lock system that decreased the average trip time would be viewed as a positive improvement in fluidity and an increase to the regional viability of short-sea shipping on the GLSLS and further abroad. This measure is effectively a subset of the OD Travel Time Distribution and would use similar GPS or AIS type data logs. Information could also be procured from the lock operators regarding the entry and exit times of all vessels, which could be aggregated and presented in a simple fashion.

Average terminal dwell time is an indication of both a port's ability to process goods efficiently and the effectiveness of modal connections to deliver and collect goods. In the context of marine freight, cargo dwell time refers to the amount of time that cargo waits, either on the vessel or in the port, to be transported to the next leg of its trip. It is not referring to the length of time that a vessel is waiting in port. A dwell time of less than 72 hours is considered reasonable, but is dependent upon the type of good and the demands of the client (Port of Vancouver, 2016). Data to fulfill this measure would need to come from terminal/yard or port operators.

Safety measures are of great importance to the various companies involved in the transportation of freight across the marine mode. The extent of intermodal connectivity with the marine industry can skew reporting as some marine related incidents can occur on port lands and be a road or rail accident and not be included in marine reporting. The safety measures specifically report on the number of fatalities and the number of accidents related to marine operation. Marine safety data focuses on accidents that are related to the operation of vessels greater than 15- tonnes. Data is readily reported by Transport Canada and the Transportation Safety Board.

Emissions represents one of the most systematically regulated segments of the transportation system. These measures focus on the level of environmental impact in terms of carbon dioxide, nitrogen oxides, sulfur oxides, volatile organic compounds, particulate matter and other greenhouse gas emissions. As earlier discussed NO_X, SO_X, and particulate matter 2.5 microns, are the most heavily tracked emissions from the marine sector. While GHG and other emissions are important, the burning of heavy fuels releases especially problematic toxins which are of immediate concern to human and environmental health. The marine sector is noted for being a major contributor of NO_X and the largest producer of SO_X within Canada (Transport Canada, 2016; The Standing Senate Committee on Energy, the Environment and Natural Resources, 2017). Environment Canada generates national inventories of air pollutants and various other reports which could be used to fulfill the data requirements of monitoring emissions.

5.3. Gaps

The most pressing gap, related to marine freight performance measurement is:

- Access to vessel-specific trip logs and cargo manifests to generate origin-destination matrices of commodity-tonnage flows;

The marine sector has in recent years benefited greatly from the implementation and expansion of advanced intelligent transportation technologies, such as AIS and real-time GPS mapping of vessels (Kress & DiJoseph, 2015; U.S. Committee on the Marine Transportation System, 2015). The decreased costs of satellite services and virtually omnipresent telecommunications has dramatically reduced the barriers to implement commercially and publicly available real-time tracking vessel tracking systems and the complex integration of world-wide port to port connections (Kress & DiJoseph, 2015). The ubiquitous nature of this technology allows for the efficient, accurate, and relatively precise estimation and calculation of vessel travel speeds, bearing, point-to-point travel times, and other key measurements with a high level of geographic specificity. Such technologies are used to track the movements of vessels moving through the Great Lakes - St. Lawrence Seaway, across Canada, and globally, as noted in Table 5-2.

Provided trip logs are available (e.g. purchased from a 3rd party), and incumbent upon the level of detail and 'ping' interval. More or less, data are available to stakeholders to develop average travel times, origin-destination matrices, travel time distribution, and emissions estimations amongst other important indicators. Despite such advances, data gaps remain at both the vessel and port levels, and on intermodal connectivity to port facilities.

Commodity data within Canada as a whole is highly limited. As opposed to the United States, a Journal of Commerce (IHS Markit) produced Piers dataset which reports on every submitted bill of lading each day providing extensive and expansive information about marine movements. Such information is not available for US-Canada marine traffic and a Canadian bill of lading report database is not readily available. Bill of lading information is collected by the CBSA, through the Advance Commercial Information System; it is unknown how readily the data is made accessible.

Table 5-2: Marine-Oriented Data Sources Relevant for Ontario

Organization	Description
Canadian Port Authorities	Various Statistics for cargo and vessels.
Statistics Canada	2011 Shipping in Canada; Coastwise Shipping Survey
American Association of Port Auth.	Ports and World Trade Statistics
Association of Canadian Port Auth.	Port Volumes, tonnages, and cargo variety.
Transportation Safety Board of Canada	Marine Safety Data – Statistical Summary. Monthly and Annualized. Occurrence Dataset and Vessel data set.
Transport Canada	Transportation and the Economy: Modal Shares in Canada-US Trade by Province
Transport Canada	Transportation in Canada: Report and Statistical Addendum
St. Lawrence Seaway Corp.	Traffic, Tonnage, and Commodity Reports
St. Lawrence Seaway Corp.	Seaway Map – Near Real-time AIS tracking.
International Joint Commission	Various Air and Water quality data for US/Canada waters.
Fraser Institute	Transportation Performance of the Canadian Provinces
Green Marine	Environmental Performance Report
IHS Markit – JOC PIERS	US import and export data at the bill-of-lading level

5.4. Chapter Appendix

5.4.1. Literature-Based Short List of Marine Freight Performance Measures

Table 5-3: Short List of Marine Measures

Theme	Measure / Indicator	Description	Jurisdiction / Source
Demand & Movement	Maritime Traffic	Aggregation of seaborne cargo handled at the port over a stated period; average growth of traffic	PPRISM; Other
	Cargo Volumes	Reported as millions of Tonnes, for bulk. Either container counts or TEU container counts	Transport NZ; TRB c/o MTS; TRB; Minnesota, Oregon, Virginia DOTs;
	Trade Composition	Reported as commodity type by tonnes for bulk, or TEUs for containers Includes container to total traffic ratio.	Transport NZ; PPRISM
	Inland Waterway Freight Movements	By tonnes, container counts, or TEUs	TRB
	Average Call Size	The ratio between the total capacity of the vessels that call at the port over a stated period and the number of those vessels. By Tonnes and/or TEU	IMT (TC); PPRISM;
Port Efficiency	Port Throughput	Common measure for ports. Reported as TEUs or Tonnes per Month or Year, or TEUs or Tonnes per metre of workable/ allotted quay /berth /wharf	IMT (TC); PPRISM; Thomas (2012); Transport NZ; Oregon DOT;
	Gross Port Productivity	Reported as Tonnes and/or TEUs per hectare of land	IMT (TC); Transport NZ;
	Terminal, Bulk, and Port Yard Productivity	Containers or tonnes per square metre or respectively allocated area, per year. Ex. Bulk tonnes moved per Bulk Terminal hectares	Thomas (2012); Virginia DOT; Transport NZ
	Gross crane productivity and Turnaround Time	TEUs per gantry or quay crane, Lifts per crane hour; TEUs Per Quay or Mobile Crane; Cargo Tonnes per Year; Seconds per TEU carried	IMT (TC); Transport NZ; Thomas (2012);
	Load Rate	Rate of loading/unloading cargo to and from vessels at a port over a stated period	PPRISM; Thomas (2012); Oregon DOT;
	Average Dwell Time, and Percentage of Dwell Time Below 72 Hours	In hours - Time cargo stays in a terminal yard waiting to be loaded. Main types: Operational, reflects performance of terminal infra-structure and management. Transactional, with clearance procedures. Storage related,	IMT (TC); Thomas (2012)

		carrier leaves the cargo at the terminal.	
	Customs Clearance	Average Time to Clear Customs Procedures	PPRISM
	Berth/ wharf/ Quay occupancy rate	Percentage of Total Berth Available for docking. Includes total length of quay.	IMT (TC)
Vessel Movement	Turnaround Time, Vessel	In Hours, typically separately for Containerized and Bulk Vessels	IMT (TC); Thomas (2012); PPRISM
	On-Time Performance	Sea-going vessels, inland shipping; rail service; truck transportation.	PPRISM; Thomas (2012); IMT (TC);
	Travel Time Estimates	Between Major and/or Common Destinations from OD pairs	TRB c/o MTS
Intermodal	Intermodal Connectivity	Level of Access to Rail and Truck Connectors	PPRISM; Virginia DOT
	Shippers within 80km of Port or Inland-Port	Measure of how accessible port facilities are to those who may use sea freight.	Oregon DOT;
	Truck Turnaround Times	Truck times through port/terminal facilities. In Minutes, of Terminal In and Out, or Gate In and Out	IMT (TC); Thomas (2012); Oregon DOT;
Infrastructure Capacity	Length of Quay	In meters, as a measure of capacity	Thomas (2012)
Infrastructure Condition	Navigation channel depths	depths at the port divided by depths at competitive ports	California DOT; Oregon DOT
	Physical condition of infrastructure	Percentage of Ports in Good, Moderate, and Poor Condition	TRB c/o MTS
Environmental	GHG Emissions	Mega tonnes of Carbon Dioxide released from the marine sector within a jurisdiction	Oregon DOT; PPRISM
	Ship NOX	Level of emissions of Nitrous Oxides and other emissions.	TRB
	Ship Particulate Matter	Level, and type, of diesel emissions from Marine vessels.	TRB
Safety	Commercial vessel accidents	Number of and as a percentage of total vessel movements.	TRB c/o MTS
	Commercial fatalities	Number of fatalities related to commercial marine freight operations	TRB c/o MTS

6.0 Air

Air

6.1. Background

Air freight plays a unique role in the global economy as the fastest yet most expensive method for moving goods. Air movements are no longer just for high-value and rushed cargoes, dramatically increasing the usage intensity of the mode. Air freight moves a miscellany of goods including: machinery, pharmaceuticals, fashion wares, mattresses, and foodstuffs. The type of goods that are moved by air are far ranging in their size, weight, and value. Mail and parcels, such as those generated through e-commerce and the major couriers, are also routinely moved by air, overnight, and then delivered to their final destinations via trucks. Additionally, in Ontario, and across Canada, there are many remote communities that can only be reached by airplane and rely heavily, if not entirely, on the goods delivered by air. While currently the fastest growing segment of air freight, E-commerce is not the primary driver of freighter traffic.

In Canada, all aspects of air movements, freight and passenger, are regulated by the Federal government, as discussed in Section 1.4.1. The National Airport System, a collection of the twenty-five busiest airports in Canada, are owned by Transport Canada but are operated at arms-length by purpose-built, non-profit airport authorities which oversee all aspects of airport operation. The Greater Toronto Airport Authority is the administrative operator of the Greater Toronto Area’s Lester B. Pearson International Airport, for example. Airports not a part of the National System may be owned Federally, Provincially, or Municipally as well. Hamilton’s John C. Munro International Airport, which is a major air freight hub for the GTHA, is owned by the City of Hamilton and operated by Tradeport International.

In Canada, and generally globally, the airport ownership/operators are not related to the airlines that fly in and out of the ports. As such, it is important to note that there is a dichotomy of performance measures which can be directly attributed to airport performance and a separate set for airline performance. Examples of measures related to the performance of airports include: runway capacity; throughput utilization; aircraft parking spaces; runway pavement condition; tenant occupancy; taxi times; number of gates; etc. (Humphreys & Francis, 2000; Sarkis & Talluri, 2004). Measures related to airline performance include: weight of cargo carried; on-time arrival performance; fuel costs; profitability; delay; loading/unloading time; etc. The difference in focus between the measures are clear and attributable to the roles the ports and the airlines encompass. In this report, a balance is struck between the monitoring of freight performance from the viewpoint of the airports and the airlines.

With respect to the overall supply chain, the aggregate focus of freight movements, from an airline and airport performance perspective, is on interconnectivity with the local road networks and the on-time arrival of aircraft. Despite the extensive operational oversight requirements of airports, in regard to the physical infrastructure they maintain, they are largely pre-occupied with the multimodal aspects of their tenants’ operations. The airports, as discussed in consultations, are more concerned about the ability of the airlines to move the goods from plane to truck, and then to efficiently get them to market.

Highway access and traffic congestion are major concerns for the operators of both Hamilton and Pearson International airports; more so than utilized runway throughput or more ‘traditional’ airport metrics. As such, the freight airlines operate overnight and land their planes in the early AM to facilitate transloading and delivery. A part of the rationale of landing early in the mornings, 3-5 AM, is to allow road carriers to avoid the commuter traffic during the peak rush periods across the major 400-Series highways. Aircrafts which arrive late have the potential to cause delivery vehicles to be caught in rush-hour traffic, triggering supply chain disruptions and late deliveries. The airlines are often able to account for planes moving behind schedule by flying them faster, but have little ability to remediate the consequences of planes that do arrive late.

The rise of e-commerce has led to an expectation among customers to get their parcels fast and as early in the day as possible. Stakeholders are saying that e-commerce is putting a lot of extra pressure on the freight system. This concern relates mostly to the last kilometre in terms of metropolitan congestion and intra-city delays but this is not a direct concern for air. There is no suggestion that the current offerings of the air carriers and future improvements cannot handle the increased demand. Canadian e-commerce is still thought to be in its early days as retailers, carriers, couriers, and shoppers adjust to the online marketplace. The implications for air freight and its associated intermodal connections is likely to be quite intensive.

6.2. Suggested Air Measures and Rationale

The air freight sector is currently considered to be well serviced by the existing infrastructure and there is little stated urgency from stakeholders to see air-specific measures in a provincial reporting dashboard. It is only on the ground, via trucks, where concerns of market access are a major consideration. Given the nature of air transport, trucks are required to move goods over the first and last kilometres of deliveries to customers and as such the measures discussed in Chapter 3 are relevant.

It is noted that airports, as providers of the primary infrastructure, do not seem to measure too many things in relation to the movement of air cargo. According to Hamilton International Airport, the primary goods movement metric of interest is the take-off weight of the planes. It is this information, provided by the carriers, that affects revenue collected by the Airport. The measurement of maximum take-off weight is of a little value in the freight measurement context as there is no way to derive the mass of the cargo, or the type of cargo carried. In contrast, the carriers of air freight are measuring all aspects of their supply chains to ensure optimization. The carriers may be concerned with issues such as the sorting operation, transfers between modes, and departure/arrival on-time performance.

