Towards Performance Measurement of Transborder Trucking Corridors: The Case of Automotive Supply Chains

August 2023

CROSS-BORDER INSTITUTE

McMASTER INSTITUTE FOR TRANSPORTATION & LOGISTICS

Towards Performance Measurement Of Transborder Trucking Corridors: The Case of Automotive Supply Chains

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August 2023

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Acknowledgements

The authors would like to acknowledge the support of our colleagues at Transport Canada in making this study possible. We are grateful to the six major automotive manufacturers who graciously agreed to participate and who provided this study important insights. We would like to thank Louis-Paul Tardif of L-P Tardif and Associates for his support in the completion of this work. Finally, we would like to thank MITL's co-op student, Nelly Chisom Okwu-Wolu, for her contributions in developing the maps shown in Chapter 4.

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EXECUTIVE SUMMARY

This study has combined a comprehensive literature review, in-depth automotive stakeholder engagements, and analysis of 2022 HERE highway speed data to derive some important insights on how transborder Canada-US highway corridors are performing in support of automotive supply chains and what might be expected in the future in a period of dynamic change as vehicle electrification increasingly takes hold.

Our review of performance measures along highway corridors shows that certain of these measures appear quite well established and accepted. Typically, deployment has been in the context of domestic corridors as opposed to transborder corridors. In principle, there is no reason that these same measures cannot be adapted and applied in transborder contexts. Buffer and Planning Time Indices are described in Chapter 2 and appear aligned with how OEMs think about corridor performance based on engagement feedback. Discussions with the US Federal Highway Administration and the Texas Transportation Institute reveal that key data and tools are already in place that would help support transborder corridor analytics, including completed research on transborder US-Mexico supply chains.

Engagement processes took place with the primary OEMs in February 2023. These occurred in the following order: Toyota, Honda, Ford, GM, Mercedes and Stellantis. Five of these six firms have manufacturing operations on both sides of the Canada-US border. Some of the most important results from the engagements are as follows:

- The two main bridges (Ambassador and Blue Water) that join Southern Ontario-Michigan (with a third soon to be added – Gordie Howe Bridge) are viewed as the most important enabling infrastructure along transborder road corridors. These bridges were described as "existential" for automotive manufacturing in Southern Ontario.

- The rise of electrification is not expected to disrupt the basic dynamics of cross-border automotive supply chains, which depend heavily on connections between Southern Ontario and the US Midwest. Hybrid electric vehicles (HEVs) and plug-in hybrid vehicles (PHEVs) were not viewed as impactful in reducing the high diversity of parts and components that are needed to run automotive supply chains. Even battery electric vehicles (BEVs), noted for their relative mechanical simplicity, were identified as retaining a lot of the same parts and components. Between similar geographical pairings, there might be some swapping out of old parts and swapping in of new parts. There was more emphasis on BEVs in these engagements, relative to hybrids, and no real mention of hydrogen fuel cells or medium- and heavy-duty vehicles.

- Key 400-series highways in Southern Ontario are expected to remain important along with Interstate 75 and others on the US side. Road connections deeper into the US such as with Georgia, Texas, and other states have emerged and will continue to be important.

- Nearshoring and localization trends have been in place for some time and have been reinforced with recent major legislation (USMCA and Inflation Reduction Act). Considering these trends and since OEMs aim for their operations to be as lean as possible, the demand for trucking and the dependence on transborder road corridors is expected to remain high.

- Electrification, and some very favourable local characteristics, are enabling the development of Bécancour, Quebec as a hub for the production of Cathode Active Material (CAM). Large-scale movements of CAM by truck, or perhaps rail, to the North American sites of battery cell production are very likely. If trucking prevails, the transborder road corridor between Quebec and the US Midwest will rise in importance for automotive supply chains.

- The logistics of moving battery cells or arrays are “punishing” due to the heavy weights involved. More battery manufacturing plants will likely emerge in the future to reduce aggregate distances travelled to assembly plants with such heavy cargoes. Various trucking configurations for these heavy loads (e.g., quad axles, Long-combination vehicles) are being explored.

- The logistics of future automotive supply chains are likely to evolve. Battery electric vehicles (BEVs) support more modularity and fewer supply chain constraints relative to combustion vehicles. The logistics of notable first generation BEVs are not a preview of the future.

- Despite the likelihood of more intense trucking activities on the Canada-US and domestic fronts due to electrification, the global nature of battery supply chains is very important. There is more desire for visibility all the way to the mine given that world automotive manufacturing in the future will be competing for the same resources. There was a suggestion of stronger involvement with all aspects of these new supply chains. Precursor ingredients for CAM may likely travel by container from varied overseas locations and might tie into rail and marine modes.

- Battery cells and assemblies are considered hazardous goods for transport (unlike CAM). The fact that the Gordie Howe Bridge will accommodate hazardous goods movements, while the Ambassador Bridge does not, is quite relevant given the rise of electrification. Even with the shipping of finished vehicles, there are issues of temperature control and ensuring that vehicle batteries arrive at dealers in the ideal state. There are thoughts that OEMs might be able to learn from other sectors (e.g., food), where temperature sensitivity in shipping is a central consideration.

- On the topic of learning curves, electrification means that there are a host of new suppliers beginning to participate in just in time automotive manufacturing. Both OEMs and suppliers are apparently having to adapt as this transition takes place.
- Automotive OEMs generally rely on layers of third parties (carriers, logistics providers) to help operate their complex supply chains. They also tend to think in terms of buffered travel durations for longer-distance movements between suppliers and assembly plants. The combination of these two reduces the OEM need to focus on the specifics of transborder corridors – key border bridge crossings excepted.

In terms of a "recipe" for monitoring and measuring the performance of transborder automotive corridors going forward, evidence gathered as part of this research emphasizes the pivotal role of the key border bridge crossings that join Southern Ontario with Michigan. Investments in IT infrastructure that permit high-end data collection on real-time or near real-time truck crossing durations is much needed. These types of investments need to extend significant distances on either side of the bridges since truck congestion does not end where a bridge ends. Enhancements that will facilitate on-the-fly diversions to other bridge crossings, as circumstances require, would be welcomed by OEMs and their logistics partners. There is an opportunity to get the best technology in place, in this regard, to greet the much anticipated opening of the Gordie Howe Bridge.

Canada-US bridge crossings obviously account for a tiny percentage of the length of transborder automotive corridors. For all other corridor locations, we believe that pooled GPS data sources that are available to governments and academic stewards of such data, and which have time lags before they can be accessed, are likely adequate for the required understanding of how corridors are performing and where localized bottlenecks are occurring. Chapter 4 of this report demonstrates how key southern Ontario corridors performed in 2022 for one simple performance measure. Overall, the carriers and logistics providers of OEMs have the real-time tools and travel time buffers in place to appropriately navigate the unplanned bottlenecks that occur along non-border corridors.

In closing, cross-border co-operation is an important aspect of moving forward. During this project's engagements, it was exemplified by some OEMs assembling a panel with representatives on both sides of the border to answer our questions. It was also exemplified by cross-border sessions involving participants from McMaster University, the University of Windsor, the Texas Transportation Institute, the Federal Highway Administration and Transport Canada. Future research initiatives should be pursued with this formula to ensure that all stakeholders are as well-informed as possible about how critical border crossings and their vicinity are performing at any given point in time.

1

Introduction

There is arguably no sector in the economy that is more prominent or significant in the minds of Ontarians and many Americans than the automotive manufacturing sector. The rich history and promising future of this sector has depended, and will depend, on the relatively seamless flow of goods between the United States and Canada. In fact, the development of advanced just-in-time supply chains has practically been premised on that, and associated trucking corridors penetrate quite deeply into Southern Ontario and the US (especially the Midwest) as a critical enabling mechanism. Figure 1-1 gives a sense of this.

It is difficult to overstate the importance of the automotive sector to the Ontario economy in terms of the myriad jobs and economic activities that it supports. The automotive sector in Ontario has traditionally been very inter-connected with the US economy and the proposed work is premised on the idea that prosperity for Ontario in this regard will continue to rely on these types of inter-dependencies, even in a time of rapid change for the automotive sector, with electrification emerging as a defining trajectory for the future. The emergence of electrification, and all that it implies for the sector, is a big part of the motivation for this study.

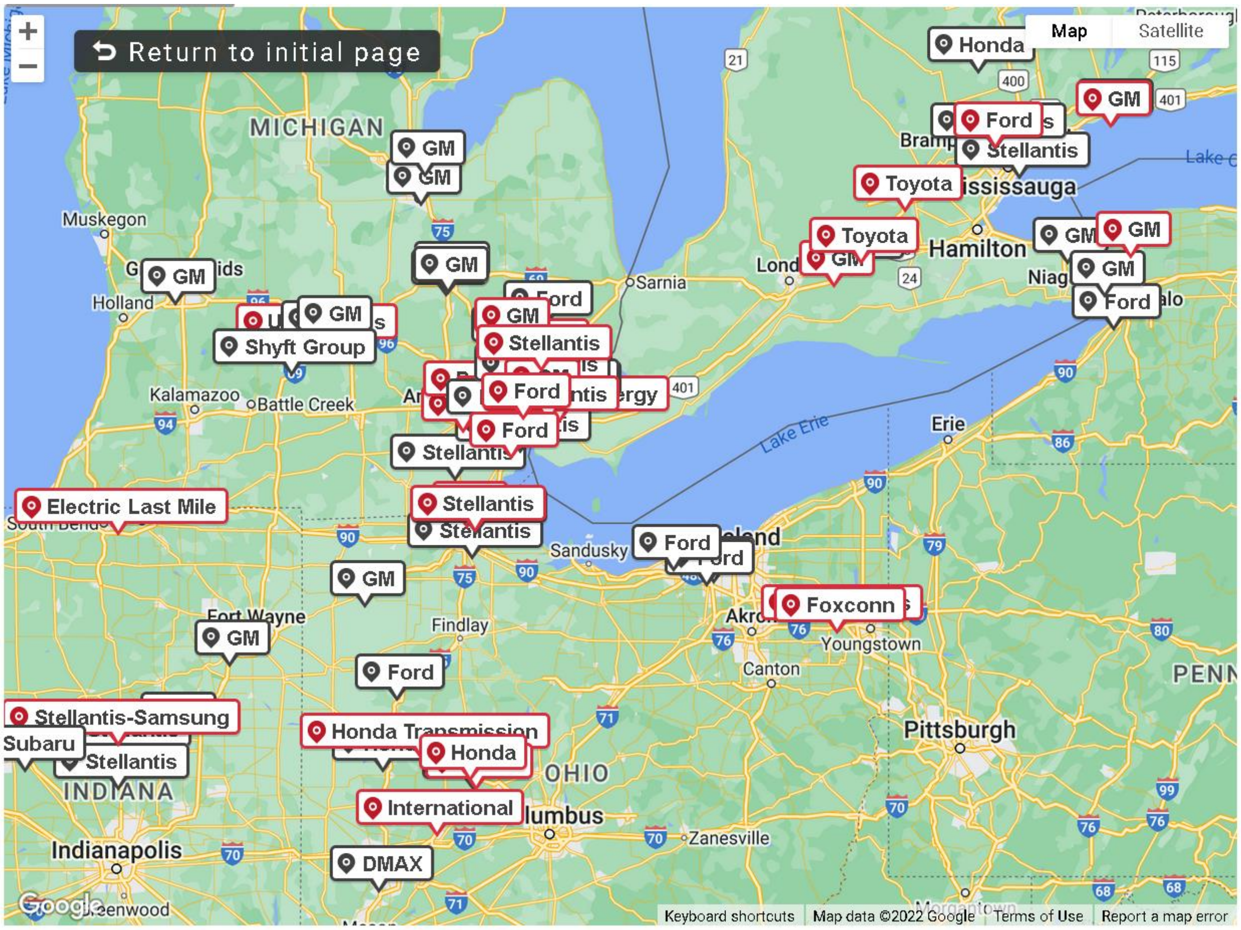

Figure 1-1: Positioning of Key OEM Facilities (source: www.marklines.com)

With the advent of the pandemic, challenges to fluid supply chains emerged, but the protest incident that took place on the Ambassador Bridge in February 2022, which itself was related to the pandemic, caused unprecedented shockwaves for the industry for a relatively brief period. The period since the onset of the pandemic has revealed, more than ever, the importance of supply chains to Canada's economy, and it is also clearer than ever that strong cross-border trade connections with the United States are critical to the economies of Ontario and Canada. In recognition, the recent Final Report of the National Task Force on Supply Chains recommended to: "*Engage the U.S. and the provinces/territories to achieve reciprocal recognition of regulations, policies and processes to enhance transportation supply chain competitiveness and productivity*."

This report is initiating activities that are aligned with this recommendation of the Task Force and which are also aligned with a Transport Canada mandate to focus on the efficiency and resilience of important and strategic transborder corridors. The report aims to set the stage for Transport Canada to monitor the performance of such corridors for the particular context of trucking and to examine what degree of monitoring seems appropriate. It brings an opportunity for Transport

Canada to link highway performance metrics to supply chain efficiency, fluidity, velocity, and resilience. It also allows for an opportunity to align with the Federal Highway Administration (FHWA) performance measurement.

This report (which is a joint effort between the McMaster Institute for Transportation and Logistics and the University of Windsor Cross-Border Institute) studies the potential to effectively measure the performance of strategic **transborder** trucking corridors that are important for the automotive manufacturing sector in Ontario, bearing in mind the additional layers of complexity that are associated with having to assess corridors that span two countries.

This study is organized as follows. Chapter 2 is focused on ways in which performance can be measured along transborder corridors, taking into account aspects such as available measures, technology and data. Chapter 3 outlines, on a thematic basis, the outcomes of a series of engagements that were held with six different leading automotive manufacturers. Five of these presently have manufacturing operations on both sides of the border. These engagements sought to investigate how OEMs are thinking about transborder corridors in this period of rapid change. Chapter 4 presents benchmarking aspects of the current situation to offer a frame of reference for the future. A brief analysis of average corridor performance in Southern Ontario is provided based on 2022 data.

Finally, a concluding section will summarize the key outputs of the study. In addition, it will identify insights and processes that could be transferable for other corridors, regions or economic sectors (and for other cross-border trucking contexts).

Measuring Performance Along Transborder Corridors

2.1 Overview

The efficient movement of goods across a transportation network is essential for maintaining and growing an economy, whether at the urban or national scale. In the province of Ontario, the automotive manufacturing industry has a strong presence, contributing a significant amount of cross-border freight trade. The highway system serving the province of Ontario has been studied over the past two decades to identify its most critical portions. Highway 401, part of the Montreal-Windsor corridor, and highway connections to the main international border crossings (Highways 401 and 3 to the Ambassador Bridge: Windsor – Detroit, MI; Highway 402 to the Blue Water Bridge: Sarnia - Port Huron, MI; Queen Elizabeth Way to the Peace Bridge: Niagara region – Buffalo, NY) have been consistently identified as some of the most critical portions of the road network (Ashrafi et al., 2017; Madar et al., 2020; Maoh et al., 2016). These corridors also connect to important segments of the American highway system to facilitate the significant trade between Canada and the United States (US). Some key corridors are highlighted for trips connecting Toronto and Chicago, namely interstates I-94 and I-69, connecting through the Blue Water Bridge in Sarnia, and interstates I-75, I-96, and I-94 connecting through the Ambassador bridge (Gingerich et al., 2015). Another important trade corridor, accessible via I-75, is with Toledo. These segments of the network facilitate the movement of large volumes of freight, both by weight and by value, and serve to connect important trade centres.

The highway connections have always emerged as major corridors for Canada-US cross-border trade, as evidenced through truck GPS data (Maoh et al., 2021). Disruptions and delays along these critical portions of the network have the potential to severely impact the economic productivity of the region. The Ontario road network has been the subject of recent study with respect to measures of robustness (Madar-Vani et al., 2022). Freight flows were explored at the industry level, given the expectation that different portions of the network will be considered critical for the movement of different types of goods. Considering the value of the goods carried across the network also adds another level to the robustness indicator by incorporating economic effects.

2.2 Concepts, indicators, and measures

Performance measures for logistics operations have been an important consideration to researchers for decades. A review of such measures was compiled by Caplice and Sheffi (1994), who evaluated metrics with respect to eight criteria: validity, robustness, usefulness, integration, economy, compatibility, level of detail, and behavioural soundness. Performance metrics were grouped based on utilization (inputs), productivity (process), and effectiveness (outputs). Incorporating the actual flow of goods across the transportation network, research efforts at Transport Canada pioneered the concept of freight fluidity, which has emerged and gained increasing traction in the past decade (Gregory and Kwiatkowski, 2011). Freight fluidity encompasses measures and indicators to describe the performance of the freight transportation system, trade corridors, and multi-modal supply chains. It is closely related to the concepts of network resilience (the network's ability to return to a state of equilibrium after a disruption), robustness (the network's ability to withstand disruptions), rapidity (the speed with which the network regains functionality after a disruption), and redundancy (the availability of secondary routes) (Eisele et al., 2016). Additionally, fluidity is also described through the current nature of freight flows on the network, which is influenced by the level of congestion, available (or lacking) capacity on roadway links, and border thickness, given by security measures in place at border crossings (Brown and Anderson, 2015).

A recent MITL report sheds light on the data sources that can inform performance measures in the province of Ontario at a multi-modal scale and considering the needs of stakeholders ranging from freight carriers to federal government agencies (Ferguson et al., 2018). Following a detailed review of a number of comprehensive freight performance frameworks across North America for all major modes of freight transport, the report notes that an effective approach is to focus on a small set of key indicators. In the case of the trucking mode, proposed performance measures center around travel distance, time, and delay (including at border crossings), emissions, road safety, and infrastructure conditions. More recent research reveals that data integration, such as can be achieved through global governance or integration with the Metaverse, leads to more efficient and effective decision-making (Deveci et al., 2022). Each of these concepts can be quantified and serve as performance indicators of freight fluidity, as they describe the ease with which freight can traverse the network.

Table 2-1: Fluidity indicators currently in use

Performance Indicators	*Measures*	*Quantification*
Reliability	• Resiliency; robustness; rapidity; redundancy • Continuous flow; just-in-time delivery; safety and risk	Network analysis; planning time index;
Speed	• Transit time; border processing time; dwell time; perishability	Fluidity index; travel time index; freeway planning time index; buffer time index
Cost	• Volume; weight; value • Wasted fuel; congestion cost	Dependent on delay

Table 2-2: Data requirements and potential data sources to inform fluidity indicators

Measures	*Required data*	*Data source*
Border fluidity	Border crossing data (crossing times, wait times, etc.)	Border control agencies
Costs	Fuel cost, delay penalties	Freight shippers/carriers
	Shipment information (weight, value, commodity type)	Freight shippers/carriers
Performance indices (PTI, FI, TTI, BTI)	Performance (travel time, congestion, speed)	INRIX, HERE, state/provincial departments of transportation
	Network characteristics (capacity, speed, volume)	INRIX, HERE, state/provincial departments of transportation

An overview of data needs is provided in (Turnbull, 2016), which group data into categories for travel time, reliability, and cost, supplied for each mode of interest. Data requirements to inform the existing performance measures often include information on transit time/speed data of freight vehicle trips (Eisele et al., 2016, 2011; Liao, 2009; Turnbull, 2016). Additionally, datasets of freight truck GPS location pings have been applied in research to develop observations of routing patterns, distribution of destinations, and stop locations (Deveci et al., 2022; Liao, 2009). The Freight Analysis Framework is a valuable source of data for US freight shipments (Liao, 2009). Of course, information regarding the type and quantity (volume, weight, and value) of freight shipments must be included when examining criticalities (Eisele et al., 2016). The previously mentioned report from MITL (Ferguson et al., 2018) notes that in the Canadian context, there is a need for greater collaboration across Canadian jurisdictions to collect and standardize freight data.

Table 2-1 summarizes the measures that have come up consistently in the literature. The first column of the table shows the three key categories for performance indicators, namely reliability, speed, and cost of transport (Pisarski, 2015; Turnbull, 2016). The second column lists the different types of measures implemented to quantify these aspects, while the third column lists some of the approaches to calculate the respective measures. To date, measures of network performance related to freight fluidity have focused on measures relating to travel time. Reliability measures could be described by continuous flow, just-in-time delivery, safety, and risk of shipments, whereas perishability and inventory costs give an indication of speed performance measures. Table 2-2 summarizes the data requirements for the performance measures and indices that appear consistently in the literature and possible sources for this data.

Travel time reliability appears to drive the development of some of the more commonly implemented performance indices (Cedillo-Campos et al., 2019; Eisele et al., 2016). The initial formulation proposed by Transport Canada includes two indices, the fluidity index (FI) and planning time index (PTI) (Eisele et al., 2011). The fluidity index compares the average travel time during a time period of interest to the free flow travel time to capture the average conditions of network travel. The planning time index compares the 95th percentile travel time (near-worst-case scenario) to the free flow travel time, accounting for high-priority urgent shipments and capture daily variations in travel time. An alternative approach defines the travel time index (TTI) and buffer time index (BTI) (Liao, 2009). The TTI is calculated as the ratio of peak travel time to free flow travel time and measures the level of congestion. The BTI is formulated by the difference between 95th percentile of travel time and average travel time, divided by the average travel time. The BTI measures travel time reliability along a freight corridor.