In the context of understanding freight movement from a provincial policy perspective, it is important to understand the extent of air freight utilization and from where cargo / passenger-cargo mixed flights are flowing. In addition to types of cargoes being carried, the usage of specific airports, and the general flight time performance of movements. Measures of safety and emissions are also especially pertinent to air movements, in terms of both air and ground operations. While it is noted that the Provinces have limited influence over air movements, the sub-national levels of government are able to directly influence the critical connections to the airports which fundamentally influence the ease with which commerce can be conducted.

Table 6-1 presents seven suggested air freight performance measures which are useful for both the private and public sectors. The indicators lend end-users an overall understanding of air freight demand and movements in Ontario. While expanding on the efficiency of movements, and the environmental externalities of operating the system.

Table 6-1: Suggested Freight Performance Measures for Air

Freighter Flight Volumes
The number of cargo and mixed-cargo flights provides a foundational understanding of the usage of air freight in Ontario and its relative importance. The greater the number of flights, the greater the demand for air freight. Presented for each Ontario airport, by inbound or outbound and domestic or international flights.
Origin-Destination Tonnage, Commodity, and Value Matrix
Ultimately it is desirable to understand not only the flows of aircrafts but the relative flows of goods in- and outbound from Ontario. Flows include the mass of cargo transported, the value, and commodity type breakdown by select airport combinations. Economic indicators for the demand and supply of air freight compliments the understanding brought forth by Freighter Volumes and lends itself well to understand how the demand for freight flows through Ontario.
Strategic Origin-Destination Trip Travel Times and Distribution
Time is an important consideration for any freight task, but especially so for air freight stakeholders. Given the point-to-point nature of air movements, end-to-end travel times between select port combinations can be captured. These are an important consideration for assessing fluidity of supply chains, especially as derived between major airports and cargo flows for goods.
On-Time Arrival and Departure Performance
Time performance is a critical consideration for air freight. More crucially is the cause of the delay and how it is attributed to the airline, airport, weather, or other phenomena. Flights are considered to be on-time if they arrive or depart within 15 minutes of their scheduled time.
Airport Capacity Utilization
Airports can experience congestion issues when operating at, or above, their declared capacity. Understanding both the capacity of Ontario airports and their relative utilization on an annual basis, provides insights into fluidity and province-wide air capacities. Over and under-utilized airports provide important information for policy developers, especially in regard to roadway expansions.
Air Freight Accidents
The primary focus is on accidents causing death or injury to persons with the indicators segmented into the accident types and relative incidence values. By maintaining information on the number and severity of air-freight related accidents, an understanding of the scale of the issue developed. Safety is generally considered to be, by and far, the most important measurement theme of all.
Emissions: GHG, NO_X, SO_X, $PM_{2.5}$
The burning of jet fuels, releases emissions and pollutants which negatively affect health, and are important to track. The aviation sector is noted as one of the largest generators, by share, of SO_X, NO_X, and $PM_{2.5}$ emissions. Sulphur dioxide emissions are a major concern due to the use of aviation fuels.

The suggested measures outlined in Table 6-1 can be classified across four themes: demand; efficiency and capacity; safety; and, environmental. These classifications are in line with the general approach taken in the other chapters. This provides a simplified, yet foundational understanding covering the extent and importance of the air freight mode in Ontario.

Freighter flight volumes is a simple measure which tracks the number of flights moving through the Province. This is accomplished at the airport level and is segmented by inbound, outbound, domestic, and international flights. This measure is a basic indicator of the level of demand there is for goods to be moved by air, either into, out of, or within the Province. In terms of data availability, point-to-point travels of aircrafts could be compiled from flight plans submitted to NAV Canada. Determining the people or goods moved would require access to the flight manifest of bill of lading, representing a major challenge.

An origin-destination tonnage, commodity, and value matrix is a wide-focusing indicator of the demands placed on the air freight system. Acting as a detailed addendum of freight volumes, the matrix presents the flows of goods between select airport pairs. E.g., Vancouver to Hamilton, or Toronto to Montreal. This presents detailed supply-chain and commodity flow information to end-users, furthering the understanding of freight flows in the provincial context. Data availability is decidedly more difficult to collect for this measure. The mass of cargo and the cargo classification types would be included on flight manifest, bill of lading, and/or other pertinent pre/post flight documentation used by the air carrier. Similar to the other modes, confidentially of business data becomes a concern; not all airlines operate out of every airport, leading to concerns regarding anonymity of data being presented at the airport level.

Understanding the temporal aspects of goods movement is one of the key tenets of the transportation problem. Perhaps no other mode has the same time-space compression effects as the air mode. These effects are captured by tracking the travel time for air freight corridors between selected airports. Airports could be selected on the amount of tonnage or specific commodity type flowing in or out of Ontario airports. The aforementioned matrix could be used to identify the top ten or twenty combinations of importance to Ontario. A distribution showcasing variability of travel times between port combinations may be of value, especially as seasonal variations in climate affect the efficiency of movement. The data requirements for this measure are relatively simple to fulfill provided flight plan data, or equivalent, is procured. All flights record the take-off time from the departing port and the landing time at the destination port.

Closely related to travel times is the ability for flights to take-off and land on-time. Time performance takes into account a wide swath of interrelated and discontinuous events which may be beyond the control of the airport or airline. Issues relating to taxiing, in-flight events, and delays in landing due to runway congestion, can affect on-time performance. As planes will seldom be exactly on-time given the myriad of factors involved, flights that arrive within 15 minutes of their scheduled time are considered to be on-time. Given the often rushed nature of air cargo, on-time performance is important for both the fluidity of the supply chain, but also airport efficiency (Pisarski, 2016).

All airports have declared capacities and maximum throughput thresholds they can maintain before incurring congestion. Many aircraft delays are attributed to airports operating beyond capacity; forcing planes to queue for a landing time, or in extreme cases to reroute. While capacity can be addressed in terms of the number of gates, parking spots, or facilities, this measure captures the runway throughput capacity of Ontarian airports and the extent to which that capacity is utilized. Airport capacity is not static and runway condition updates are constantly updated by NAV Canada's *Operational Information System* highlighting runway closures or outages. Tracked over an annual basis, the measure can highlight airports which are consistently incurring over or under capacity issues and can be correlated with the on-time performance and O-D Matrix measures. Airport in-bound, out-bound flight traffic data would be required to fulfill the data requirements of the measure.

Safety measures are of immense importance to air freight. Both on-ground and in-air events can have fatal consequences if not handled appropriately. Extensive safety and operating guidelines exist for nearly all aspects of air flight in Canada and are monitored carefully by the Transportation Safety Board. Air safety data and measures focus on accidents and fatalities that are directly related to the operation of aircrafts, as opposed to events that occur on the ground due to non-aviation vehicles. Data requirements are fulfilled via the information fed into the airlines and airports safety management systems which send data to Transport Canada and the associated Transportation Safety Board.

Emissions represent one of the most systematically regulated segments of the transportation system. These measures focus on the level of environmental impact in terms of carbon dioxide, nitrogen oxides, sulphur oxides, volatile organic compounds, particulate matter, and other greenhouse gas and pollutant emissions. Similar to the marine sector, NO_X, SO_X, and particulate matter 2.5 microns, are the most heavily tracked emissions for the air sector. While GHG and other emissions are important, the burning of jet and aviation fuels releases especially problematic toxins which are of immediate concern to human and environmental health. Environment and Climate Change Canada generates national inventories of air pollutants and various other reports which could be used to fulfill the data requirements of monitoring the emissions levels of aircraft.

6.3. Gaps

The most pressing gap, related to air freight performance measurement, is:

- Access to flight plan and flight manifest data, in aggregate or component form, for flights beginning or ending in Ontario.

As discussed briefly in the description of each suggested measure, data availability is a concern. While the data is acknowledged to exist, procuring that data at a level which could be sufficiently detailed to inform the measurement framework, is not immediately possible at present. The foremost concerns as they related to air freight are being able to differentiate among freight, passenger, and mixed movements at an airport origin-destination level. Then additionally, to understand what, and how much of, goods the aircrafts are moving between those airports. Current data provides information about how much cargo is processed through an airport and whether it is international or domestic, but does not identify the flows between airports.

For air freight, only a small number of documents would be necessary for measurement reporting. For example, access to completed flight plans provides the departure and destination airports, the take-off, estimated travel, and landing times. Further, flight manifest, or bill of lading, documents would provide extensive information about commodity flows, which would fulfill the needs of the O-D matrix. While a level of this data is available from Statistics Canada, Table 6-2, the geographic specificity and level of aggregation is too coarse to be of great value to a provincially focused framework; though, it does represent a good starting point.

An issue, more than a gap, related to air performance, is that many of the suggested measures will be of limited specific value to the airlines, as for their operations, these are metrics which they already understand. Whether they evaluate the measures to the same degree is unknown, but having an aggregate understanding of air freight performance, as opposed to an airline-specific viewpoint, may be of interest to some. It is considered that the measures will be of value for the public-sector stakeholders and perhaps road freight operators.

Table 6-2: Air-Oriented Data Sources Relevant for Ontario

Organization	Description
Statistics Canada	Aircraft Movement Statistics
Statistics Canada	Itinerant movements, by type of operation, aircraft maximum take-off weight, at airports with NAV CANADA towers. Table 401-0009, Table 401-0019
Statistics Canada	Domestic and international itinerant movements, by type of operation, airports with NAV Canada towers. Table 401-0029
Statistics Canada	Air cargo traffic and flights, tonnes. By province and/or Ontario airports. Table 401-0045.
Transport Canada / Statistics Canada	Air accident rankings for top commodities, package types and initiating events. Annual (number). Table 409-0010.
Statistics Canada	Air Carrier Traffic at Canadian Airports (51-203-X)
NAV Canada	Operational Information System
Environment & C.C. Canada	Emission and Pollutant Tracking

6.4. Chapter Appendix

Table 6-3: Short List of Air Measures

Theme	Measure / Indicator	Description	Jurisdiction / Source
Demand	Air Freight Throughput	Volume in Tonnes or $'s by period	Region of Peel; ACI-NA (2014)
	Annual Volume of Freighter Flights	Number of freight aircraft through airports, and aggregate for region.	ACI-NA (2014)
Capacity	Number of Runways	At each major freight airport	ACI-NA (2014)
	Declared Throughput Capacity	An indicator that measures limit on the allowable throughput of a facility.	CANSO (2015)
	Throughput Capacity Utilization	Assesses how effectively capacity is managed. Measures demand as a function of available airport capacity.	CANSO (2015)
Efficiency & Delay	Delay Attributed to Capacity	Aircraft delay is often the product of demand exceeding capacity. Delays related to capacity constraints may be tracked through delay codes.	CANSO (2015)
	Percent of on-time arrivals and departures	Percentage of freight flights that arrive and depart within 15 minutes of planned time.	Oregon DOT; Gossling (1999)
	Average departure delay per flight	Average delay a freight aircraft experiences departing and taxiing.	Gossling (1999)
	Aircraft Loading and Unloading Time	Average time to unload a standardized aircraft cargo hold	ACI-NA (2014)
Flight Times	Flight time between ODs & variation	Assess planned travel times versus actual travel times for an OD pair.	CANSO (2015)
Intermodal	Efficiency of Airport Roadway Access	Truck Travel Time; Average delay experienced in traveling to and from the airport.	Gossling (1999); ACI-NA (2014); Oregon DOT;
	Truck Trip Buffer	Trips that end within 45 minutes of highway travel from airport	Gossling (1999);
	Truck Trips to Airports	Vehicle-Kms of travel per year by trucks making trips to freight airports	Gossling (1999)
Environmental	GHG emissions	In Mega Tonnes of CO2 Equivalent	Oregon DOT
	Aircraft VOC and PM emissions	Level of aircraft emissions from regional Origin or Destination	Gossling (1999)
Safety	Aviation Crashes	Number over observed period.	Virginia DOT;
	Incidents	Per 1,000 operates at freight-significant airports	Oregon DOT`
Infrastructure Condition	Condition of Runways	By Pavement Index, Good, Moderate, and Poor	Oregon, Iowa & Michigan DOT; ACI-NA (2015); Gossling (1999)

7.0 The Multimodal System

The Multimodal System

7.1. Background

The purpose of this chapter is to select a set of freight performance measures for Ontario that focus on aspects of the overall performance of the freight system and to offer perspectives that are not possible when freight transport is considered one mode at a time. Like the mode-specific chapters of this report, the list of suggested measures emerges as a process informed by both the literature and discussions with stakeholders.

McMullen and Monsere (2010) note that mode performance is inherently interdependent in that investments in one mode can affect the performance of other modes. A repeated example throughout the stakeholder interviews was increasing funding to public transit as a means of reducing the number of vehicles on the road. McMullen and Monsere also suggest, in general, that the bulk of performance measure activity has been focused on highways. Based on consultations, the interdependence suggested by McMullen and Monsere certainly is perceived but there is a strong sense that measures derived need to transcend freight movements per se and take into account, or at least acknowledge, aspects such as land use and people movement which are very definitely related to the performance of the freight system. As it turns out, most performance problems in the freight system in Ontario are seen as being focused on the GTHA where there is an intense locus of all forms of activity – freight-oriented and otherwise.

With regard to the other observation by McMullen and Monsere on the emphasis on highways, feedback suggests that a very strong focus on freight-oriented highway performance is justified in Ontario. As was noted in the introductory chapter, the Province directly provides and regulates much of the road infrastructure in Ontario, in conjunction with the municipalities. Roads are the first and last kilometre connectors of all freight and passenger vehicle movements and are a major enabler of economic activity. Roads represent a unique public-access good in which roadway vehicles, including essential services, share the road with relative equivalence. Highway freight is critical for interregional movements, but freight needs to be able to access the highways via municipal roads. There is a need for further attention to be paid to other urban roads such as arterials including those in core urban areas, and not just highway movements.