2.3 Applications of freight fluidity measures

In addition to its Canadian applications (Eisele et al., 2011), the concept of freight fluidity has also been applied to jurisdictions in the United States (Eisele et al., 2016; Pisarski, 2015) and Mexico (Cedillo-Campos et al., 2019). At a global scale, the INRIX Global Traffic Scorecard (Pishue, 2023) summarizes the most recent trends in urban congestion across over 1,000 cities, including detailed breakdowns for the most congested US cities and corridors. The global analysis is conducted using GPS-derived travel times for urban commuting. The Urban Mobility Report (Schrank et al., 2019) speaks to the state of congestion in the US and the associated implications with respect to the various costs due to delays. The National Freight Fluidity Program in the US represents an effort to understand the state of the transportation system, identify vulnerabilities, and implement strategies to improve the efficiency of supply chains (I-95 Corridor Coalition, 2018). Using publicly and commercially available data from a representative sample of establishments from different industry sectors, the framework implements travel time measures to calculate travel time reliability and cost of freight trips for each industry's supply chains. The data also accounts for commodity types, modes, and trade types (domestic, export/import). A similar framework has also been proposed for the state of Florida to analyze last mile flows, identify bottlenecks, and assess travel time reliability (Sakhrani et al., 2017). Freight fluidity has also been studied in the US for marine applications, with a recent application to the Port of Baltimore (Kruse et al., 2022). Similarly to the trucking applications, inbound and outbound travel times, as well as dwell times of ships within the ports informed fluidity measures. The baseline travel time (BTT) , travel time index (TTI) , and planning time index (PTI) were used as metrics of the port's performance and the findings revealed that variability in harbour stay time was the major contributing factor to the variability in port cycle time.

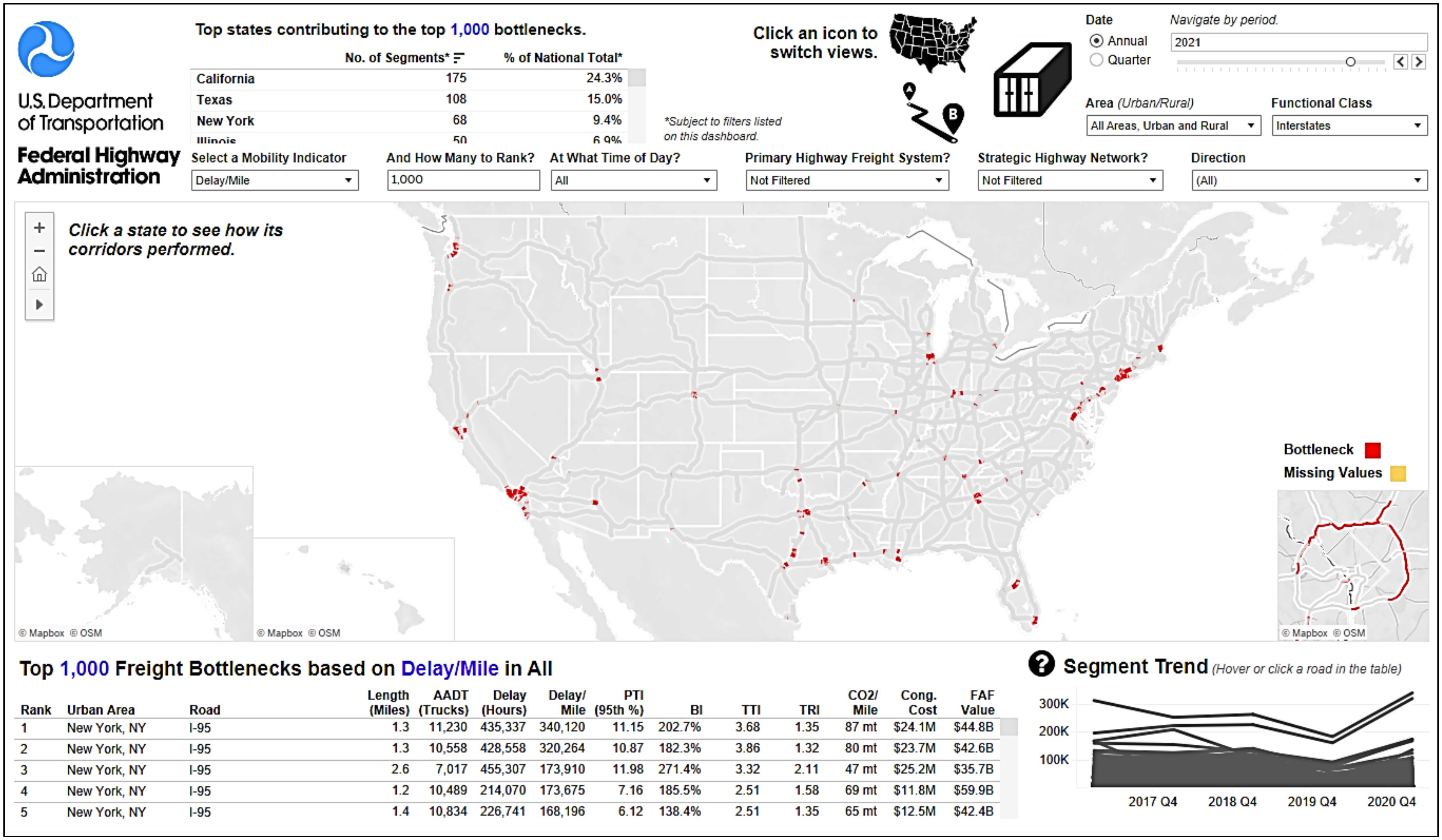

Figure 2-1: FHWA National Freight Bottlenecks dashboard provides a ranked list of freight bottlenecks at the national or state level, along with additional detailed information

The US Federal Highway Administration (FHWA) has developed several publicly available tools for visualizing critical freight corridors and their characteristics, including the National Freight Bottlenecks Workbook (FHWA, 2023). The following set of figures showcase the different visualizations available through these dashboards, including a number of performance metrics and mobility indicators (delay/mile, PTI, TTI, Buffer Index, Truck Reliability Index, CO2 emissions/mile, congestion cost, (FAF) shipment value). The corridors are ranked on the basis of these measures, which provides a valuable contribution to cross-border fluidity. The corridors connecting to international crossings between Canada and the US, especially those in Michigan leading to/from the Ambassador Bridge, corroborate the conditions present on the Canadian side, where the Highway 401 corridor comprises one of the vital trade corridors.

Figure 2-1 shows the overview of all US corridors included in this ranking, with those marked in red highlighted as the top-ranked bottlenecks, while Figure 2-2 zooms in on the Detroit region, highlighting highway I-75 (one of the connections to the Ambassador Bridge) as the top-ranked bottleneck for the State of Michigan. Similar views of the highway connections to the Blue Water Bridge and Peace Bridge are respectively shown in Figures 2-3 and 2-4. These rankings and measures provide valuable information about the criticalities present on the US side of the border. Connecting this information to an analysis of the Canadian freight network will lead to a more holistic understanding of the conditions and needs of the transportation system. The rankings of the US highways also, once again, highlight the importance of the connectors servicing the international border crossings.

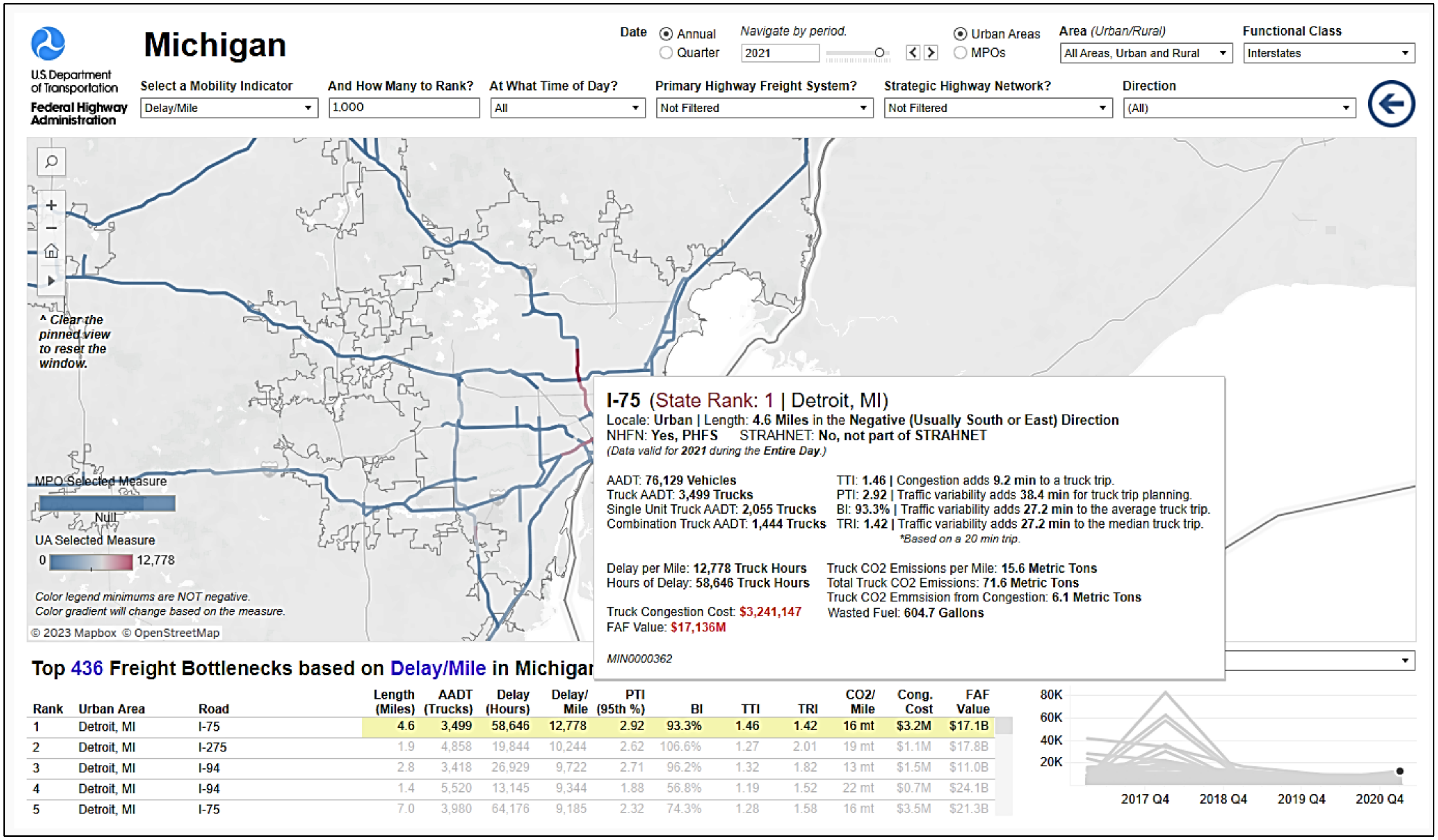

Figure 2-2: FHWA National Freight Bottlenecks dashboard highlighting the Detroit region and a highly-ranked bottleneck corridor of I-75