It was clear from several consultations that a lot is expected from government. And of course, some of those consulted were representatives of government and it became obvious that there are a great many complexities and hurdles to be overcome for government to meet those high expectations. Expectations seemed to apply particularly to the Ontario government, as opposed to municipal or federal governments. Broadly speaking, the Province is seen as being primarily responsible for transportation and land use in Ontario with "pockets" of federal responsibility as it relates to marine ports and airports. It was suggested that, as a senior level of government, there is a strong need for the Province to play a leadership role in coordinating with municipalities on freight and to provide the guidelines that would apply.

The methodology employed by the European Union provides a good frame of reference that the Province could work with to develop a municipal data collection framework. It was noted that municipalities were at differing stages of development with regard to their preparedness on freight and that it could only be with strong leadership at the provincial level that this variability could be reduced over time. "Silos" certainly emerged as an issue in co-ordination between the province and municipalities and, interestingly, the same factor was coming up on an intra-organizational basis.

There is a consensus among participants that there is a need to focus on the system as a whole as it relates to freight performance. To do so, it is necessary to consider interactions with non-freight movements and to consider aspects such as how governments of all levels interact with one another in support of excellent freight performance across all the modes.

Table 7-1: Suggested Freight Performance Measures for the Multi-Modal System

End-to-End Transit Times and their Distribution for Selected Supply Chains
This measure is a multi-modal version of a similar measure presented earlier for the road mode and also related to the end-to-end supply chain work (over much longer distances) led by Transport Canada on freight fluidity. As in the other cases, a focus on overall times and their distributions (including travel and dwell times) is very helpful. Also, as in the federal cases, appropriate and distinct supply chains would need to be chosen.
Modal and Temporal Split of Provincial Freight Tonne-km
This measure aims to track modal split of freight movements over time and also the temporal movement of goods in the context of the 24-hour day and across the 7-day week. Modal splits are a focus to address whether there are trends to more of a “mass transit” of goods which may reduce emissions per tonne-km moved. The diurnal split focuses on assessing whether “off-peak deliveries” are gaining traction.
Public Sector Human Resources Focused on Freight
It has emerged from consultations that the number of human resources dedicated to freight policy, planning and engagement is likely a good measure of the ability to reduce “silos” within and between large public organizations. The measure could be expressed in full-time equivalents though a worker should be omitted if freight accounts for a small % of allocated time. The metric could be reported and tracked provincially for all levels of government.
Logistics Costs as a Percentage of Ontario GDP
Such a measure, which transcends specific freight modes, has a history of appealing to private sector stakeholders (TRB, 2011b) and the OECD compares countries around the world on this metric. The measure does not imply anything about the inter-relationship between logistics costs and GDP, only the relative sizes of both. Lower is better.
Pressure from Land Uses Proximate to Freight Facilities and Corridors
In specifically designed “buffer” areas around key freight corridors and facilities, residential population and employees at their workplace can be tracked. Their counts can perhaps be distance-weighted so that those further from the critical freight infrastructure are weighted less. The beneficial impacts of public transit could be netted out. An increase in this indicator over time suggests that the freight system will be under greater and greater pressure from competing land uses and associated transport movements.
Origin-Destination Tonnages by Commodity
This would be an aggregation of tonnage flows between key pairings of origins and destination within and outside the province and is proposed in response to stakeholder requests for some geographic specificity in provincial goods movement flows. To respect any confidentiality concerns, the data need not be broken down by mode although the indicator is clearly more useful if there is some commodity detail.

7.2. Suggested Measures for the Multimodal System and Rationale

It makes sense to follow the example of Federal freight fluidity work that focused on Canada's linkage to international supply chains to derive supply chain characterizations that are most relevant for Ontario. The federal efforts have a more national and international perspective, that have tended to focus on particular important supply chains such as those of grain and potash which do not have unduly complex movements (Eisele et al., 2011). One might be tempted to choose the automotive sector for its importance to the Ontario economy. In some contexts, there is tight integration with the border with multiple back and forth movements for certain components and this would be difficult to characterize in a measure. There may be more appropriate automotive examples.

From the perspective of the Class 1 Railroads, it was suggested that measurement needs to be done at the supply chain level since there are multiple players in supply chains and sources of overall delay may depend on any one of them. They noted that it might not be the largest or most well-known company that is responsible for slowdowns. Each supply chain is unique so within a performance measurement dashboard, a small subset of important supply chains would need to be chosen.

With regard to geographic scope of supply chain movements relative to Ontario, tracking movements to their endpoint within North America or to their nearest major hub appears most reasonable. In the case where there is no North American endpoint (for example the Great Lakes- St. Lawrence Seaway handles international movements into the upper Great Lakes), such a movement could be tracked to its international origin/destination. In the scheme of things, such movements might not satisfy an "importance" criterion to be included on a dashboard.

It was suggested in the introductory chapter that measures would be sought which could easily be related to either improvement or deterioration in performance. In the multi-modal context, there are some challenges to this. Certainly, there is a lot of interest in diverting freight movements to other modes that are perceived as being cleaner and there is also an interest in diverting freight movements to non-traditional times of the day. There is mixed feedback with regard to each item questioning the viability of either shift in many contexts. If anything, more interest was observed in finding ways to shift freight from congested highways to Highway 407 than to different modes, though this was generally seen as cost prohibitive. Perhaps the most meaningful statement is that any of these shifts is dependent on the particular freight context. Recognizing that there is a lot of context-sensitivity, measures are suggested in Table 7-1 that monitor the current state of freight movements by mode and time of day.

The importance of context and the need for case-by-case thinking is best highlighted in an example provided by a notable representative of heavy industry in Ontario. This firm ships two distinct heavy cargoes between the two provinces. Rail has been considered for both cargoes but in each case a rail car would need to be configured differently. There are ways to handle both cargoes on a specially-configured rail car but this has not yet been fully implemented in Canada and requires a significant investment. At present, the prospect of shifting these goods to rail remains an untapped opportunity as the firm presently ships the cargoes by truck as they consider it too inefficient, at present, to deal with rail over two primary cargo types. Potentially, government incentives/involvement of some type could help to facilitate change. Compounding the problem of shipping by truck to Quebec is that winter load regulations on Quebec highways mean that trucks need to be much lighter in the winter for the Quebec-based portion of the movements. The unfortunate implication is that twice as many truck trips between Ontario and Quebec are often required to do the same job in winter.

The Public Sector Human Resources Focused on Freight is a measure that attempts to assess each local municipality's allocation of resources to freight policy, planning, and/or performance monitoring in terms of equivalents to full-time positions. While there may be challenges in compiling such data across jurisdictions, the measure seems compelling in its simplicity. Results can be reported for Ontario and for each level of government.

The land uses measure seeks to offer an assessment of how other urban activities are putting pressure on important freight sites and corridors. In Ferguson et al. (2016), significant employment clusters in the Toronto area were assessed through a GIS exercise that leveraged Canadian census data estimating jobs at the place of work. Results of this exercise are noted in Table 7-2.

Table 7-2: Significant Employment Clusters in Toronto Area

Employment Cluster Location/Vicinity	Estimated Job Count
Downtown Toronto	455,435
Toronto Pearson Airport Vicinity	372,405
South of Hwy 401; East of Don Valley Pkwy	182,540
Hwy 400	210,440
Hwy 404 / Hwy 407	128,250
Hwy 427 / Gardiner Expy /QEW	81,840

The largest job cluster is downtown Toronto and it is spatially very concentrated. Much more so than any other of the employment areas, the downtown node depends heavily on public transit, commuter rail and bus. There is a giant, sprawling employment cluster centred on Pearson airport that has almost as many jobs as the downtown but which is much more dependent on the automobile. This area is, of course, a major goods movement hub for

Ontario and accordingly, the types of jobs found here will differ from what is found in the downtown core. Similar observations apply for a large employment cluster centred on Hwy 400. These two large employment clusters go a long way to explaining high levels of traffic and congestion, for example, on Hwy 401 between Hwy 427 and Hwy 400. And of course, freight movements along these corridors are more challenged due the magnitude and sprawling nature of these job clusters. These results give some indication of the merits of measuring jobs and residential population on freight-sensitive sites.

7.3. Gaps

Improvement is required in giving participants in the system access to commodity-specific flows (not specific to modes) between relevant geographies in Canada and the United States. Ideally, this would be done to capture interactions between smaller geographies such as urban areas. Such information could assist in the identification of new business opportunities for the movement of goods and ultimately improve the freight system. At present there would be challenges in compiling such data: for example, rail data obtained through Transport Canada is not highly disaggregated in geographic terms and there are limitations in trucking-oriented data. A commodity-flow survey would assist in many aspects.

There is a need to increase the tracking of truck traffic through airport, rail, and marine port facilities. Data collection could be initiated, or enhanced, for: the number of trucks entering and exiting multi-modal facilities, the duration a specific vehicle is loading, the commodities being carried by those trucks, and the localized movements they make once exiting the facility. Such data collection may need to take place in association with the carriers, tenants, local municipalities, the Province, and the Federal government, but would provide valuable insight. Understanding how vehicles move once having left freight facilities can assist in planning truck routes and decreasing local congestion. Truck GPS data is improving access to this type of information, but lacks commodity flow information.

In this regard, it is interesting to consider the multi-modal connections of Ontario's ports. These ports are small relative to Canada's major ports and have invested less in data collection and business intelligence analysis. Little to no data are readily available from Ontario ports on the tracking of trucks through the port terminals and yards. The Ports of Montreal and Vancouver are both major innovators on these fronts requiring any trucks moving through the port lands to be equipped with Port-specific GPS beacons. Ontario's ports have little information about traffic patterns and flows; as noted by consultation, tenants may know more about traffic patterns than the port. Technology varying from gate counters and weigh-in-motion to GPS and Bluetooth tracking could be implemented at varying levels of cost to improve knowledge of the situation.

8

8.0 Conclusions

Conclusions

This analysis has been based on an extensive review of freight performance literature from multiple jurisdictions, from a review of material on how the multimodal freight system works in Ontario and from an extensive set of in-person interviews with representatives of all modes and from the public and private sectors. From these efforts, a set of suggested measures for Ontario has emerged (see Table 8-1) that will assist stakeholders in assessing how the freight system is performing and evolving. Permutations of potential subsets of performance measures are essentially infinite and subjectivity is thus an aspect of this exercise. For the subset indicated, the data required to support these measures, with some exceptions, is generally in place but many of the sources are likely to improve over time.

In terms of the selected measures, there is emphasis on the measurement of efficiency. There is emphasis on variability/reliability and on environmental implications of goods movement. Economic measures are restricted to reporting on the value of goods moved and in assessing logistics cost in Ontario as a percentage of Provincial GDP. The freight system is seen as an absolutely critical economic enabler. As such, measures dealing with the economic impact of goods movement/the freight sector are seen, for the purposes of performance measurement, as somewhat redundant and potentially misleading in analogy to measuring the importance of blood flow to human health. There is a lot of emphasis on understanding freight demand, preferably in terms of tonne-km but also in terms of total travel in kilometres and the respective origins and destinations.

The number of measures where it is difficult to tell the difference between improvement and deterioration is minimized. The measures are generally selected so as not to be too intrusive into the detailed workings of firms in the freight sector. So, for example, there is not a measure that deals specifically with truck utilization. Nevertheless, a lot of useful information can be applied under this philosophy. There is an effort to build in some geographic specificity by aggregating across the modes so as not to compromise confidentiality, as is an explicit concern for Class 1 rail and many road carriers. Finally, there are measures that seek to assess the pressure of other land uses on freight movements and which attempt to address how Ontario jurisdictions are marshalling human resources and working together in pursuit of the improvement of the freight system.

The remainder of this concluding chapter highlights some of the important insights that have emerged from this research.

The Need for Simplicity

A review of the literature and other jurisdictions revealed that the most advanced freight jurisdictions track a relatively small number of simple, understandable measures. This aligns with results from consultations indicating minimal expressed desire for reporting on freight performance to emphasize complexity and/or a large numbers of measures. Partly, this reflects that many stakeholders are very busy managing their day-to-day operations. The basic characteristics of parsimony and simplicity are very relevant in public-facing and intra-organizational contexts having to do with the freight system. Having too many measures or overly complex measures can lead to “paralysis by analysis.” Further technical analysis may require digging deeper into data than is represented in a performance framework and perhaps consideration of a more sophisticated set of measures.

A final list of freight performance measures may come across as almost anti-climactic; this is exactly how it should be. The issue is not to derive exotic new measures, since this review suggests no shortage of measures already in existence, but to apply a few simple ones relentlessly and to incorporate the results of that measurement into policy and organizational action. It was observed through this process that some of the successful private sector firms consulted seemed to have a small handful of very simple measures that were followed with laser focus. The focus in this report on the overall system is different, but not materially so. As well as outlining suggested measures, Table 8-1 offers a brief comment on how the measure is served by existing data sources and where further leadership or collaboration might be required to realize the full potential of a measure.

Table 8-1: Suggested List of Freight Measures for Ontario

MODE	COMMENT
Road	
Strategic Corridor Truck Travel Times and their Distributions	Well-Served by Emerging/Current Big Data
Commercial Vehicle Registrations % that are Low/Zero Emission	Provincially Maintained
Composite Travel Delay	Improved, Leveraging Multiple Sources
Border Crossing Travel Times and their Distribution	Transport Canada Maintains
Percentage of Road Pavement that is in Good Condition	Provincially Monitored
Truck tonne-km and Vehicle Kilometres Travelled	Gaps remain but reducing with new data sources
Rail	
Revenue Tonne-Kilometres	Reported Via Transport Canada/ Railways
Carloads	Reported Via Transport Canada/ Railways
Train Velocity	Reported Via Transport Canada/ Railways
Terminal Dwell Time	Reported Via Transport Canada/ Railways
Dangerous Goods Accidents	Well Covered by Transport Canada
Marine	
Vessel Volumes	Port Authorities / Port Operators
OD Tonnage, Commodity and Value Matrix	Provincial / Federal Leadership Required
Strategic OD Trip Travel Times and Distribution	Port and Vessel Operators
Annual Transits and Trip Time Distributions of Lock Systems	St. Lawrence Seaway Management Corp.
Average Terminal Dwell Time	Port Statistics
Air	
Freight Flight Volumes	Transport Canada And NAV Canada
OD Tonnage, Commodity, and Value Matrix	Provincial / Federal Leadership Required
Strategic OD Trip Travel Times and Distribution	Transport Canada And NAV Canada
On-Time Arrival and Departure Performance	NAV Canada And Airport Operators
The Multi-Modal System	
End-to-End Transit Times / Distribution (Select Supply Chains)	Learnings from Transport Canada
Modal and Temporal Split of Provincial Freight Tonne-km	Smaller Areas Associated with more Gaps
Logistics Costs as a Percentages of Ontario GDP	Commonly Reported (e.g. OECD)
Public Sector Human Resources Focused on Freight	Provincial / Federal Leadership Required
Pressure from Land Uses Proximate to Freight Facilities	Provincial Leadership / possible University Project
Origin-Destination Tonnages by Commodity	Provincial / Federal Leadership Required
Emissions: GHG, NO_X, SO_X, $PM_{2.5}$	Generally Well-Established Methods
Accidents including injuries and fatalities	Well-Maintained Data across Modes

It's About the System and Its Participants

There is no one party in Ontario that really dominates the freight system. It is a collective entity with a very large number of participants and stakeholders. As well, the general public participates through their own mobility choices and general lack of acknowledgement about the importance of freight movements. Through a freight performance measurement system and its representation in a tool such as a dashboard, there is an opportunity for the Province and its partners to assist all freight participants in better understanding the freight system and how it is evolving.

Moving Beyond Freight to Properly Measure Freight Performance

There has been a clear result that stakeholders do not wish freight performance to be addressed purely in freight terms. The efficient movement of goods is recognized to be interdependent with movements of people, particularly in large urban areas. Movements of people are related to aspects such as where they live and where they work. If traffic congestion related to people movement deteriorates in the future, it is generally agreed by those consulted that there will be significant consequences for the freight system. The set of recommended measures includes a small subset that seeks to acknowledge this interdependence.

Multi-Jurisdictional and Intra-Organizational Silos

Silos are a problem that affect progress between and within organizations and this has been suggested by collected feedback in the present study. Some feedback suggests that the actions of a few key people within organizations can have a significant impact on collaborations. It is known, for example, that municipalities in Ontario often do not share freight data (if it is collected) with the Province. A measure has been suggested that tabulates public sector human resources dedicated to freight. Overall, there is a need for objective indicators of how well multiple jurisdictions are engaged and working together on freight.

Disengagement/Perceived Lack of Information

A subset of stakeholders from the private sector may underestimate what has been done or the quality of research or information available. A smaller carrier, for example, confessed a sense of just getting by on a day-to-day basis and trusting their mode association to be an able representative of their interests. Again, in this case, there was a lack of awareness on available research work or available information to assist in his firm making maximally informed strategic decisions. Research may not be sufficiently accessible to the stakeholder – 1) in terms of actually being identified and located and 2) in terms of being assimilated if it is located.

Some statements made had a cynical quality or a sense of resignation about deteriorating freight performance (mostly having to do with the roads). Counteracting this theme, there was general interest in a well-conceived focal web page/dashboard featuring useful information on freight performance.

Made-in-Ontario Measures Needed

While it is advisable to pay heed to what other jurisdictions have done, and some chosen measures mirror what has been seen elsewhere, Ontario's circumstances are unique and measures need to be chosen that make the most sense for a wide range of Ontarian participants. Some of the measures chosen highlight performance for specific examples of infrastructure or for specific road corridors that are of enormous importance to the province. These are inherently Ontario-specific. It is fair to say that a system of measures for Ontario will look different than a set derived for a different province or at the federal level. An appropriate level of detail is required to validly represent the freight phenomena of interest.

Safety is the Highest Priority but Efficiency Concerns are always Mentioned First

A common response among stakeholders is that safety is the highest organizational priority. Excellence on safety is a good business practice and the negative implications of sub-standard safety are potentially fatal for a business. The environment ranks highly as well, though there can be conflicts with financial imperatives, but more direct concern is expressed about safety.

However, in terms of reporting on freight performance as it relates to the general system, measures of efficiency and aspects such as on-time performance are of more interest. Efficiency concerns naturally appear to come first in consultations. On a dashboard, such measures could occupy prominent locations and measures of safety can be less prominent. Prominence in this case is not a statement on relative importance.

By Mode, Concerns are Weighted to Road and by Geography, to the GTHA

Ultimately, the major freight performance theme on the minds of stakeholders is the performance of roads within major Ontario metropolitan regions. All of the modes are linked to roads in some manner to address first and last kilometre movements and all are thus affected by traffic congestion. Discussions about roads comprehensively permeated consultations with virtually all stakeholders. In terms of geography, concern about freight performance in Ontario is very much focused on metropolitan concerns, especially in and around the Greater Toronto Hamilton Region, which is one of North America's largest metropolitan regions. A possible exception is the border crossings which did receive some attention although even these are generally located in (smaller) metropolitan contexts.

Show Efficiency and Reliability Jointly

There is considerable discourse on speed/efficiency versus reliability as though they are polar concepts. But both be seen as attributes of an overall travel time distribution where efficiency is essentially represented by central tendency in the distribution while reliability is an attribute of the right tail of the typically positively skewed distribution. The depiction of actual probability distributions on a dashboard can highlight how both elements co-exist.

Data Conclusions

The backdrop for freight data appears to be improving rapidly and it is a time where data gaps related to freight planning are getting smaller. The trend toward “Big Data” certainly applies in the freight sector and it is becoming possible to know about individual freight movements - sometimes in real time. With regard to freight data, it is a period of transition in Canada and it is being assessed how data collected in the private sector can be aggregated to inform public policy and create tools, such as freight dashboards, with which many can interact.

The American Trucking Research Institute in the United States appears to be an interesting model. Via private sector partners, it has access to relevant and important data on a massive number of North American commercial trucks which it aggregates for the benefit of many stakeholders. The data it produces, for example, have been useful in measuring end-to-end supply chain performance.

For the purposes of a dashboard, some data are likely to “turn over” faster than others. Measures that are dependent on infrequently administered surveys will not change often on the dashboard and perhaps should occupy less prominent positions. On the other hand, speed data, which can be reported on in its own right or used as an ingredient for the calculation of delay can be updated much more frequently. These types of considerations are likely to affect the design and organization of a dashboard tool.

Despite the fact that it would be data collected only every few years, the development of a national shipper-based Commodity-Flow Survey would appear to beneficial on a number of fronts. Most significantly, it would correct a tendency in Canada for the collection of survey data a mode at a time. It will give a better sense of the shipper perspective which is closer to where decisions about freight movements are made.

Appendices

9.1. Freight Planning and Performance Measurement across Many Jurisdictions

Table 9-1: Progress on Freight Planning and Performance Measurement at (State/Provincial)

Jurisdiction	Progress/State	Identifiable FPMS?
Ontario	A Plan for Urban Goods Movement Data in the GTHA ○ Recommends six classes of performance measurement indicators for urban goods movement in the GTHA: Economy/Productivity; Commodity / Service Flow; Commercial Vehicle Movement; Road Network Performance; Intermodal Performance; and, Environmental and Social Impact. • MTO Transit Supportive Guidelines provide information for the selection of measures, but they are looking at passenger transportation and not freight. The freight supportive guidelines are meant more for municipal information than high level planning. • Metrolinx: GTHA Urban Freight Study: core of the study was the development of actions to increase the capacity for and efficiency of freight movement within the GTHA. • Greater Golden Horseshoe Transportation Plan, available in 2018 • Multimodal transportation plan	No
British Columbia	• B.C. On the Move (10 Year Transportation Plan) ○ Identifies need for a Provincial Trucking Strategy, including: bridge infrastructure upgrades; heavy-load (85-125 tonne) pre-approvals; streamlining permitting; and, review need for truck parking, staging, inspection pullouts, and chain-up/off areas. ○ Identifies need for investment in local and regional airports, introduced B.C. Air Access Program. Looking to expand international air cargo series, and expanding industrial bases surrounding airports.	No

	○ Identifies need for investments into ports and rail: develop safe port operations and handling of hazardous materials; expansion of port bulk, breakbulk, and container capacity; enhance rail efficiency and safety through infrastructure investments ○ Pacific Gateway Transportation Strategy: Creation of a Regional Traffic Management Centre; various port, airport, & rail terminal capacity expansions through BC Job Plan	
Alberta	• Business Plan 2016 – 2019 ○ Developing a multi-modal transportation network is a main tenet; Developing a transportation asset management system. ○ Provides series of performance measures and for the system, e.g: Exports by mode of transportation; physical condition of provincial highways; fatalities and injuries per 100k population.	No
Saskatchewan	• Ministry of Highways & Infrastructure, Plan for 2016-2017 ○ Goals include: improved road conditions; reduced congestion on high-traffic corridors; improved safety. Series of performance measures including: travel time around major urban congestion areas; utilization by industry of high clearance corridors; bridges inspected / upgraded; • Saskatchewan Plan for Growth, Vision 2020 and Beyond ○ Large investments in transportation infrastructure; Focus on roads and bridges • Performance Measures in 2011-2012 Ministry Plan: Km Counts on highway system carrying "primary weights;" percentage of highway system in good condition.	No
Manitoba	• Annual Report of the Department of Infrastructure and Transportation ○ Mentioning of Manitoba Infrastructure and Transportation Performance Measures ○ Pavement Condition (IRI, SDI, SAI); BCI for Bridges; number of KM of highways renewed, inspection frequency of dikes, dams, etc; • website shows freight traffic (tonnes) over the last 30 years • Manitoba International Gateway Strategy – corridor initiatives • 2006 TAC Survey: Monitor noise emissions; level of service; average speed; volume	No
Yukon	• 2006 TAC Survey ○ Fatalities and injuries per MVK; Pavement and Bridge condition; Traffic Volume ○ Due to low population and low volumes collision rates and other measures lose much of their meaning as small fluctuations can create large yearly variances	No
Northwest Territories	• Inside the Hard Drive: Status, Challenges, and Current Initiatives of the Department of Transportation: Use business planning with output-based measures: annual VKT on network; percentage of network rated excellent, fair, and poor; Percentage of all-weather network by surface; Number of bridges and culverts with good to excellent rating. Reliability of winter roads with data and modelling to determine ice variability, ice creation techniques, and cost-benefit analysis of replacing ice roads with permanent bridges; Accident Rates per MVK.	No
Nunavut	• Road transportation performance measurement plays minor role, some measures related to airports. Few major roads exist, measures would be focused on material suitability more than efficiency of movements.	No
Quebec	• 2006 TAC Survey ○ Accident Rates per MVK; Injuries and Fatalities per MVK; Percent of Incidents involving Trucks per MVK; Rail Crossing incidents; Bridge Conditions;	No
New Brunswick	• Provincial Multimodal Transportation Strategy - Does not define FPMs or a freight plan • 2006 TAC Survey: Level of Service (spot analysis); Bridge Conditions; Pavement Conditions (IRI, RCI, PCI, SDI); Collision Rates	No
Nova Scotia	• Transportation and Infrastructure Renewal Business Plan 2016-2017 Identifies need to expand highway network, exploring use of tolls to provide safer infrastructure; Fatalities and serious injuries	No
Newfoundland & Labrador	• 2011 – 2014 Strategic Plan ○ Identifies needs for improved transportation infrastructure: number of bridges rehabilitated; KMs of roads resurfaced; marine-focused, not focused on freight	No

BCI = Bridge Condition Index; IRI = International Roughness Index; RCI = Ride Comfort Index; RQI = Ride Quality Index; SDI = Surface Distress Index; SAI = Structural Adequacy Index; PCI = Pavement Condition Index; MVK = Million Vehicle Kilometers

Table 9-2: Progress on Freight Planning and Performance Measurement (Municipal)

Jurisdiction	Progress/State	Identifiable FPMS?
Vancouver	• Transportation 2040 ○ Promote modal shift of long-distance goods from truck to rail; implement congestion management strategies (signal timing, turn movement, and monitoring); maintain efficient network of truck routes; support local production and delivery; support low-impact movement and delivery of goods. Will consider efficient loading and unloading practices when reviewing plans/proposals. • Mentions monitoring performance helps to understand whether they are moving towards goals in the right direction. States that already started more rigorous monitoring of infrastructure performance, no specific mention of freight and truck impacts	No
Hamilton	• Section within a chapter of 2015 Transportation Master Plan Highlights existing opportunities and challenges for goods movement by truck, air, rail and ship. Highlights need for proper infrastructure provision, regulation, and management regarding goods movement systems	No
Greater Toronto Hamilton Area	• A Plan for Urban Goods Movement in the GTHA by Metrolinx, UoT ○ Identifies dimensions of urban goods movement – unit of analysis, geographic orientation, mode of transportation, type of organization generating commercial travel, timing. Identifies 6 performance indicators for urban goods movement, data available to measure them, and additional data needed • GTHA Urban Freight Study by Metrolinx ○ Defines urban freight and the 10 objectives for urban freight in GTHA, freight transportation challenges and strategic directions/actions ○ Acknowledges testing of different infrastructure and operational measures is required to improve efficiency, but no discussion on what the measures are	No
Peel Region	• Goods movement economic impact analysis report ○ Chapter on performance indicators and definitions of them ○ Highlights that when performance measures are established, Region can regularly monitor the measures against a dashboard to determine whether objectives are being met	Yes / under development
Edmonton	• Edmonton Goods Movement Strategy report from 2014 ○ "It would also develop the performance measures and evaluation criteria for implementing the Goods Movement Strategy, providing a tangible means to evaluate our progress towards achieving the Strategic Objectives" ○ Recognition that things need to be measured, but no indication of any measuring occurring	Recognizes Need for FPM
Halifax	• Initial stages of creating an Integrated Mobility Plan ○ Focus will be on intra-regional mobility, regional infrastructure that facilitates inter-regional goods movement • Regional Goods Movement Opportunity Scoping Study (2016) ○ Provides an assessment of the current state and potential future states of goods movement in the regional with a multi/inter modal focus.	No
City of Portland, Oregon	• Technical report from second phase in 2004 had freight performance measures and indices report proposing measures and indices to evaluate how the City's transportation system is performing for freight's movement	Yes
New York City, USA	• Freight Mobility Report for New York in place • Lack of data – investing in new ways to collect it: Weigh-in-motion ○ Utilize off-hour delivery programs; curbside management; remote sensing	
Tokyo, Japan	• Metropolitan Expressway Public Corporation (MEX), the road service provider in the area uses performance measures, including: average speed; duration of congestion; number of crashes; average crash recovery time; and electronic toll collection. • MEX does not differentiate between freight and general traffic.	