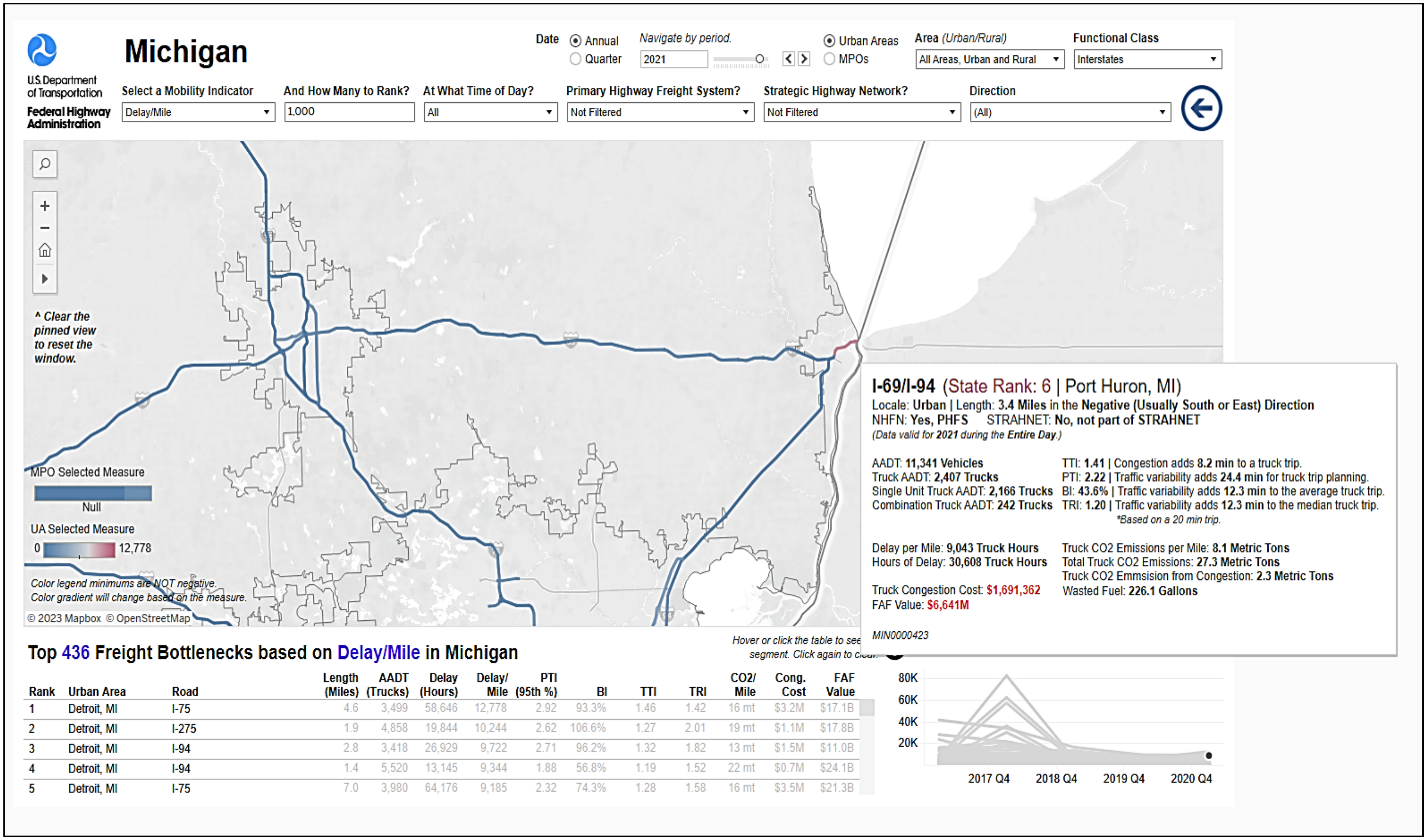

Figure 2-3: FHWA National Freight Bottlenecks dashboard showing the I-69/I-94 highway connection to the Blue Water Bridge

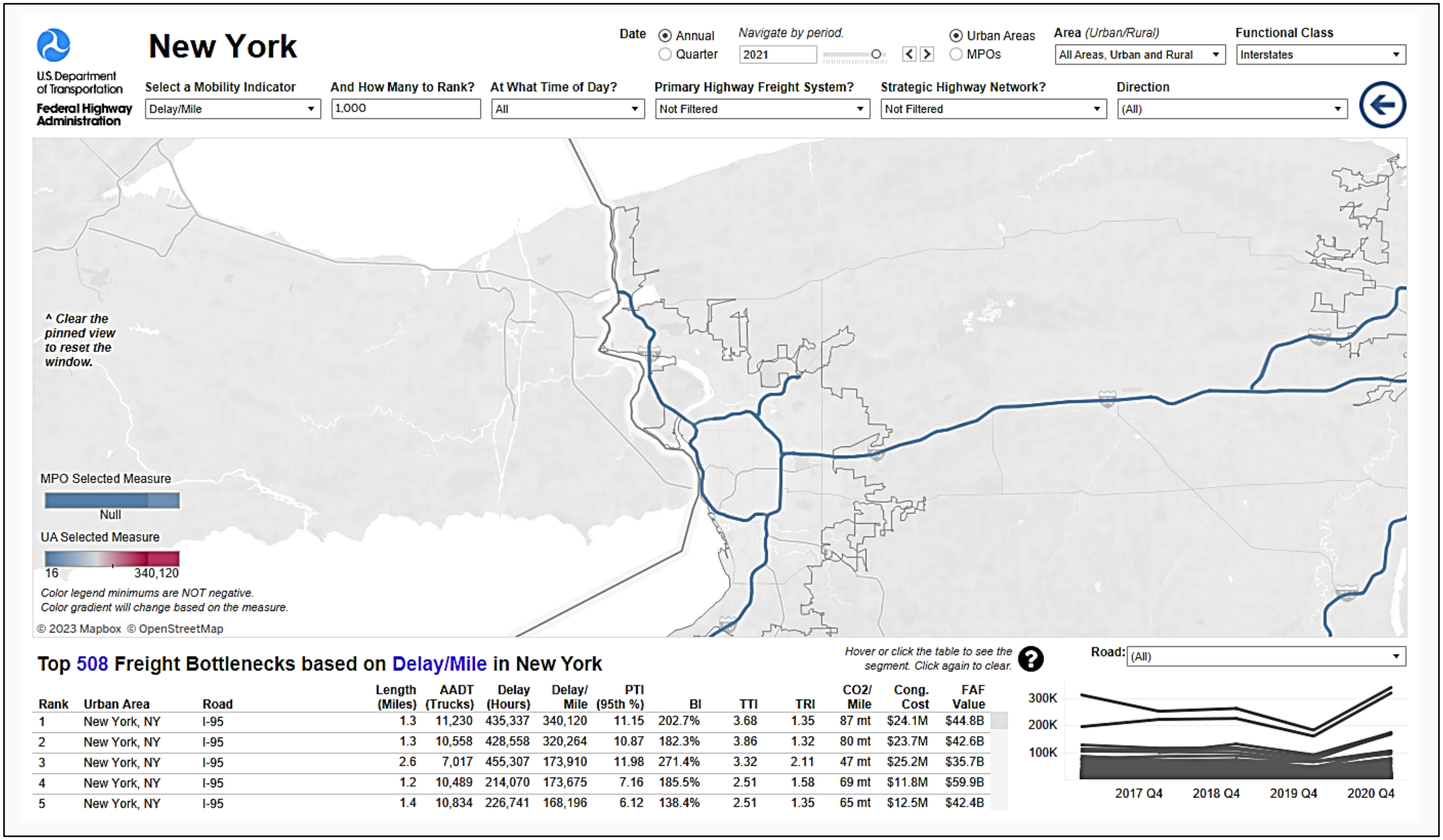

Figure 2-4: FHWA National Freight Bottlenecks dashboard showing the I-190 highway connection to the Peace Bridge and the Queenston-Lewiston Bridge

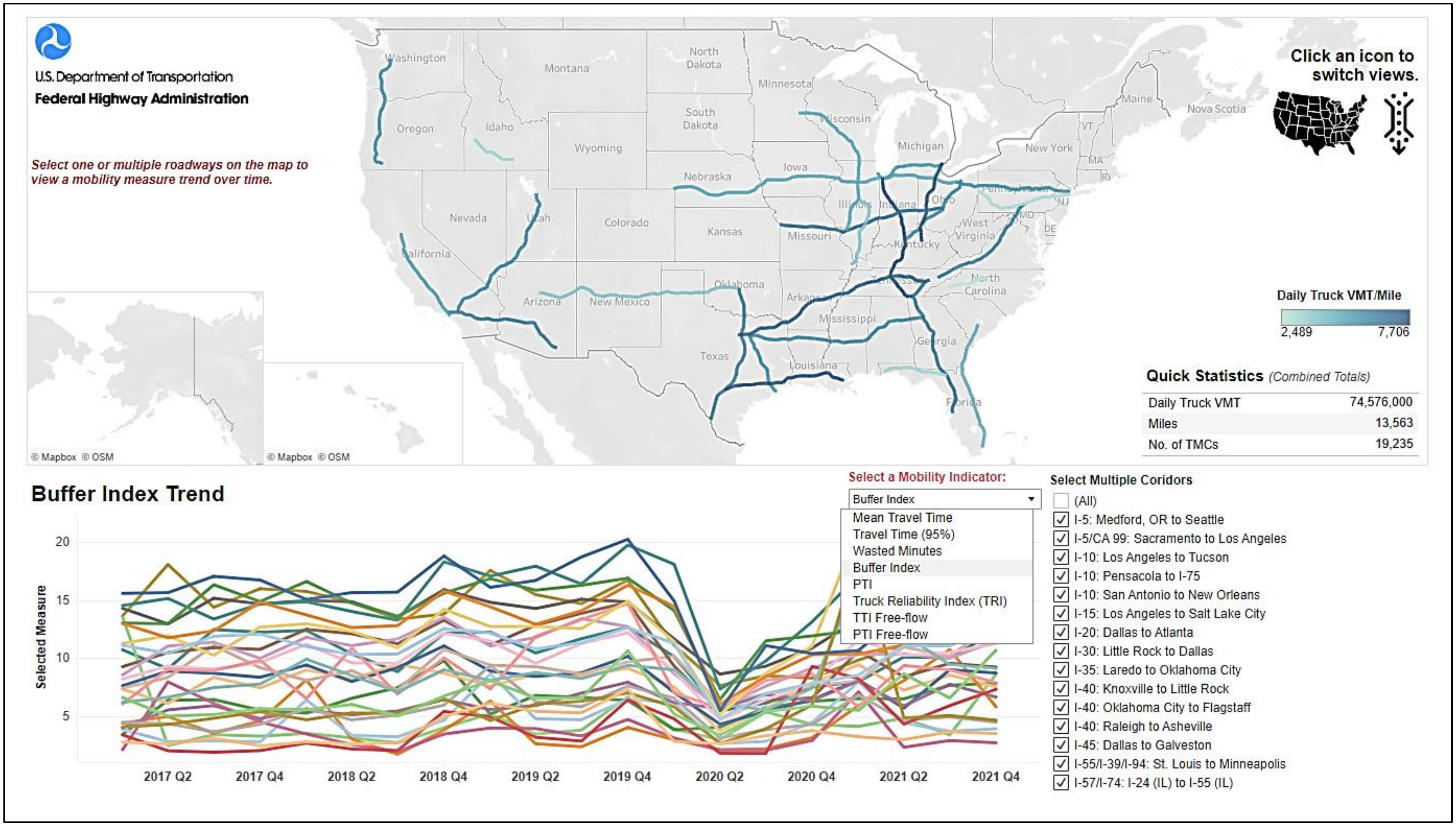

Figure 2-5: FHWA Freight Commodity Corridors dashboard provides an overview of national freight corridors and associated performance measures