Sources: (WSP Canada Inc, 2015); (City of Vancouver, 2012); (City of Portland, 2006); (City of Edmonton, 2014); (New York City DOT, 2015); (MLIT, 2004); (Ontario MTO, 2016); (Ontario Ministry of Infrastructure, 2006)

Table 9-3: Progress on Freight Planning and Performance Measurement at (International)

Jurisdiction	Progress/State
Australia	• Austroads provides a series of road performance measurement indicators for both Australia and New Zealand. Focuses on: Road Safety; Asset Management; Travel Speed; Lane Occupancy; Congestion. • PM data is fed from the bottom-up into the national level measures, each major jurisdiction has its own performance management system. Provides a best-practices guide on how data should be collected and interpreted.
Queensland, Australia	• Queensland Department of Transport and Main Roads ○ Extensive use of performance management in all levels of decision making and evaluation. • Working on developing an integrated, multi-modal strategy for freight goods ('task')
New Zealand	• Operates an extensive Freight Information Gathering System & Container Handling Statistics program that builds off the Statistics New Zealand data. ○ Collects and provides information on freight movements for rail, sea, and road; Road transport is not the primary mode; heavy focus on sea and rail freight movements. Does not have a freight performance management system explicitly, but: • Extensive use of performance measurement that deals with many freight related issues: safety, congestion management, infrastructure management. • Extensive and leading use of Intelligent Transportation Systems (ITS)
Japan	• It was noted in the research that a Japanese performance measurement program created in 2003 was discontinued/ unviable due tax and funding changes by 2010; (Price, Miller, Fulginiti, & Terabe, 2011) ○ Under this scheme, 17 national indicators were identified and prefectures (states) could add their own measures. All measures had established targets. • Utilizes a performance measurement system focusing on: reducing traffic congestion; improving the environment; improving safety; linking regions; preparing against disasters; improving regional attractions; and, reforming road administration. High focus on safety and congestion easing. • Extensive information is collected on freight movements throughout Japan, including commodity flow surveys. Large amounts of data and statistics are produced. • Extensive use of KPIs throughout all levels of government, but from the research and materials available, a FPM system was not identified. • Extensive use of ITS to collect data for congestion management.
Stockholm, Sweden	• The Stockholm Freight Plan 2014-2017 • Urban Freight Focus but no discussion of FPM

9.2. An Overview of Truck Utilization as a Potential Performance Theme

Truck utilization is an important theme where it is useful to determine where the focus of the private sector would end and the focus of the public sector would begin. The idea that trucks would travel about full is an appealing ideal but one that is not possible to achieve in practice. For one thing, it is not a minor exercise to determine what fills the trucks that travel on the roads.

A truck's degree of fill can be measured along three dimensions and for any given load, one of these dimensions will be the limiting factor since a truck cannot likely be filled along all dimensions at once. The three dimensions are weight, volume and deck area. Some trucks for example, depending on their cargo, might tend to "cube out" before they "weigh out." A U.K. survey of non-food retailing fleets revealed an average deck utilization of 74%, an average weight utilization of 54% and an average volume utilization of 51% (UK Department of Transport, 2003). Of the three, deck utilization was the most stable factor across fleets. The collection of this type of detailed data required an in-depth survey effort that could only be undertaken for a set period of time and required significant commitment from participant fleets. The collection of such data on an ongoing, systematic basis would be very challenging. And the challenge to continually collect such data across a wide range of fleets for public-facing performance measurement would be daunting indeed.

McKinnon (2015) suggests that governments must be cautious in employing utilization data as a freight performance measure since the under-loading of vehicles can be perfectly reasonable in many circumstances. For a given firm, there may be concerns about minimizing inventory, optimizing warehouse space or staff productivity at a loading bay that may be at odds with the average level that a truck gets filled. In the urban distribution context, a performance measure that dealt with truck "load factor" could be problematic in that "time" is the main focus of operations as opposed to load factor (Arvidsson et al., 2013). Also in the urban distribution context is the fact that a truck will progressively get emptier as tours proceed – the object of the game is to empty the truck.

Given that it will be difficult and perhaps undesirable to base measures on degree of fill, a potentially less cumbersome approach would be to assess whether trucks are running empty. This is something that is well-tracked in the U.K. and the Eurozone (Eurostat, 2016a) and it has been done for a long time. In the UK, it has been documented that the percentage of truck-kms run empty declined from 34% to 26.5% between 1973 and 2003 but has actually been on the upswing since. In the 2016 UK Logistics Report, the percentage of heavy truck kilometres that are run empty is reported as 28.8% for 2014.

In the same way that there are questions about how much could be done to improve truck utilization, similar concerns can apply to empty trucks. McKinnon and Ge (2006) analyzed a large, multi-company database of truck movements representing different levels of the grocery supply chain. It was possible to review the fleet data retrospectively to figure what could have been done in reality to reduce empty trucks. Across 29 fleets, it was found that there was very little opportunity to reduce the distance that trucks run empty – suitable backloads were identified retrospectively for 2.4% of empty journey legs. They found that there were strong operational constraints, especially when the average length of haul was short, scheduling was tight in terms of delivery windows and when refrigeration was involved.

Ultimately, the most likely measure that potentially could be developed for Ontario is percentage of truck-km run empty. At present, the best source for this would appear to be the Ministry of Transportation Commercial Vehicle Survey as the statistic is not officially tracked. Ferguson et al. (2014) worked with these data for Ontario and found that 42% of truck legs were run empty based on the 2006 data. These results may have been biased upwards as “empty” was a default response for drivers instructed not to divulge information about cargo. This problem was apparently remedied in the 2012 iteration of the survey.

9.3. The Quality of Pavement, Bridge, and Tunnel Infrastructure

For freight movement, rough roads translate into real costs. Anything from fragile goods (e.g., foodstuffs and consumer electronics) to industrial equipment can be damaged in transport over poorly maintained roads (Minnesota DOT, 2016). As the Minnesota DOT developed its 2016 *Statewide Freight System Plan*, stakeholders including key government officials, business, and industries from both the US and Canada, identified pavement and bridge conditions as a top concern for the road transportation network. Freight movements associated with larger, heavier trucks were judged as particularly vulnerable to poor road conditions.

There is little variability across the reviewed literature about what indicator should be used to monitor pavement conditions. Typically, it is: the percentage of roads/highways in good, fair, and poor condition on freight significant corridors or amongst highways based on appropriate index measures. Common techniques for assessing pavement condition include the Ride Quality Index (RQI), International Roughness Index (IRI), and the Pavement Condition Index (PCI) (Minnesota DOT, 2007; Hajek et al., 1989; Sayers & Karamihas, 1998). The latter is based on multiple indices and as such could be the best approach. Details on each are beyond the scope of this report.

The Government of Ontario utilizes Automated Road Analysers to collect data about the condition of roads. These high-speed vehicles combine aspects of the RQI, IRI, and visual analysis elements into a single unit to assess roughness, rutting, cracking, and road texture (MTO, 2016b). Ontario collects and calculates pavement distress (Distress Manifestation Index), wheel track rutting (mm) and roughness (IRI). These three indices are integrated into the Pavement Condition Index to provide an overall analysis of pavement condition. Additionally, Ontario maintains a *Pavement Condition for Provincial Highways* database which is updated yearly (MTO, 2016a).

Concerns have been raised about the limited usefulness of the 'Percentage of Roads in x, y, or z Condition' measure. Such a measure provides no insights into the future condition of the road network (it can only be presumed that road conditions will deteriorate over time), the rate at which the network will deteriorate, where the network is most adversely affected by poor conditions (mapping the index does provide value in this concern), and the duration that a road segment has been underperforming.

At a minimum level, it is recommended to implement a measure that will code the PCI values into 'Good,' 'Fair,' and 'Poor' categories and report those codes as a percentage of the total roads monitored. Ideally, the Ontario PCI database would be expanded to include freight significant corridors including local/arterial roads within municipalities to provide a fuller image of the conditions for the extent of the freight network, rather than just the highways. Variations and additions to the base measure would ideally include the conditions of high/low-volume segments, the conditions of high/low-volume segments in rural areas, and the average period that roads are classified as 'poor,' split between rural and urban areas. Considering the Province already collects and monitors pavement conditions on low-volume roads, this should not be difficult (Ningyuan et al., 2006). Additionally, the measure can be used to track the quality of maintenance programs over time periods.

Of the literature reviewed, performance measures relating to bridge condition tend to fall into three categories: bridge condition; deck condition; and, number of structurally deficient bridges as a percentage of the total number of bridges (FHWA, 2008; Helmerich et al., 2008; McGhee, 2002; FHWA, 2016; Michigan DOT, 2017). Relevant performance measures for Ontario should be based off the data available through the Ontario BMS and the *Bridge Conditions* dataset. BCI and PCI provides the necessary index values to populate the identified KPIs.

Bridge and tunnel failures are rare and dramatic events that can cause large disruptions. The literature indicates that most advanced jurisdictions operate Bridge Management Systems (BMS) to assess and monitor the condition of bridges and other related pieces of infrastructure, including tunnels and culverts. Each BMS reviewed included at minimum an indexed value, ranking score, or Likert-scale type code to provide an at-a-glance condition metric. Due to a multiplicity of methodologies, techniques, and engineering codes across national borders, inter-jurisdictional comparisons of bridges should be done so with great caution.

The Bridge Conditions Index (BCI) is used by the Province and by municipalities to schedule maintenance and rehabilitation work for the approximately 2,800 bridges under MTO jurisdiction (Ontario Ministry of Transportation, 2015a). While it is not an indicator of safety, it provides a good indication of the state of repair of bridges and can highlight those that require maintenance or further inspection (City of Toronto, 2017). BCI values range from 0 to 100, values less than 60 are 'poor' and maintenance is needed within a year, between 60 and 70 are 'fair' and maintenance is needed within the next five years, and values greater than 70 are 'good' and maintenance is not needed within the next five years (Ontario Ministry of Transportation, 2015b).

Ontario is home to only a handful of major vehicle tunnels: Detroit-Windsor, Thorold, Townline, and Welland Tunnel. Failures/incidents are rare but do happen as most recently highlighted by an overpass collapse in Montreal in 2011 and the closing of the Townline Tunnel in 2010 after the discovery of a pipe failure (Forand, 2010; Toronto Star, 2011). A measure similar to the Road and Bridge condition measures can be utilized to monitor the condition of tunnels in Ontario, specifically the Detroit-Windsor Tunnel as a major freight linkage. As a key element outlined in the Ontario Manual, it is recommended to monitor tunnels on the basis of "structures with a high proportion of elements in the Poor Condition State" and assessing those values through 'poor,' 'adequate,' and 'good' codes with data from the OBMS.

9.4. Freight Performance Issues at Canada-U.S. Border Crossings

Ontario and border freight performance

Anderson (2012) provides an in-depth look at the importance of the Canada-US border to Ontario, highlighting in particular the importance of road freight as a vehicle to Ontario's trade relationship with the US. Unlike most conventional trade relationships where one locale, nation, or region holds a comparative advantage or in demand resource that provides the impetus for trade; Ontario's trade relationships stems from integrated production and supply chains that span the border. In the case of Ontario trade, companies exchange goods and services with each other and within themselves to produce some finished good (Maoh et al., 2017). According to the U.S. Bureau of Economic Analysis, in 2007, 32.1% of Canada U.S. trade in goods was intra-firm (EBTC, 2008). Transportation equipment account for 38.6% of the total intra-firm trade (ibid). According to the same source, 30.9% of Canadian trade in goods with the U.S. involved affiliates of U.S. companies operating in Canada (ibid). The result of this constant intermingling of processes is that Ontario, if it were its own nation, would have a proportion of exports and imports to GDP larger than that of trade driven countries like China, India, or Japan (Anderson, 2012). Almost 80% of those exports travel to the United States. Almost 90% of those US exports are manufactured goods (ibid). Almost 75% of those goods move by road via trucks carrying those goods across a few key ports of entry (ibid). As a result of the importance of road freight moving across the Canada-US border by truck, the analysis of cross border freight performance metrics here will focus primarily on that mode of transport.

Chapter Overview

Attempts to develop freight performance metrics to measure cross border movements began in earnest after 2001, just as the policy focus at the national level shifted towards greater security at ports of entry into the US. In an attempt to advocate for the importance of free movement of freight across the Canada-US border, many studies tried to estimate the cost of the 'border effect' on freight performance (Grady, 2009). Some of the most influential border impact studies from the early post 2001 period up to today are reviewed here in greater detail in order to provide insight on how cross border freight performance is evaluated.

The key difference between measuring border freight performance and other freight metrics is that shipments across the border can in some way be captured by changes in provincial and national level trade. In fact, many studies interested in measuring cross border freight performance utilize this methodology, satisfied that measuring aggregate changes in imports and exports is a good proxy for how cross border freight transport is performing. There are serious limitations to this approach, confounding variables like changing exchange rates and global economic slowdowns complicate the ability to come to any concrete conclusions about the strength of cross border shipping. Fewer studies measure cross border freight performance through disaggregate metrics, the kind of familiar measures of performance discussed at length throughout this document like travel time delay and variability. Others evaluate cross border freight from an environmental perspective, evaluating the impact on air and ambient noise at the traffic chokepoints border points of entry inevitably create (Oiamo, 2015). Even difficult to find are studies that take a multilevel approach to evaluating cross border freight performance, comprehensively evaluating both changes in macro level trade and a detailed cost estimate of border impacts on carriers (Maoh, Khan, & Anderson, 2017). The most detailed of these comprehensive studies, despite being more than a decade old, is discussed at length here (Taylor et al., 2004).

One additional note, what is an interesting element of cross border freight performance in particular is the presence of a number of Canadian authored studies, an element less apparent in the development of freight performance metrics on the whole. This likely is in part due to the asymmetrical trade relationship where the importance of the US to Canada as a whole and Ontario in particular has spurred much interest into the impact of the border on trade.

<u>Data Considerations</u>

Trade and Aggregate Travel Data

Macro level cross border freight data is abundant, has a long history, and is readily available from both Canadian and US sources. This is likely one key reason that leads many cross-border freight studies to rely on trade as a proxy for performance. Two main sources emerge as data inputs into macro level cross border freight analysis. From Statistics Canada, the Trucking Commodity Origin Destination Survey. And from the US Bureau of Transportation Statistics, their own TransBorder Freight Database.

Some sources include:

- North American TransBorder freight database – Collected by the Bureau of Transportation Statistics, contains freight flow data by commodity type and by mode of transportation (rail, truck, pipeline, air, vessel, and other) for U.S. exports to and imports from Canada and Mexico. The database includes two sets of tables; one is commodity based while the other provides geographic detail.
- Commodity Flow Survey – Collected by the US Census Bureau and Bureau of Transportation Statistics, provides information on commodities shipped, their value, weight, and mode of transportation, as well as the origin and destination of shipments of commodities from manufacturing, mining, wholesale, and selected retail and services establishments.
- Trucking Commodity Origin Destination Survey – Collected by Statistics Canada measures the commodity movements and the outputs of the Canadian trucking

industry, assesses the industry's growth rate and contribution to the Canadian economy.

- International Frontier Counts (Cansim 427-0002) – Collected by Statistics Canada recording the number of vehicles travelling between Canada and the US.
- Canadian International Merchandise Trade Database (CIMTD) – Collected by Statistics Canada this online database offers detailed trade data using the Harmonized System (HS) classification of for a number of Canadian trading partners.

Disaggregate Shipping Data

Firm level data is harder to come by. Firms tend to perform their own evaluations their cross-border shipping performance, build those costs into freight pricing, and then guard that data in a competitive business environment. As a result, firm level data is less abundant than macro level economic data and crossing counts. Some key sources do exist and present in two forms GPS data that collects truck movements across the border and survey data used to uncover the perception of cross border freight performance from managers in the trucking industry.

Some sources include:

GPS Data

- Border Wait Time Measurement Project - Collected through a joint partnership between Transport Canada and Turnpike Global Technologies, GPS data measures travel times across a number of major Canada-US crossing through digital trip logs.
- The Canadian National Roadside Survey - The NRS is a joint federal-provincial-territorial data collection and analysis project using passive data gathering technology of trucking operations including not only Canadian-based commercial trucking firms but also U.S.-domiciled trucking firms operating in the Canada-U.S. trade context and private trucks operated by shippers for their own account.
- Western Washington Probe Data – a joint GPS data collection study by the Western Washington University Border Policy Research Institute and the US Department of Transportation, captured variability in freight truck cross border travel times at the Blaine-Douglas Border.

Survey Data

- The Cumulative Impact of U.S. Import Compliance Programs at the Canada/U.S. Land Border on the Canadian Trucking Industry – Collected by Transport Canada in three separate surveys, Owner Operator, Private Carrier, and Shipper Questionnaires, details the cost of compliance with cross border trusted trader programs.
- Cross-Border Impediments Facing Canadian Shippers Trading with US Markets: Insights from a Recent Survey - survey used to improve the mobility of goods in Canada and between Canada and the US. The collected data serves as the basis for developing models that represent the patterns of freight transportation.

- Customs-Trade Partnership Against Terrorism (C-TPAT): 2010 Partner Survey – Detailed cost benefit analysis survey of C-TPAT approved operators.
- Service Time Variability at the Blaine, Washington, International Border Crossing and the Impact on Regional Supply Chains – interviewed carriers on the impact of cross border travel time variability.

Environmental Health Data
Some sources include:

- The Windsor, Ontario Exposure Assessment Study (WOEAS) - utilized personal, indoor and outdoor monitors to estimate the exposure of adults and asthmatic children living in Windsor to air pollutants in 2005 and 2006.
- Detroit Air Toxics Pilot Study – collected data on the variability of particulate matter and air toxics in the Detroit MSA.
- Detroit Exposure and Aerosol Research Study(DEARS) - data captures the variations in air quality across many Detroit neighborhoods, includes both residential and personal air quality monitoring measurements.
- Cross Border Institute Community Health and Traffic Impact Survey - Surveys measured noise annoyance and disturbances, health and wellbeing, attitudes towards the community and environment, travel habits and demographic characteristics.

<u>Early Estimates</u>
Aggregate Trade
Even prior to 2001, border impacts were a major topic of interest in Canada. In 1999, Former Prime Minister Brian Mulroney was quoted saying that businesses on each side of the border absorb $30 Billion dollars in crossing costs each year. Another early attempt by the Canadian Manufacturers and Exporters Association (2001) to quantify border costs broadly estimated that the border added as much as 6% to the total of most every Canadian manufactured good, with some particularly cross border reliant supply chains add as much as 13% to their final product.

However, following 9-11 interest in evaluating cross border freight performance really begins to take shape. Reports from academics, business, government, and policy institutes began to appear almost immediately, many focused on impacts that a new high security border regime presents to cross border freight. The US Manufacturers Alliance (2001) reported that paperwork alone adds 13% to the cost of NAFTA approved goods, and that delayed shipments cost an additional 3% on top of that. Other studies used a different approach, estimating cross border impacts by how much trade could improve on the whole. A report from KPMG Canada (2002) equates those percentages in dollars to approximately $350 million dollars Canadian annually. Those costs include freight performance measures of delay, employee overtime, return freight cycles, and additional equipment.

Many studies attempt to evaluate cross border freight performance through aggregate measures of trade. This approach was common in the years following 9-11 as the security environment at the border tightened, potentially affecting cross border freight carries. The first major study into the impacts of 9-11 on freight came from the Conference Board of Canada (2003). This study counterintuitively found that tightening border security had no effect on Canadian exports except at one crossing, the Port of Fort Erie. This report suggests that although certain industries have had to deal with the extra costs of security, this has not affected overall trade output. Although nominal trade indicators did show that overall trade between Canada and the US has declined over the past decade; the study goes deeper to look at cross border trade trends in specific ports and for specific commodities. From these trends, the Conference Board of Canada believes that other factors may have more greatly contributed to overall trade loss. These factors include a technology bust cycle for certain component manufacturing firms, and the global restructuring of certain commodities.

Other studies do conclude that increased border security has effected cross border freight performance. A report from Steven Globerman and Paul Storer (2008) concludes that bust cycles and global industry restructuring did not contributed significantly to cross border trade loss. This conclusion was reached by comparing trade data with statistical trends pre-and post 2001. On the whole then Globerman and Storer believe that a thickening border can be blamed for Canadian export shortfalls ranging from $10.3-13.7 billion dollars US from the end of 2001-2005. While the Conference Board of Canada found similar losses in overall trade, they assigned these losses to different trade metrics than border security enhancements at specific ports. Globerman and Storer, found that when looking at individual crossings, some show a rise in trade over the period they studied. These conflicting results exemplifies the difficulty of measuring cross border freight performance thorough aggregate measures of trade.

Grady (2009) performs a similar analysis of aggregate cross border trade. From 2000-2007 both the share of goods exported to the US fell, from 86.7 percent to 79.3 percent. Goods exports to the US as a percentage of GDP declined around 10 percent over that same time period. This 10% decline in exports by GDP is the figure most often quoted in border impact studies dealing with the cost of enhanced security policy. However, this figure may only partially reflect true trends as outside factors such as price increases and exchange rate can prove difficult to gage in regard to trade.

To remove these mitigating variables the author looks at exports to the US in constant 2002 chained dollars. Also, the author removes trade in energy and forest products from total trade as these two outliers saw either a dramatic increase in trade after 2001 as in the case of energy; or a dramatic decrease in trade as in the case of forestry. The changes experienced by these two industries were beyond the scope of enhanced security policy at the border. By making these adjustments to export data for 2000-2007 the author shows not only did exports to the US decline overall; but that the decline in cross border trade shows a long-term trend of stagnation in several industries. The auto industry again is highlighted as one that is particularly vulnerable.

Overall an estimated 9.3 percent of Canadian exports to the US were lost from 2000-2007. This results in a dollar impact of around $30 billion Canadian dollars in lost trade stemming directly from the September 2001 border impacts in the 2009 year of analysis.

Carrier Specific: Delay, Variability and Administrative Costs

Post 9-11 the Canadian federal government played an instrumental role in measuring cross border freight performance. A detailed Transport Canada commissioned report by DAMF Consulting (2005) found that majority of trucking costs stem from port of entry delays and variability in crossing time. The study acknowledges that the costs associated border crossing times are difficult to estimate, and that due to a reduction in trade following a slowdown in the global economy in the late 2000s, carriers still believed that delay costs were increasing at the border. In a survey of Canadian carriers 85% estimated an increase in border wait times, delays that the study estimated cost the trucking industry up to $75 dollars Canadian per hour. The total cost of these delays was estimated between $231 million to $433 million per year. In addition to delay impacts, border compliance cost a typical Canadian carrier between $171,000 to $341,000 per year.

In (2004) the Ontario Chamber of Commerce (OCC) commissioned a study titled, "The cost of Border Delays to Ontario", to advocate for improved freight performance at the border, this study attempted to define a wide array of carrier specific costs. The OCC states that at present the major border impact is uncertainty cause by growing delays at the border, attributed to enhanced border security post 9-11. much of the resulting border impacts on the trucking industry. Stating that delays of commercial trucks can cost from $3.17-4.23 dollars per minute; an average delay of 30 minutes at the border can cost the 14 million crossing trucks $1.3 billion per year. In addition to these costs the OCC estimates secondary delays and cabotage restrictions impact the trucking industry with an annual cost of $1.83 billion dollars.

The report then examines lost production as a border cost, with the OCC in this case reporting a $7 million-dollar loss to the Ontario economy should a 4-hour border delay occur at the Windsor-Detroit border corridor. This figure is assumed to be the result of a complete closure of the border and not individual truck delay. A four-hour closure is a rare occurrence with the only event of this magnitude occurring immediately after September 11th. Along with lost production the OCC attribute increased inventory costs to border delay. If the shipments are not timely this increases the amount of inventory a plant must hold in order not to hold up production. The stoppage of a production line due to late deliveries of “Just in Time” inputs is estimated at S1.64-3.55 billion dollars in lost productivity.

This impact primarily affects the auto industry, the top cross border trade sector producing upwards of $153 billion in trade, of which Canada owns a more than 8-billion-dollar trade advantage. Therefore, due to the size of trade reliant on the border, it stands to reason that the auto industry will be heavily affected by border impacts. Second, this industry is heavily reliant on ‘Just in Time” (JIT) shipments to reduce the level of inventory necessary for production. The OCC estimates using the Center for Automotive Research figures that one hour of extra inventory costs US assembly plants $570,000 per hour, while Canadian plants reliant on JIT shipments would pay an extra $1,056,000 for an addition hour worth of inventory.

A report to the US government by Goodchild et al. (2008) illustrates a similar attempt at quantifying the costs of crossing delay and variability on the cross-border trucking industry. The study found that carriers were in fact building in larger buffer times when crossing the Western Canada-US border eliminating the potential costs of late shipments but through the added cost of buffer times. While average crossing time only totalled about 1 hour 20 minutes, trucks would leave a full 2 hours of buffer to cross over the border with cargo to incorporate delay. The fact that buffer time due to variability more than delay was the more significant impact on cross border freight performance was supported by Coates et al. (2009). These authors too found that while the average delay at most bridge crossings were fell approximately between 8 and 14 minutes, the maximum wait time could be several hours if congestion was high and the truck was targeted for secondary inspection. As a result, to build in a buffer time that would allow the product to arrive 95% of the time on time, the shipper would have to build in a 3-hour buffer or more. While Coates et al. did not evaluate the economic impact of these buffers, Goodchild did, finding that these buffer times were not seen by many carriers as economically significant costs, especially to US carriers, while variability on the whole was by and large accepted by the Canadian or US carriers surveyed. According to Goodchild, there is some logistical slack in border operations, and much of these costs is absorbed by the driver and higher prices for cross border shipments per haul. This represents a significant difference in cost estimates as Transport Canada places delay costs at $200 to $400 million dollars plus per year to carriers alone.