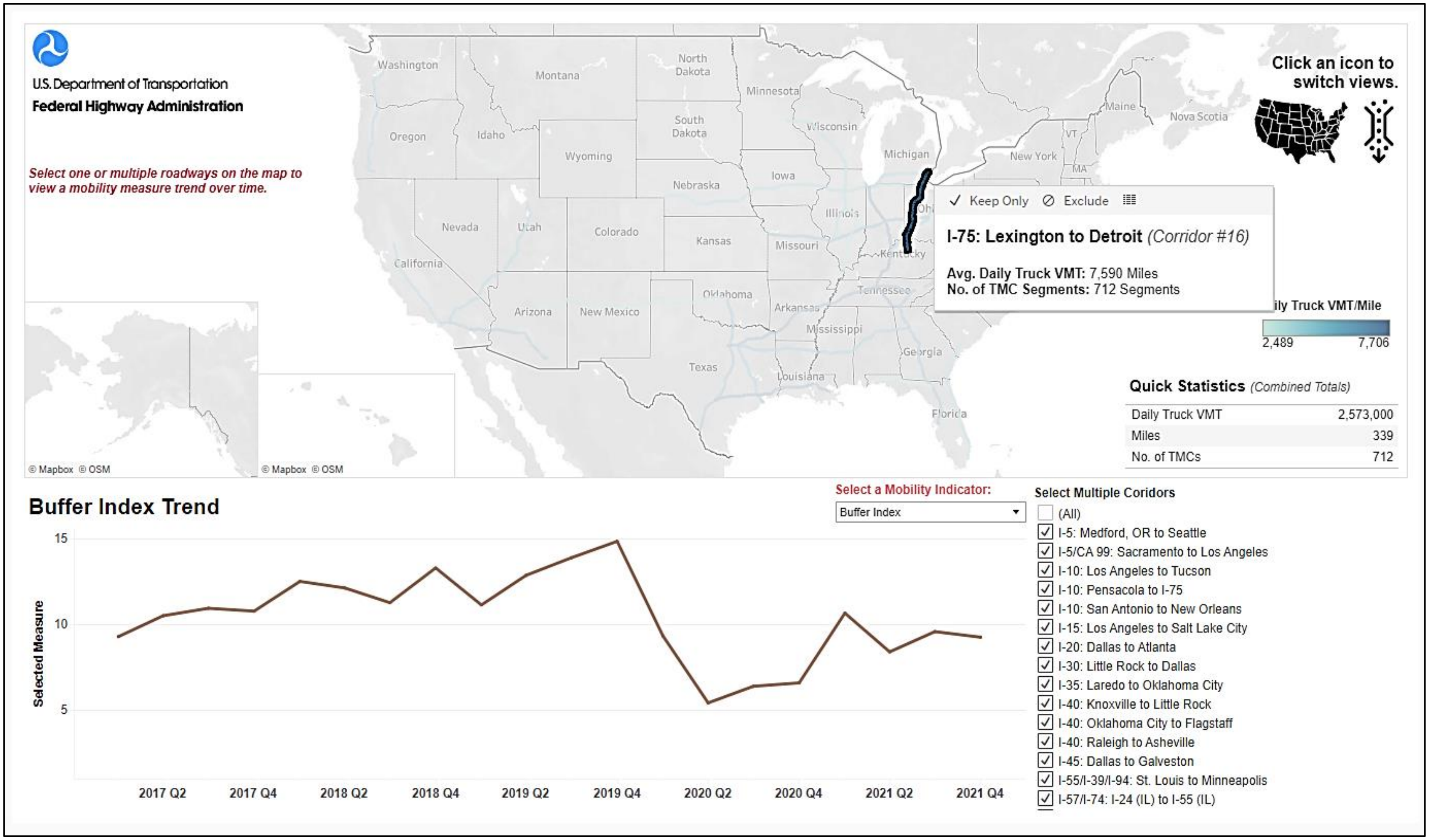

Figure 2-6: FHWA Freight Commodity Corridors Dashboard highlighting the I-75 corridor from the Ambassador Bridge in Detroit

A second tool made available by the FHWA is the Freight Commodity Corridors dashboard, which visualizes the change in selected mobility measures over time for the most critical highway corridors (FHWA, 2023b). Figure 2-5 shows the default view, comparing all corridors included in the analysis, while Figure 2-6 isolates the I-75 corridor to explore the trends observed specifically for this highway segment.

2.4 Cross-border fluidity

Cross-border freight movements will be subject to some behaviours and decision-making processes that differ from freight activity within the country. A survey of Canadian freight shippers revealed that the border plays an important role in the way that cross-border freight activities occur. Shippers are sensitive to border delays and costs, potentially leading to increased reluctance to engage in cross-border trade (Maoh et al., 2017). Border crossing times have been studied for the three major crossings between Ontario and the US (the Ambassador, Blue Water, and Peace Bridges) to identify the impact on border delays on freight trips. While the majority of trips experience a minimal delay, those for which the delay comprises over 5% of the travel time are not negligible (Gingerich, 2017). Freight activities may account for expected delays, however any additional unexpected delays can curtail productivity. Eisele and Villa (2015) recommends that performance measures for freight fluidity be appropriately scaled, both in terms of geographic and temporal scales. That is to say, performance measures and quantification of freight flows ought to be computed for individual corridors and gateways across different modes of interest, by appropriate time intervals, with the ability to expand the scope as needed.

One instance was found in the literature of freight fluidity concepts being applied to a cross-border context, where freight movements between Texas and Mexico were examined (Eisele and Monsreal, 2017). The Border Fluidity Index (BFI) was presented here, using data from the Border Crossing Information system on wait time and crossing time for the points of entry along the Texas-Mexico border. The BFI includes all segments of cross-border trips, including travel time in both countries of origin and destination, processing times on both sides of the border, as well as the border wait time. The BFI includes elements of travel time, travel time reliability, and transportation cost, expressed through respective indices.

As the literature concerning the fluidity of cross-border movements is not extensive, this creates an opportunity for the current research to fill this gap in knowledge by examining the significant volumes of freight crossing the US-Canadian border using similarly defined performance measures. Quantifying the fluidity of the three major border crossing mentioned above with respect to the considerable amount of freight activity generated by the automotive industry will introduce an additional layer of realism to the characterization of Ontario’s transportation network and the identification of criticalities.

2.5 Cross-Border Institute data and research work

The Cross-Border Institute (CBI) at the University of Windsor has been studying the movement of trucks across the Ambassador Bridge for the past 10 years. The CBI has deployed traffic sensors (namely, Remote Traffic Microwave Sensors (RTMS)) on Huron Church Rd to detect and record the count of US- and Canada-bound trucks (by size) that cross the Ambassador Bridge. The recorded data provide the number of trucks that were detected by the RTMS every five minutes for each lane. As a radar sensor, the RTMS records the vehicle that it senses while the vehicle passes through the field of view. The recording starts when the vehicle enters and exists the field of view, as shown in Figure 2-7. Typically, the RTMS is calibrated to detect vehicles moving in a particular lane. For instance, Huron Church Rd consists of three lanes and so the RTMS is calibrated to detect the vehicles in each of the three lanes pertaining to a given direction. The detected vehicles by the RTMS can be viewed in real time using an RTMS Utility software, as shown in Figure 2-8.

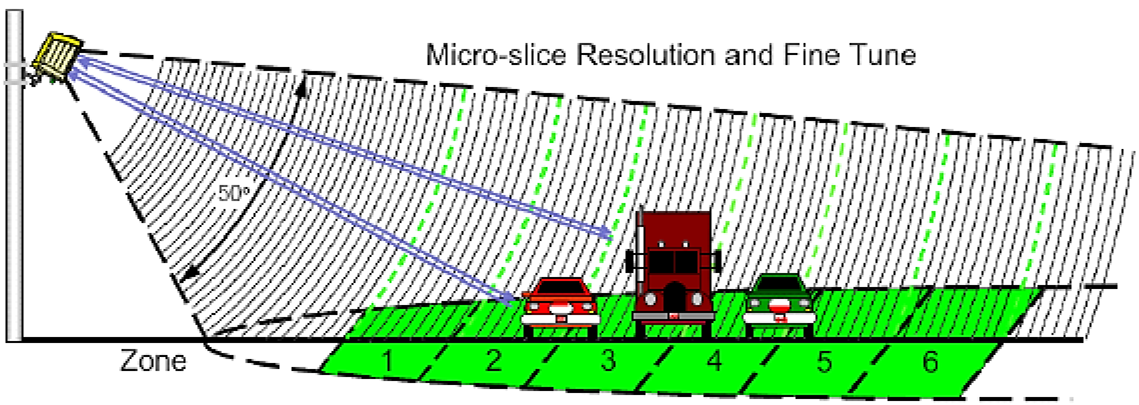

Figure 2-7: Beam range of RTMS (Source: Image Sensing Systems Inc., 2013)

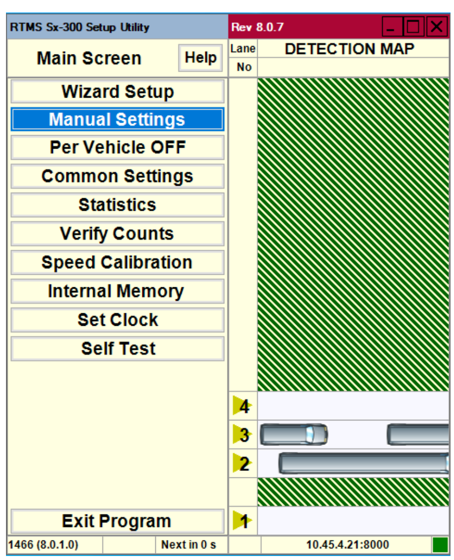

Figure 2-8: CBI's RTMS utility for US-bound traffic

The detected vehicles are recorded based on their length. The breakdowns shown in Figure 2-9 highlight the classification scheme used by the CBI's RTMS.