Other major measures uncovered by the Transport Canada study include paperwork and other administrative costs associated with increasing cross border regulations. This is due in large part to the cost of driver training and bonuses reported to Transport Canada. Moreover, FAST (Free and Secure Trade) compliant security upgrades, totalled an additional cost for sampled carriers from $244,000 to $488,000 per firm. Even carriers which did not wish to become FAST certified were hit with million-dollar computer and administrative costs in order to comply with new e-shipping procedures which became standard in the PAPS (Pre Arrival Processing System) and ACE (Automated Commercial Environment Technical Information) programs. Food carrier compliance paid an additional $60 to $75 dollars per trip to meet security regulations, racking up surcharges such as "FDA Clearance Fees" A total of 3.8 million trips were made across the border by Canadian carriers in 2005, and based on a $20-dollar surcharge estimate by Transport Canada, applied regulation costs can total more than $77 million dollars.

<u>Taylor et al., 2004</u>

The most comprehensive report on border freight performance, "The Canada-US Border: Cost Impacts, Causes, and Short to Long Term Management Options" was conducted by researchers at Wayne State University (Taylor et al., 2004). The study focuses on estimating the cost of border crossing transit times and uncertainty, changes in traffic levels, and the initial impact of September 11th on the Canadian and US economies. The authors accomplish this task by combining raw data on crossing times with the study of several bodies of literature including: 750 newspaper articles from the US and Canada; 45 border related reports. Secondary sources are supplemented with site visits and 173 interviews of manufacturers, carriers, customs brokers, trade associations, and border related stakeholders. The authors use this information to estimate macro and detailed cross border costs.

The first impact considered by the authors are macro costs on trade. Accordingly, the first cost estimate concerns the impact the border has had on trucks carrying Canadian exports into the US post 2001. After 2001 US imports of goods by land fell 10.8 percent, concurrent with a cross border truck traffic decline of 2.2 percent. Removing economic downturn as a variable, total economic growth in the US was flat to up around that time, although there was a slight reduction in total US industry production of around 3 percent. Dollar exchange rates were also unchanging in the early 2000s. Furthermore, auto related production actually rose in the US by more than 4 percent over this same time period. This was Canada's largest export to the US at the time. Therefore, this study's findings suggest that border impacts immediately following 2001, have indeed had a major effect on cross border commercial trade and traffic. Taylor estimates these impacts at 6-7% of total trade over that time period, or 4 percent of truck borne trade. The authors then state that it may be the 'perception' of border delays and uncertainty which may have attributed to some of the total reduction in trade. This idea is important and the effect of perception will be discussed further in relation to personal crossings.

The study then returns focus to commercial impacts, illustrating higher freight prices for cargo crossing the border. Border crossing rates are estimated at 10-35 percent higher than similar domestic trips. This does not include wait time or border crossing consignment fees which are often additional charges added on by carriers. In total 1-2 billion dollars in administrative costs can be assigned to crossing the border. This estimate is derived by taking 4-5 percent of cross border trade (an estimate for shipping costs), and then applying a 10, 15, and 20 percent surcharge to shipping costs to arrive at total additional administrative costs. By using this method, the extra administrative costs associated with crossing the border is .94 billion USD, 1.59 billion USD, and 2.35 billion USD. In short administrative costs represent less than 1 percent of the value of total trade by the authors' estimates.

Another major cost the authors attribute to the border is crossing times. Much of cross border trade by dollar is associated with time sensitive materials and therefore carriers often must meet strict delivery windows. Furthermore, the authors point out that consignees may assign a penalty to windows not met. Due to these circumstances carriers must often plan for greater border crossing times than needed creating slack in the supply chain. This additional time more often than not is non-recoupable.

Planned border crossing times in this study are set at 1.5-2 hours. The authors use several reports from logistics reports, shippers, and the US Federal Highway Administration to pin down allocated costs for shipping truck and cargo at $150 USD. By combining planned crossing time estimates with this cost figure crossing time impacts are estimated by Taylor at 1.2 to 2.41 billion USD.

The authors then break down macro cost impacts into detail. For example, the cost estimate for planned crossing time is broken down in this section into impacts such as primary and secondary inspection costs or lost productivity. Also, a small amount of costs is assigned to personal crossings.

Using crossing time data for several major Canada-US crossings Taylor estimates that commercial carriers and manufacturers almost equally absorb the costs of crossing the border. Carriers must deal with primary and secondary inspection, reduced travel cycles, and documentation and compliance costs for a total of nearly 1.9 billion dollars US. Manufacturers consequently are assigned nearly 2 billion in additional dollar costs from lost productivity and extra inventory. Operating border costs, including the cost of staffing the border; duties, fines, and fees; and administrative costs are estimated by Taylor to range from nearly $5-8 billion USD. Total costs (delay costs and operating costs) represent about 4 percent of total Canada-US border truck trade. Keep in mind that these specific costs are equal to the total cost of managing the border, and not necessarily additional border costs due to enhanced security. The method of cost estimation for these detailed cost breakdowns stems mainly from available border data, federal source information, and interviews.

As is seen from Taylor, the cost of managing the border runs into the billions. Furthermore, due mainly to increased uncertainty and variability at border crossings by 2003, carriers and manufacturers alike were estimated to absorb nearly an additional $2 billion dollars US each in crossing costs. Due to the fact that these commercial costs, along with management costs make up the bulk of Taylor's estimates; the authors in this case advocate for greater co-operation by Canada and the US to decrease inspection time, more border staffing, and better infrastructure. In the long term, the authors advocate a returned examination of the perimeter approach. This report is an important example of macro and detailed cost estimates which are backed by data and sources. Therefore, Taylor may represent the most comprehensive and accurate border policy cost impact study in the literature.

Recent Studies on Cross Border Freight Performance

Most recent studies show that freight performance at the border has improved since the immediate impact of 9-11. Whether or not this is due to improvements on behalf of the governments or government agencies involved, or a testament to the shipper's ability to adapt, no definitive conclusion can be drawn at this time.

Gingrich (2016) found that border delays at three major crossings (Ambassador, Blue Water, Peace Bridge) only resulted an average increase between 2% and 3% of the total trip travel time. The overall delays for truck trips were also deconstructed into the proportion of a trip with no delay (75% average), expected delay (19% average), and unexpected delay (6% average).

Maoh (2017) in a survey responded to by more than 1,000 Canadian trucking firms, many from Ontario, found that despite these findings delay seems to be the most significant impact on freight performance at the border with over 60% agreeing or strongly agreeing that delay is a major problem. Two other freight performance factors at the border in which the majority of respondents agreed posed problems are regulatory including the high cost of cross border customs fees (56%), and the administrative cost of adhering to cross border regulations (51%). This last finding coincides with another significant freight performance issue, the possibility of having goods impounded (42%). Despite this, there are a significant number of firms who have adapted to the new border crossing environment, 43% agree or strongly agree that the border does not affect their trade relationship with the United States. While the border itself does not seem to pose a major issue for these adaptive firms, there is less support for customs "trusted trader" programs on the whole, with approximately 60% finding them unimportant. Reinforcing the difficulty of taking an aggregate trade evaluation approach to cross border freight performance, almost 75% of the respondents agreed that the strength of the Canadian dollar has the greatest impact on trade with the US.

Environmental Impacts

There are a small number of studies dedicated to evaluating the impact of cross border freight on the health of local residents.

Luganaah et al (2006) found significant increases in respiratory admissions to the local hospital in Windsor, Ontario both one and 6 months following the border slow down after 9/11. The average admission was also significantly higher one year later. These SO_2 and CO concentration levels were found to be generally higher after 9/11 than one year before and immediately before.

Although border crossing congestion has generally decreased since 9-11, Lemke (2015) as recently as last year found a significant association between asthma and air particles in Windsor, and even higher instances of those particles in neighborhoods near the border in Detroit, indicating a potentially greater possibility of acute asthma events there (a direct comparison could not be made due to the different health care systems).

Oiamo et al (2015) found that noise pollution at the Windsor-Detroit border corridor was near the upper limit of the noise threshold imposed by the World Health Organization (55 decibels). Despite this only approximately 30% to 37% of individuals in the area considered noise a problem. Most residents feared the effects of air pollution 60% to more than 70%, coinciding with the findings of both Luganaah and Lemke.

Solutions to Improve Freight Performance

DAMF (2009) was commissioned by Transport Canada to produce recommendations that would lead to improved cross border freight performance. They suggest several areas of focus

1) Continue to improve the pre-processing initiatives at border crossings, specifically the ability to preapprove paperwork automatically away from the border itself.
2) Improve customs brokerage within the industry itself, standardizing fees, invoices, and its communications with carriers.
3) Improve the process for becoming a ‘trusted trader’ both as a shipper and driver. A lack of FAST approved shippers that is hindering the ability of Canadian carriers to take advantage of potential benefits from the U.S. security regime.
4) Improve truck delay. Improve Infrastructure and fully staff customs booths.

9.5. Public Sector Freight Regulation and Ownership

The regulation of Canada's transportation system is distributed between the three levels of government: Federal, Provincial/Territorial, and Municipal/Local. As a general rule of thumb, the Federal government plays a limited role in the direct provision of infrastructure while regulation is limited to areas of national concern or of entities that are inter-provincial/territorial in nature. As Figure 9-1 highlights, Transport Canada, intuitively, plays the largest role in the Federal administration and legislative regulation of the transportation system through various acts, agencies, crown corporations, and shared governance entities. Areas of explicit Federal governance include: air movements, inter-provincial railways, waterway and marine movements, international borders, and limited inter-provincial and critical infrastructure either owned directly by Transport Canada or through an affiliated entity. The Federal government retains authority over these categories through the various acts administered by Transport Canada as well as Public Safety Canada, Infrastructure Canada, and Environmental and Climate Change Canada. Public Safety Canada, through the Canada Border Services Agency oversees aspects of international trade, including the importing of goods and border security. Environment and Climate Change Canada's primary role in the transportation sector is through the Environmental Protection Act and the regulation and monitoring of emissions and pollutants. Infrastructure Canada provides capital funding for a wide-assortment of public infrastructure including public service buildings, transit improvements, and road, highway, and bridge investments. Funds are provided to federal and provincial level governments and agencies for major projects, including the Jacques Cartier and Champlain Bridges as well as the Windsor-Detroit Bridge Authority, both of which Infrastructure Canada has shared oversight of. Outside of their specific areas of direct oversight, the notion from stakeholders is that the Federal government is there to provide capital funding dollars for major projects that will improve the flow of goods and people.

The Federal government additionally maintains a large stake in the ownership or shared governance of a number of key pieces of Canadian infrastructure, as laid out in Figure 9-2. Foremost, the Federal government is the owner of the airport lands that collectively make up the National Airport System; though, these airports are operated at arms-length by their respective airport authorities who act as the landlords and providers of facilities and miscellaneous equipment. Transport Canada also explicitly operates a number of smaller airports across the country. The Federal government's role in the marine system is similar as they retain ownership of many of the Canadian Port Authorities lands, but the Port Authorities themselves operate at arms-length and each level of government has appointed board members. Transport Canada additionally operates numerous smaller ports in a more direct manner. Though this specific ownership structure is in flux due to the divestment process that the Federal government is undertaking through the Port Asset Transfer Program (Transport

Canada, 2016). The Federal government also retains ownership of the Canadian side of all international seaways, often via shared-governance Crown Corporations. The Great Lakes St. Lawrence Seaway Corporation is an example where the seaway is jointly managed with its counterparts in the United States. While Transport Canada and the Federal government have jurisdiction over railways, since the privatization of the Canadian National Railway Company in 1995, the government has little ownership or direct responsibility in the provision of infrastructure or equipment. The extent of Federal ownership is limited to VIA Rail, which has been a Crown corporation since 1978. The role of the Federal government in terms of the rail mode, is focused on legislative regulation, especially in regard to safety and emissions.

Generally, it is not the role of the Federal government to provide road infrastructure. While there are exemptions, such as with National Parks, the role of the government is focused on major bridges, both inter-provincially and internationally, and all border crossings. Much of Federally owned bridge infrastructure is owned by the Federal Bridge Corporation, but numerous different Federal agencies and corporations have varying degrees of input and responsibility for bridges across the Country. There are additionally shared governance structures for the Canada-United States bridge border crossings. Similar to rail, much of the Federal government's involvement with road transportation is through legislative regulation focused on safety and emissions.

The role of the Provinces and Municipalities is far more nuanced and direct in the provision of certain types of infrastructure and regulation. While the Federal government retains oversight of air, inter-provincial rail, and marine modes, it is the role of the Provinces to provide and regulate road transportation, specifically provincial highways, and the role of the municipalities to provide local roads. Ontario provides road transportation services and legislative regulation via the Ministry of Transportation and the Highway Traffic Act which sets out the rules of the road, speeds, licensing, and permitting, among numerous other operational considerations. The province also has oversight over intra-provincial rail movements which are defined and discussed in Chapter 4. Similar to the Federal oversight structure, the Provincial structure is influenced by multiple Ministries with the Ministry of Transportation taking the lead role, Figure 9-3. The Ministry of Environment and Climate Change and the Ministry of Infrastructure play fundamentally similar roles to their Federal counterparts, implementing Provincial-level environmental actions and providing infrastructure funding to Provincial agencies and municipalities for major projects. The Ministry of Northern Development and Mines plays a unique role in Ontario as the Ministry oversees the Owen Sound Transportation Company and the Ontario Northland Transportation Commission. The former provides air services to Pelee Island in southern Ontario while the later operates, among other services, the Ontario Northland Railway which provides rail freight and passenger services for northern Ontarian communities and mining economies. The Ministry of Municipal Affairs sets out the land use planning and legislative existence of the municipal level of government within the Province. While the Provincial government is involved with the operation of all modes, to varying degrees and forms, the primary focus is on the provision of interregional highways, bridges, and other critical road infrastructure as well as the regulatory oversight of the Provincial road network.

While the focus of the Provincial government, especially Ontario, is the provision of road network infrastructure, the Province does have vested interests within each mode, as overviewed in Figure 9-4. The Province, through the Remote Northern Transportation Office owns and operates a number of small airports throughout Northern Ontario where road access is limited or non-existent. These facilities operate under the Federal law administered by Transport Canada and NAV Canada. The Province, as mentioned above, owns two transportation crown corporations which provide a variety of air, marine, and rail services. These are generally small players which are important, or critical in the case of the Ontario Northland Railway, for the impacted local economies for the movement, both in and out, of freight goods. These entities generally operate at arms-length from the provincial government, but the recent decision to reorganize instead of divesting the Ontario Northland Transportation Commission is an indicator of the rather direct role the government can and does play in the overarching operation of these entities. The Owen Sound Transportation Company is another example of a Provincial Crown Corporation that provides ferry and air services within Ontario. Apart from the rail track, locomotives, and other related infrastructure and equipment owned by the Ontario Northland Railway the provincial government's ownership of rail infrastructure is generally limited to the ownership of the GO Train service through the Metrolinx agency, which provides passenger rail services. While these are not freight services, some of the GO Trains do operate alongside corridors across which the major railways operate, similar to VIA Rail which shares portions of the track. The overwhelming focus of the resources of the Province go towards the provision of highway and related infrastructure allowing for the movement of vehicles and good by road between economic regions and municipalities. The Province is the owner, operator, and maintainer of most of the highway, bridge, and culvert infrastructure across the Province, with a handful of privately owned examples, primarily the 407 Express Toll Route. The Province operates the King's Highways, which includes the 400-Series controlled access highways, as well as Secondary and Tertiary level highways/roads across the Province. The Provincial Government is the primary provider of the highway network and maintains legislative jurisdiction over the regulation and operation of all roadways within the Province.

Municipalities, are often considered to play the smallest role of the three levels of government in the regulation and provision of infrastructure as it relates to goods movement. While in reality, municipalities – including County, Regional, Single-Tier, and Lower-Tier levels of local government – are tasked with the provision of local and arterial roads within their respective jurisdictions, enabling the first and last kilometre movement of virtually all freight.

Municipalities also retain the right to enact by-laws which can affect anything from parking regulations to stopping/loading zones on local streets; both of which are important considerations for carriers of freight to their final destinations, especially courier services. As is detailed in Figure 1-5 some municipalities may have a greater level of influence and involvement in the transportation system than other neighbouring municipalities. The City of Hamilton for example, is noted for being the owner of the Hamilton International Airport, a major cargo centre for Southern Ontario. There are many other examples of municipally owned airports. As a part of the shared governance structure of the Canadian Port Authorities, municipalities that are home to port lands have seats on the local board of directors of the port, and there are limited examples of municipally owned ports throughout the country. Within Canada there are only two known examples of a municipality owning a local railway, one being owned by the City of Guelph, and the other by the City of Winnipeg. Municipalities can play a large role in the movement of freight by virtue of the way their roads, intersections, and signalling systems are designed and programed; systems built with truck movements in mind can reduce or limit the impact of freight movements on intra-municipal congestion. As with the Provincial government, the majority of municipal resources are directed towards the transportation mode, split between public transit systems and the provision of local roadways and expressways.

The role of the private sector in the provision of infrastructure in Canada is limited. While the new Federal Infrastructure Development Bank hopes to make use of private funds to expand national infrastructure, there are limited examples of direct ownership and maintenance of infrastructure by private firms. The most obvious exemption from this statement are the railway companies which are wholly dependent on the provision of their own infrastructure. Private firms are generally the suppliers of the equipment that transit across the transportation network including private vehicles, trucks, airplanes, vessels, and locomotives and associated equipment. The provision of transportation infrastructure is considered a public good and its use is for the movement of private individuals and firms to enable economic activity.

9.6. Glossary of Terms

TERM	DEFINITION
AIR CARGO CONTAINERS	Containers designed to conform to the inside of an aircraft. Three categories: pallets; lower deck; and, box-type.
BILL OF LADING	A document that establishes the terms of a contract between a shipper and a transportation company. It serves as a document of title, a contract of carriage and a receipt for goods.
BULK TERMINAL	A purpose-designed berth or mooring for handling liquid or dry commodities, in unpackaged bulk form, such as oil, grain, ore, and coal. Bulk terminals typically are installed with specialized cargo handling equipment and rail lines to accommodate cargo handling operations with ships or barges.
CARGO	See Freight.
CARLOAD	Shipment of freight required to fill a rail car.
CARRIER	An enterprise/business/firm that offers transportation services, typically referring to air, road, and marine modes.
CONTAINER TERMINAL	An area designated for the stowage of cargoes in container; usually accessible by truck, railroad and marine transportation. Here containers are picked up, dropped off, maintained and housed.
CONTAINERIZATION	Stowage of cargoes in a container for transport in the various modes.
CROSSDOCK	Crossdock services involve unloading products/goods from a truck or container directly onto another truck for delivery. Items are not put away but merely staged near dock doors to await loading. Therefore, there is little to no storage, and turnaround time between receipt and shipment is usually less than 24 hours.
DWELL TIME	Dwell time can refer to 'Cargo Dwell Time' or 'Transport Equipment Dwell Time.' The former referring to the length of a time cargo specifically is waiting to be moved, transloaded, or otherwise. While the later refers to the amount of time that a vessel, railcar, or otherwise is sitting and waiting before proceeding.
FLEET	The vehicles in a transit system. Usually, "fleet" refers to highway vehicles and "rolling stock" to rail vehicles.
FLIGHT DATA MONITORING	Routine collection and analysis of digital flight data generated during line operations to provide more information about, and greater insight into, the total flight operations environment.
FLIGHT PLAN	A flight plan serves two main purposes. First, it provides information to NAV CANADA, which facilitates planning for the provision of air traffic control services. Second, it is the basis on which alerting service is provided to pilots.
FOR-HIRE MOTOR CARRIER	A person engaged in the transportation of goods or passengers for compensation.
FREIGHT	Any commodity, good, product, or cargo being transported.
FERIGHT CONTAINER	A reusable container having a volume of 64 cubic feet or more, designed and constructed to permit being lifted with its contents intact and intended primarily for containment of packages (in unit form) during transportation.
FREIGHT FORWARDER	A broker that functions as an intermediary between shippers (consignors/consignees) and carriers. Functions performed by a freight forwarder may include receiving small shipments (e.g., less than container load) from consignors, consolidating them into larger lots, contracts with carriers for transport between ports, conducts documentation transactions, and arrange delivery of shipments to the consignees.
GENERAL CARGO	General cargo consists of products or commodities such as timber, structural steel, concrete forms, agricultural equipment that are not conducive to

	packaging or unitization. Break-bulk cargo (e.g., packaged products such as lubricants and cereal) are often regarded as a subdivision of general cargo.
INTERMODAL	Used to denote movements of containers or trailers interchangeably between transport modes, i.e. the equipment is compatible within the multiple systems.
INTERMODAL TRANSPORT	Enables cargo to be consolidated into economically large units (e.g., containers, bulk grain railcars) optimizing use of specialized intermodal handling equipment to effect high-speed cargo transfer between ships, barges, railcars, and truck chassis using a minimum of labor to increase logistic flexibility, reduce consignment delivery times, and minimize operating costs.
INTERMODALISM	Typically used in three contexts: 1) most narrowly, it refers to containerization, piggyback service, or other technologies that provide the seamless movement of good and people by more than one mode of transport. 2) more broadly, intermodalism refers to the provision of connections between different modes, such as adequate highways to ports. 3) In its broadest interpretation, intermodalism refers to a holistic view of transportation in which individual modes work together or within their own niches to provide the user with the best choices of service, and in which the consequences on all modes of policies for a single mode are considered.
JUST-IN-TIME	In this method of inventory control, warehousing is minimal or non-existent; the container is the movable warehouse and must arrive "just in time."
LESS-THAN-TRUCKLOAD	A quantity of freight less than that required for the application of a truckload rate. Usually less than 10,000 pounds and generally involves the use of terminal facilities to break and consolidate shipments.
LINEHAUL	The movement of trains between terminals and stations on the main or branch lines of the road, exclusive of switching movements.
MAIN TRACK	A track, other than an auxiliary track, extending through yards or between stations, upon which trains are operated by timetable or train order or both, or the use of which is governed by a signal system.
MARINE TERMINAL	A designated area of a port, which includes but not limited to wharves, warehouses, covered and/or open storage spaces, cold storage plants, grain elevators and/or bulk cargo loading and/or unloading structures, landings, and receiving stations, used for the transmission, care, and convenience of cargo in the interchange of same between land and water carriers or two water carriers.
MODAL SHARE	The percentage of total freight moved by a particular type of transportation
MULTIMODAL TRANSPORTATION	Often used as a synonym for intermodalism. In this report, multimodal refers to cargo that is transloaded from the equipment of one mode to another, often with intermediate storage
OCEAN GOING CONTAINER	Usually made of steel, it is a large rectangular box designed for easy lift on/off by cranes
OWNER / OPERATOR	Independent trucker who drives the vehicle for them self or on lease to a company
PAYLOAD	The maximum load that a unit of equipment may carry within its total rated capacity. The payload is the Gross Vehicle Weight Rating (GVWR) less the tare weight or actual weight of the unloaded vehicle. Weight of commodity being hauled. Includes packaging, pallets, banding, etc.
PORT	A harbor area in which are located marine terminal facilities for transferring cargo between ships and land transportation
PORT AUTHORITY	Body established by law to have specified powers including the right to act with respect to a defined area of responsibility. Often used to apply to any quasi-autonomous or quasi-independent agency which has adequate authority over and effective management of a port

PORT OF CALL	Port where a ship discharges or receives traffic
PRIVATE CARRIER	A commercial motor carrier whose highway transportation activities are incidental to, and in furtherance of, its primary business activity
PRIVATE TRACK OR SIDING	A track located outside of a carrier's right-of-way, yard, or terminals where the carrier does not own the rails, ties, roadbed, or right-of-way and includes track or portion of track which is devoted to the purpose of its user either by lease or written agreement.
RAIL WAYBILL	The document covering a shipment and showing the forwarding and receiving stations, the name of consignor and consignee, the car initials and number, the routing, the description and weight of the commodity, instructions for special services, the rate, total charges, advances and waybill reference for previous services, and the amount prepaid
RAILWAY CAR	A railway car designed to carry freight, railroad personnel, or passengers. This includes boxcars, covered hopper cars, flatcars, refrigerator cars, gondola cars, hopper cars, tanker cars, cabooses, stock cars, ventilation cars, and special cars. It also includes on-track maintenance equipment.
RAILWAY YARD	An area provided with a system of tracks and associated structures, where railway trains are assembled, and railway cars are switched, stored or serviced
REVENUE TON MILE / TONNE KILOMETER	The movement of a ton or tonne of freight one mile or kilometer for revenue
ROLLING EQUIPMENT	Includes locomotives, railroad cars, and one or more locomotives coupled to one or more cars
SAFETY MANAGEMENT SYSTEM	Consists of systematic, explicit and comprehensive processes for the management of safety risks, that integrates operations and technical systems with financial and human resource management, for all activities related to an air operator or an approved maintenance organization
SHIP’S MANIFEST	A list, signed by the captain of a ship, of the individual shipments constituting the ship's cargo
SIDING/SPUR RAILWAY	Track connected with the primary track, sometimes leading to a production or storage site, and used for passing, temporary storage, or loading and unloading of railway cars
STEVEDORE	A person or firm that contracts with a vessel's owner, agent or charter operator, or with the owner of the cargo, to load or unload a ship or barge in port
TERMINAL STORAGE	Service of providing warehouse or other terminal facilities for the storage of inbound or outbound cargo, including wharf storage, shipside storage, closed or covered storage, open storage, bonded storage and refrigerated storage.
TERMINATED CARLOAD	A carload which ends its journey and is unloaded on a particular railroad
THROUGHPUT	A measure of productivity for cargo (e.g., containers per day/month/year) processed and handled through a facility
TRAILER ON FLAT CAR/ CONTAINER ON A FLAT CAR/	Transportation of containers or trailers on the chassis of railroad flatcars – i.e., intermodal service
TRAIN DENSITY	1) The number of trains that can be operated safely over a segment of railroad in each direction during a 24-hr. period. 2) The average number of trains that pass over a specified section of railroad in a specified period
TRANSLOAD	To move goods from one carrier or mode to another carrier or mode by way of physically transferring the goods from the vehicle to the next. E.g., A container will be taken into a facility and transferred to a domestic container or truckload. The enclosures are not interchangeable between modes or vehicles, as opposed to intermodal units.
TRANSPORT VEHICLE	A cargo-carrying vehicle such as an automobile, van, tractor, truck, semitrailer, tank car or rail car used for the transportation of cargo by any mode. Each cargo carrying body (trailer, rail car, etc.) is a separate transport vehicle

TRANSSHIPMENT	The transfer of goods from one carrier to another or to an intermediate destination and then to a final destination, for trans-loading, consolidation or deconsolidation.
UNIT LOAD	Packages loaded on a pallet, in a crate or any other way that enables them to be handled at one time as a unit
VESSEL	Every description of watercraft, used or capable of being used as a means of transportation on the water
WAREHOUSE	A place for the reception, delivery, consolidation, distribution, and storage of goods
WEIGHT TON (TONNE)	There are three types of weight tons: 1) The short ton, 2,000 pounds; 2) The long ton, 2,240 pounds; and 3) The metric ton (tonne), 2,204.68 pounds
WHARF	A landing place where vessels may tie up for loading and unloading of cargo
WHARF DEMURRAGE	Charge assessed against cargo remaining in or on terminal facilities after the expiration of free time, unless arrangements have been made for storage
WHARFAGE	Charge assessed by a pier or dock owner against freight handled over the pier or dock or against a steamship company using the pier or dock

Sources: (Government of Canada, 2017), (US DOT, 2017)

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