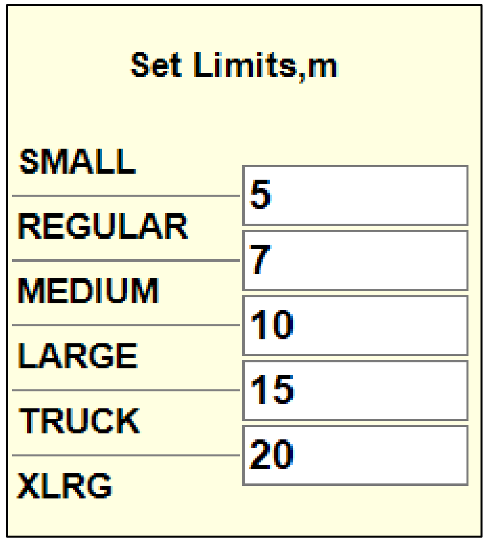

Figure 2-9: CBI's TRMS vehicle classification based on vehicle length

Beside the RTMS data, the CBI has also utilized truck GPS data to study the movement of trucks through Canada's major land borders including the Ambassador Bridge. More specifically, the truck GPS data was used to study cross-border delays. The conducted work provided a better understanding of the crossing-times distribution at major land borders in Ontario and has resulted in a number of studies. For instance, Gingerich et al. (2016a) provided novel results on the nature of border-crossing time by type of industry and length of trip between the origin and destination for the two major U.S.-Canadian land borders. Another study by Gingerich et al. (2016b) introduced the concept of entropy to classify truck stop events that are derived from truck GPS data into primary and secondary. The novelty in the study is the ability to utilize a concept like entropy to characterize the type of truck stop events. Other noteworthy studies that looked into the movements of trucks across the Canada-US border include Maoh et al. (2016), Maoh et al. (2018) and Anderson et al. (2019). Further, a recent study by Maoh and Anderson (2021) examined the impacts of COVID-19 on the movement of trucks across the Ambassador Bridge. The study utilized RTMS data to examine the pattern of border related truck traffic before, during and after the pandemic. The study offered novel results which indicated that while the pandemic had a short-term impact on truck movements (i.e., for one month only), the flow of trucks started recuperating in May of 2020 and returned to above normal during the summer of 2020. The study concluded that such results indicate that the industrial supply-chains across the Canada-US border are highly resilient.

Research at the CBI also focused on understanding the border crossing choice behavior of Canadian trucks. The study by Maoh et al. (2021) focused on all trucking trips that moved across the four major land borders in Ontario and the USA. The study offered new insights into the role that the geography of the trips origin and destination plays when it comes to the choice of a land border. Further, the work in Moniruzzaman et al. (2016) made use of both GPS and RTMS data to develop models for predicting the volume of trucks and the crossing times (minutes) on the Ambassador Bridge. The objective of the models was to predict volume and crossing times in 15-minute intervals up to 2 hours in advance. A number of artificial neural network (ANN) models were developed, trained and validated. The results were promising suggesting that data such as the ones utilized by the CBI can be used to develop predictive models for land borders.

2.6 Summary Thoughts on Performance Measurement

The concept of freight fluidity has been gaining traction over the last decade or more. As such, travel-time-based performance measures have since been implemented in a variety of applications and jurisdictions. The fluidity of the transportation network is governed by the network's reliability, speed, and the associated cost of transport. Research has found travel time to be a consistent proxy to quantify these indicators. The current chapter outlined metrics consistently appearing in the literature, including the Fluidity Index, Planning Time Index, Travel Time Index, and Buffer Time Index. Possible sources of data to inform these measures include location-based sensor data (e.g., HERE or INRIX datasets), state or provincial transportation survey data, data from freight shippers or carriers, and information from border control agencies. Figure 3-10 offers an overview of some of the key aspects related to this chapter.

Freight fluidity measurement across international borders in North America has been explored in a limited fashion so far, with the literature revealing research only for the US-Mexico context. Cross-border fluidity can be quantified using similar performance measures as established freight fluidity approaches that employ travel-time-based indices. The Border Fluidity Index that has been developed in the US context, considers all segments of cross-border trips, including legs of travel on both sides of the border, as well as the cost, time, and reliability associated with the border crossing itself. There is good potential for these measures to be implemented in Canada-US cross-border contexts that are relevant for automotive and other supply chains.

Figure 2-10: Summary of Chapter Concepts

3

Results of Engagements with Major Automotive Manufacturers

Engagement processes with the major automotive manufacturers were arranged predominately during January 2023 and carried out in February 2023. Both the Global Automakers Association and the Canadian Vehicle Manufacturers Association were consulted to help identify the best specific contacts per automotive firm.

The engagements sought to gather intelligence on how these primary original equipment manufacturers (OEMs) evaluated key transborder highway corridors and which ones were thought to be most important. Those basic insights were originally intended as a means to an end in determining which corridors to focus on. As it turned out, the discussions turned out to be quite rich and detailed, and provided information to help to shape the nature of future inquiry and in directions that might not have been anticipated.

The engagements were semi-structured in nature and were partially governed by a list of questions which are shown in the Appendix . With this approach, the discussions were governed by a structure that would not act as a "straight jacket" should further lines of questioning arise naturally.

Table 3-1: OEMs that were consulted and when

- Toyota (February 2nd)
- Honda (February 3rd)
- Ford (February 7th)
- GM (February 9th)
- Mercedes (February 9th)
- Stellantis (February 23rd)

Table 3-1 identifies the OEMs that participated in these discussions and the dates on which each discussion took place. The identities of the OEM representatives that were involved are not revealed in this report and the results presented below generally do not reveal the particular OEM that offered the feedback.

The organization of this chapter is straightforward: essentially sub-sections of the primary themes that have emerged are presented and these are accompanied by appropriate discussion to provide the necessary colour. These written sections are based on careful analysis of the audio recordings of the sessions that took place.

3.1 "Existential" Infrastructure

In these discussions, border infrastructure was essentially viewed as "existential" by multiple Canadian representatives of OEMs and one OEM used precisely this term to describe the primary bridge crossings from Michigan into Ontario.

For that OEM, the blockade of the Ambassador Bridge in February 2022 shut down Canadian production for 6.5 days and also certain US production sites in the Midwest for 3.5 days that were dependent on materials flowing in from Ontario. It was stated that if the Ambassador Bridge were closed again, for whatever reason, that "there is nothing that can be done" and operations would shut down again within "one or two days." This OEM also stressed the importance of key 400-series corridors in Ontario saying that their operations would "die" if Hwy 401, 402, and 403 were not running smoothly.

A second OEM emphasized that whether components are coming from as far away as Mexico, or many other places in between, that "we don't use a lot of crossings." The Ambassador Bridge especially was highlighted as fundamental, and the Gordie Howe Bridge was anticipated to be so.

This OEM noted that the free flow of traffic at the border to ensure that their commercial trucking carriers can cross in the most automated fashion possible is “critical.” This OEM as well experienced shutdowns during the 2022 incident and encountered excess costs from associated inefficiencies that had a big impact on their financial performance in 2022. Events such as what happened in 2022 may occur in a context where a bounce back “recovery opportunity” is not possible, especially if planned production is full and production and supplier capabilities are “maxed out” at the time and into the foreseeable future. It was further stressed that any delay at the border (or the apron where trucks come off after negotiating the bridge) can cause a whole “daisy chain” of backups within the industry.

This OEM emphasized that “regardless of how the supply chain feeds in … we need to ensure our borders are open” and that this was not only for the movement of product. Smooth cross-border movements of people in support of automotive supply chains was stressed as well. While cross-border infrastructure was placed on a pedestal for its importance, it was stated that “every road, route, bridge, tunnel are all vitally important” in relation to key corridors infrastructure beyond the border.

3.2 Continuing Importance of the US Midwest (with newer extensions to the South)

One aspect that is consistent across the OEMs with a strong presence in Ontario is the significance of the US Midwest states to their operations. One OEM characterized the important cross-border lanes as being Ontario-Michigan, Ontario-Ohio, Ontario-Indiana, Ontario-Mexico, and Ontario-Texas (all of these implying connection as opposed to direction). These lanes all have in common that they need to cross at the major Michigan-Ontario connection points. It was noted that “almost all logistics with the US are coming across via Michigan.” Another OEM stressed Ontario, Michigan, Ohio, Tennessee, Indiana and Illinois as hosting the majority of their suppliers while also noting an emerging “more dispersed supply base” in the southern US (e.g., Tennessee, Texas, Alabama, Mississippi) in reference to themselves and other OEMs.

In terms of how the US portion of the main corridor is perceived, most OEMs tend to highlight I-75, which is important for connections to Ohio, Kentucky, and Tennessee. Even West Virginia, which is less commonly mentioned, hosts an engine plant for at least one OEM that was described as being locationally enabled by the I-75 corridor. The Mississippi River was mentioned as another unifying geographic feature to characterize the location of plants and supply base, especially considering a longer distance perspective that may extend into Texas and Mexico.

Conspicuous by its absence is any real emphasis on the Niagara border crossings. Ford, for example, mentioned its Buffalo stamping plant for sheet metal. As far as the Niagara crossings are concerned, Buffalo is connected in a handful of cases but there is little mention of connections beyond, that use the I-90 or I-81 corridors, as examples.

There was no real sense from the discussions that electrification is going to cause any shift in emphasis away from the Midwest (or its more recent extensions to the south). Toyota identified its upcoming North Carolina battery plant as a facility that features prominently in their initial electrification thrust. Alabama was identified as an important US manufacturing centre for Mercedes and this continues to be the case with the emergence of EVs.

3.3 Resilience/Redundancy

The themes of system resilience and redundancy were prominent during the discussions. The Ambassador Bridge blockade was a stern test of system resilience and redundancy, and essentially the system was found wanting. When the Ambassador Bridge was blocked, the Blue Water Bridge in Sarnia picked up some, but not enough, of the slack (based on the feedback).

One OEM noted that the bridge crossings are not equipped equally to process goods flows. Rerouting solutions to Sarnia were tried at the time of the blockade but these efforts failed to a large extent because there were too few lanes and too little staffing in any case. Capacity for the FAST program was noted as important at the border as well but alternates did not have enough relative to what was lost at the Ambassador Bridge. For this OEM, the takeaway was that government leadership needs to be coordinated federally, provincially, and municipally to achieve “an elevated and quick response” in scenarios such as what was experienced.

A second OEM alluded to how the crisis at the crossings caused many drivers to “time out.” With trucks essentially parked or moving very slowly on the bridges, the delays had drivers concerned about breaking the rules if their shift exceeded the legal limit. There were OEM efforts to gain exceptions, given the circumstances, but apparently many drivers were wary and did not want to risk penalties. The OEM described this situation as a type of “workforce” bottleneck, but it seems clear that during the crisis, multiple factors were interacting to induce even worse outcomes. The main underlying cause in this example (other than the protest itself) was an inability of the system to cope when the leading bridge was closed with the difficulties not necessarily being infrastructural in nature. The bottom line for this OEM was that in the future, they do not want their trucks to be “sitting on the bridge or on either side of the bridge” for significant periods of time.

OEMs were asked to comment on bottlenecks of concern, and other than the bridge crossings, the next ranking concerns seemed to relate to work stoppages at major Canadian and US ports or in the rail sector, which were seen as putting pressure on the logistics system. These seemed to rank higher than particular road bottlenecks along major trucking corridors. One noted that an "internal industry" has practically been created to detour around major ports suffering problems. The example of Tacoma was used in relation to avoiding periodic Port problems at Vancouver or Prince Rupert due to strikes or work actions. Rail disruptions were seen as problematic as well. This OEM saw port issues as being port-specific more so than globally related.

A second OEM tied issues with Ports and other important locations to the potential for increases in international trade (some potentially tied to electrification). They suggested that as Canada embarks on trade agreements, that the infrastructure needs to be there to support the trade agenda.

3.4 The Scale of Trucking Movements (Cross-Border and Otherwise)

OEMs with large North American supply chains generate a significant number of truck travel miles within North America per year through their respective carriers. To give some sense, the US Bureau of Transportation Statistics estimated that in 2020, domestic truck activity of all types collectively amounted to approximately 300 billion miles travelled. Automotive OEMs, with their extensive supply chains, are among the larger firm-specific contributors to these totals. The total annual miles travelled for all OEMs in North America is in the billions.

As it relates to Canada, the majority of truck miles occur in the Province of Ontario due to the concentration of OEM and supplier manufacturing-related operations in Ontario compared to other provinces. Cross-border movements and mileage appear to be slightly skewed toward the US bound direction. Relative to most Intra-US movements, those that were cross-border were characterized as high mileage (and a lot of volume) but lower frequency. The cross-border movements were contrasted with Michigan-to-Michigan “shuttle network” movement which are higher frequency between plants and offsite locations. Because manufacturing plants tend to operate from Monday to Friday, it was suggested that freight related to OEM manufacturing operations often crosses the border into Ontario at the end of a week (e.g., Friday) so that it arrives at the plant earlier in the following week. For longer truck movements (e.g., from the Southern United States), it appears that the border crossing might be more in the middle of the week. It also appears that Ambassador Bridge is preferred over the Sarnia crossing likely due to the fact that the Ambassador Bridge is oriented to a wide swath of states centered on the I-75 corridor.

3.5 Some Stability and Some Change

It was natural during engagements to discuss the implications for supply chains of electrification so that a linkage could be made to specific travel corridors. The main result of these discussions was that while much was expected to stay the same, significant change was expected as well. The early part of this section deals with the stable aspects while the latter part examines significant changes.

To assess a question about the stability of supply chain sourcing with electrification, an OEM noted that 50% of their vehicle content comes from the US, 10% from Mexico, 30% from Canada and 10% from Asia. It was suggested that they did not see these allocations changing dramatically with the rise of electrification. They noted that with plug-in hybrids (PHEV) and hybrids (HEV), almost everything is being retained, relative to internal combustion vehicles, in terms of parts and components. In the cross-border sense between Ontario and the Midwest, this OEM foresaw a similar dynamic with elements of battery supply chains swapped in as other elements were swapped out. The establishment of more battery manufacturing in Canada (it is mostly all earmarked for the US for them as things stand) could modify that equation.

Even battery electric vehicles (BEV) were identified as retaining a lot of the same parts and components. It was noted that some components for combustion vehicles are big and bulky and have poor cubic efficiency for shipping (e.g., fuel tanks). BEVs are effective in removing some of these "awkward" components from supply chains that presently tend to be sourced locally and not far from assembly plants. The implication for corridors was that many existing longer-distance flows, of the type that would apply also to BEV's, would be retained in the future (perhaps with some swapping out of the old and swapping in of the new) but changes might be likely in more localized contexts.

One OEM noted that they are going through a big change as a company in how they operate, with a changing supplier base being a particular challenge. Electrification has meant dealing with a whole new group of suppliers and new raw materials, and with components that they have not had to worry about before. There was mention of having to incorporate these new suppliers into this OEM's approach. Many new suppliers, for example, are not used to just-in-time, and with that there is a learning curve.

Aligned with the theme of change is some uncertainty. The primary Ontario OEMs are apparently not equally advanced in their electrification plans. Toyota, for example, has named one battery plant so far that will be located in North Carolina and coming online in 2025. Toyota stated that the battery supply chain in North America is "really just starting" for them and that other plants similar to the North Carolina one will be needed. They suggested that, to some extent, other OEMs were in a similar state with a lot of new facilities coming online in 2025-26.

In terms of changes, a second OEM noted that there is a whole new drive system, a lot of new players in the supply chain, and that they did not yet have the planned forecast for how battery production would look. A third OEM stated that a lot of aspects were being examined from the customs perspective due to the impacts of electrification. Decisions were still being made about overseas sourcing of certain components which could imply more use of vessel or air. They stated that it was "too early" to say where certain raw materials like CAM might be sourced from.

Another significant change mentioned is that electrification requires OEMs to pay much more attention to aspects like temperature control and hazardous goods transport. Temperature exposure and the duration of it and linkage to product warranties must be monitored. Ambient temperature concerns relate to finished products and also to battery modules in transport. It is important to ensure that battery charge levels on finished vehicles are tracked so that there is enough buffer for vehicles to arrive at dealers with sufficient charge. Complications increase when large distances are involved, and this happens more often with expansions that have taken place in the southern US. An OEM noted that there would probably be things to learn from the food sector, with its considerable experience in transporting temperature sensitive goods.

With electrification, more focus is required on hazardous materials aspects. Precursor elements such as lithium (a Class 8 Corrosive) are challenging to transport. Cathode active material (CAM) which uses lithium and other inputs (discussed in more length in Section 3.8) is actually more stable to transport and not considered hazardous. Battery cells or assemblies, which use CAM and other components as inputs, are considered as hazardous goods and are classified under placard 3480. As such, batteries at the level of cells (or further assembled), cannot cross at the Ambassador Bridge, which does not accommodate hazardous goods. As such, the rise of electrification is also well-aligned with the completion of the nearby Gordie Howe Bridge that will permit movements of hazardous goods.

3.6 Vertical Integration and Moving Up the Supply Chain

Perhaps not surprisingly, with all that has been written about the global sources of key ingredients (e.g., rare earths) that enable the electrification of mobility, there was a theme of "moving up" the supply chain. OEMs are more pre-occupied with the upstream components of supply chains than they would have been in the past. It could be characterized as more vertical integration in terms of focus. More visibility is required into mining activities, for example, and the potential for future mine locations, because the situation must be viewed globally with numerous automotive sector participants competing for the same materials.

It was noted that despite what the Canadian government might ideally want, not all upstream battery inputs will be sourced from Canada. Containers might be important for such commodities arriving from overseas and rail could be involved in moving these further inland. In some cases, processed materials could be received from the US for batteries being manufactured in Canada. A lot is to be determined yet.

There was evidence mentioned of an upstream focus in terms of battery cells as well, though the theme did not come across clearly with all the OEMs. Using approaches of the past, OEMs would be entirely outsourcing all aspects of battery cell activities to a Tier one supplier. With the critical role of batteries, some OEMs are opting for a more hands-on approach in working with suppliers/partners/joint ventures.

3.7 Circling the Wagons

It was just noted that with electrification, OEMs are more focused on vertical integration in relation to “moving up” the supply chain. That thinking has a clear international component to it. At the same time, an emphasis has been noted on localization and an increasing prominence for trucking going forward. The two trends are not inconsistent with one another.

An OEM noted that the trend has been in place for the last five years and that they have “really started to circle the wagons.” They stated that a decade ago, greater numbers of parts and components began coming from overseas but this had started to change even before the replacement of the North American Free Trade Agreement (NAFTA) with the United States-Mexico-Canada Agreement (USMCA) and the implementation of the US Inflation Reduction Act. It is expected that the new legislation will further localize various aspects of their supply chain. This localization has changed the footprint of OEMs, requires that more miles be driven by truck, and ensures that highway corridors have and will become even more important in the future.

3.8 CAM and Quebec

One component of batteries that was mentioned prominently was “Cathode Active Material” or CAM. Many of the key commodities that we hear about in relation to batteries (e.g., lithium, cobalt, nickel) are constituents of CAM but this processing of the raw materials is unlikely to be done at what are typically identified as “battery plants.” CAM plants need to be located adjacent to a water body, with wastewater discharge operations involved as well, but battery cell plants need not adhere to this constraint. Theoretically it is possible to manufacture CAM and battery cells on the same site as two different operations, but it is likely to be advantageous to separate these two primary operations and ship the CAM to where the cells would be produced. Three prominent announcements of the past year, the GM-Posco joint venture CAM plant at Bécancour, BASF at Bécancour and Umicom in Kingston are aligned with this separation of functions and do not produce battery cells.

One of the interesting aspects about CAM is that it is easy to transport relative to some of its component raw materials or relative to batteries themselves. For example, lithium is considered a hazardous material for transport as are battery cells or assemblies. CAM is not considered as a hazardous good for transport. It was mentioned that CAM is essentially exempt from participating in the just-in-time dynamics that apply in many other aspects of automotive supply chains. Once it is manufactured, it does not need to move on to the next stage of manufacturing immediately. While a precise figure on the usable "shelf life" of CAM was not provided, it was thought to be in the order of weeks.

The greater flexibility in the transport of CAM (e.g., bulk movements, no hazmat constraints, not just-in-time) implies that movement by rail is a distinct possibility. It was noted that direct rail into battery cell sites (e.g., in Southern Ontario or in the US) may not always be an option, suggesting that trucking might have to play at least some role.

As has been made clear in the media, the focus for CAM in Quebec is no doubt on Bécancour, which is located near Trois-Rivieres. It is relatively easy to transport the required inputs there and processing activities benefit from plentiful hydro-electricity. Bécancour has been the site of multiple CAM announcements, has good connections to rail and is at the site of a port which can accommodate ocean-going vessels. Unlike the Umicore site in Kingston, Bécancour can have good marine access even during the Seaway winter closure. The dock on the St. Lawrence there has apparently received interest/investment from a number of companies but capacity in the vicinity needs to be built out more.

The fact that Quebec will likely be prominent in the CAM stages of battery supply chains linked to primary OEMs is one of the important takeaways of these engagements (and also from recent media reports). The central role of Quebec suggests some significant future freight flows from Quebec to Ontario and from Quebec to the US that could potentially be by truck or rail, based on feedback. A lot of the Quebec connection to the US is likely to be via Southern Ontario with the associated implications for the transportation system. There could be CAM flows from Quebec to locations closer to the eastern seaboard that might not utilize the Hwy 401 corridor much. For example, there is Toyota's first major battery plant in North Carolina.

3.9 Battery Supply Chains are Heavy but promote modularity

In the engagements, there was some variation in terminology/concepts associated with battery components. Cathode Active Material, which has been discussed, is typically referred to as CAM and is well known. Battery cells are also well-known, but they can take different forms. Tesla cells are noted for being cylindrical. Small "pouches" is another form factor. Cells may typically be moved to an assembly location to make a module and then from module the next step is full battery back assembly. Module and battery pack assembly stages could be co-located. The term module seems to be commonly used although Ford referred to it as an "array."

With this brief background in mind, it was stated that electrification helps promote thinking in a more modular way, which can have impacts on supply chains. Related logistics and supply chain can apparently be viewed as an optimization problem that changes as new manufacturing nodes enter into a network. Battery cells themselves can be used across different vehicle makes and models, which simplifies things, and this generates interesting possibilities. With BEVs, there is no need to design around the restrictions of a V8 or 4-cylinder engine.

As multiple sites come online per OEM, it was suggested that this might lead to more movements of battery cells relative to movements of finished battery assemblies (or modules) in the operation of supply chains. Cells feeding an assembly plant could come from any one of several facilities in the future. It is generally more efficient to move battery components as cells rather than finished battery assemblies because cells "cube out" better in a truck. It was speculated that more cell-intensive transportation in conjunction with multiple facilities could lead to more regional forms of manufacturing that would impact the demand on road corridors (perhaps reducing some longer distance truck movements).

Related to this viewpoint on the future, consider that today's BEVs do not necessarily serve as a preview of how supply chains look in the future. GM noted that the popular Chevy Bolt (now to be discontinued) was developed in a traditional way in terms of interactions with Tier One manufacturers. However, it was suggested that things would evolve for the next generation of electric vehicles. Another OEM appeared to focus more on the present or near future, noting that battery packs/modules were being manufactured at their Tier 1 suppliers and then being shipped for final assembly. The responsibility of this OEM to ship batteries only when these got to the "module state" was emphasized.

While electrification may promote outcomes that are more modular for supply chains, a defining aspect is that batteries are big, heavy, and bulky and this causes logistics challenges. An OEM suggested that ideally battery cell production should be located as close to the end user as possible to avoid "punishing" logistics costs. This OEM noted that with their unwieldy physical traits, batteries are unlikely to be involved in the cross-docking operations that work so well for many other aspects of the supply chain in efficiently linking suppliers to assembly plants.

It was suggested that the unfavourable economics of moving cells, and especially more finished modules and assemblies for long distances, combined with high levels of future demand, imply that many new battery plant announcements could be expected from OEMs. The general rule has been that big and bulky inputs tend to be supplied from nearby with engines and transmissions being a possible exception. Batteries were not predicted to be an exception. A contrast was made with electric motors and inverters, which are shipped more easily. For that case, this OEM suggested that these could be manufactured in one place to supply their North American operations.

3.10 Trucking Configurations: Long combination vehicles and Quad axles

One of the distinguishing aspects of battery supply chains is that large weights are involved. For moving CAM by truck, we heard that it is hard to achieve good cubic utilization, but trucks get filled up in weight terms rather quickly. Rail is certainly part of the conversation for movements of CAM but was not mentioned for contexts in which battery components are in more advanced stages, closer to being incorporated into vehicles.

With trucks being central to battery movements, and given the weight constraints, there was discussion of truck configurations. Two approaches that were mentioned were long combination vehicles (LCVs) and quad-axle configurations, both which permit more weight to be carried per truck trip. The former is essentially one tractor pulling two long trailers, which distributes very large amounts of weight over many axles. The latter is associated with a single trailer but again spreading the weight (lesser amounts than with LCVs) over more axles.

LCVs have been used sporadically in the past. One OEM had used LCVs to move engines (conventional) but expressed some uncertainty for this mode in battery contexts. The use of LCVs is associated with some additional complications. For example, LCVs are typically not to be used in poor weather conditions. LCVs are typically associated with major highway contexts, but it is worth noting that they are quite incompatible with roundabouts that are increasingly used to enhance traffic flow in certain urban contexts. One OEM specifically expressed concern about a roundabout being planned near one of their key facilities. This was mentioned in the context of trucks shorter than LCVs.

Another OEM was not currently using LCVs but appeared interested in their potential, including in an environmental sense. They noted a crucial constraint with 400-series on and off ramps in Ontario. These interchanges apparently need to be approved for LCVs by the province of Ontario. They noted that only one off-ramp between Toronto and Windsor had been approved that would align with their carrier base. Some were approved east of Toronto, but this was not relevant for OEMs operating to the west. It was suggested for the authorities to go back and re-evaluate certain interchanges that had previously been assessed for approval over a decade ago. For the constraint with interchanges alone, LCVs were judged currently infeasible for use by this OEM.

Any complications of LCVs are amplified in a cross-border corridor sense. LCVs are more widely accepted in Canadian provinces at this stage then they are in US states. Michigan is a relevant exception in this regard. Twin trailers are not unusual in the US, but typically it is pairings of 28-foot trailers and lobbying is currently taking place to extend to twin 33-foot trailers federally. Combinations over 80 feet are not allowed federally though obviously there are exceptions by state. LCVs of 130 feet and over are not unusual where they are allowed (more so in western states). Not all states in the Interstate 75 corridor, for example, permit LCVs. The overall sense from feedback is that there are too many complications to really depend on LCVs for automotive supply chains though there is interest for the future and in battery contexts.

What will actually happen with trucks and battery supply chains is still being worked out by OEMs for the most part. There are obvious constraints with LCVs so solutions with shorter configurations and more axles are being considered. An OEM noted that, for now, a standard 53-foot truck was a likely solution for movements from as far south as Georgia, but they suggested there had been a lot of discussion about tri or quad-axle configurations given the weight density of battery-oriented cargoes. That OEM had been using quad-axles between Ontario and Indiana but not as far south as Georgia. The actual availability of trucks with quad axle configurations is an issue. Challenger Freight (recently acquired by Fastfrate) was noted as one carrier that has run a lot of quad-axle trucks in the past decade.

In a related theme, weight restrictions in the US, which are not aligned with limits in Ontario, were identified by an OEM as a leading supply chain bottleneck. For several relevant US states, it was noted that a typical trailer with tandem axles can carry only 45,000 pounds versus 56,000 pounds in Ontario. Ohio is one of those states but has recently allowed permits to be purchased which allow multi-axle trailers to carry 70,000 pounds plus. But the permits are expensive (labelled as a "cash grab" by this OEM) and apply only within Ohio. Michigan does not require a permit for such a truck movement.

3.11 Being as Lean as Possible

The "just-in-time" nature of automotive manufacturing is well-known but, in these discussions, the concept was characterized more often as being "lean", or at least as lean as possible. The fact that OEMs seek to be lean no doubt puts additional pressure on trucking corridors to function consistently well. One interesting point raised is that being lean is based on being capable and OEMs have developed a great deal of capability in this regard over the years.

As evidence of capability, one OEM noted that they handle approximately 2,000 trucks a day at its Ontario plants. Shipments are received from some suppliers up to 16 times a day and when received, these shipments go straight into a vehicle. Multiple OEMs noted that there are bulkier items (e.g., seats, doors, fuel tanks) that cannot be stored at the plant and as such, these items tend to arrive within 45 minutes of the actual operation. There is no inventory on site for such items.

Clearly there is a high volume of trucks and suppliers across the OEMs but at the same time, all it takes is an issue with one supplier to cause serious problems. The solution in these cases is to run "expedites" or "premium logistics" to address the problem. These types of more costly shipments were described as a daily occurrence given the scale of the operations.

Whether the movements are accomplished with (or typically without) expedites, the flow is from supplier to assembly without the “banking” or storing of a lot of material. Only a tiny percentage of shipments are stored somewhere. Involved in this process is often a cross-docking component where an intermediate facility allocates all the shipments that come from given suppliers into trucks that are destined for given assembly plants. These cross-docking operations tend to be located on the US side.

An OEM commented that the past two years has seen a lot of supply chain volatility that is not just semi-conductor related. In response, this OEM has been carrying possibly double the typical inventories at Ontario plants just to better absorb fluctuations. The more the uncertainty, the greater the tendency to order and hold more. However, it is hard for an OEM to be lean if they are playing it safe with larger inventories. As it was put: “You can be either learn or safe but not both.” A cautionary stance makes it more challenging to achieve profitability, but even increased inventories do not imply large inventories. As another OEM put it: “We [generally] don’t need five or ten days of safety stock – we are at much lower levels than that.”

3.12 High OEM Reliance on 3rd Parties for Transportation

In relation to the freight movements of parts and components, cross-border and otherwise, it was clear that OEMs rely heavily on third parties. Typically, they do not have their own fleets of trucks, tractors or trailers. One of the OEMs did run its own private fleet for some fairly localized parts movements on either side of the border. But this accounted for only a minority of their cross-border activity.

In terms of dealing with carriers on a day-to-day basis, it appears that most of the OEMs outsource to a logistics firm. Penske Logistics was mentioned frequently. A minority of the OEMs did not employ such a firm and instead dealt directly with carriers themselves. OEMs might make the decisions about the actual carriers to use but Penske might decide what carriers to use in a given context for day-to-day load tendering. It appears that such a firm plays a prominent role when expedited shipments/premium logistics are required and also helps with what was referred to as network design (moving toward the overall most efficient network). With the help of a firm such as Penske, an OEM will also know where a truck is at a given point in time and what is on it.

Interestingly, an OEM credited a close relationship with its carriers (all tending to be on the smaller side) as one of the reasons that they were able to avoid a shutdown at the time of the Ambassador bridge protest. That OEM did not indicate that they used a logistics provider as an intermediary.

Another OEM that did employ a logistics provider indicated that they were nevertheless working directly with carriers on matters of supply chain carbon footprint and the move toward net zero.

The use of more energy efficient equipment in relation to trucks, trailers and tires were given as examples. There were indications that hydrogen was being considered for future long-haul movements while battery electric trucks were being associated with the short haul, in terms of what might be expected from their carriers.

3.13 Buffered Circles More so than Corridors

One underlying premise that motivated this report was that it is wise to pay close attention to the end-to-end transborder road corridors on which automotive supply chains depend. There was not evidence uncovered to suggest that this concept is flawed but there was evidence to suggest that OEMs are not preoccupied with the details of how a given corridor is performing. As indicated in the prior section, the involvement of perhaps two layers of third parties in governing day-to-day truck movements greatly reduces the need for OEMs to closely examine corridors. Individual bridge crossings at the border are certainly more top of mind.

What did become clear is that when OEMs think strategically about flow of materials into their facilities, they are more likely to model buffered time circles, radiating outward, around those key locations. Each circle defines a certain duration and this duration will be “buffered” so that the associated time will safely exceed the actual travel times, taking into account all the travel time variability that could reasonably be expected. The buffered part of course is crucial for keeping plant operations up and running. Certainly, specific problems or bottlenecks with key corridors feed into the types of travel time results that determine safe buffer times. But the buffered approach allows OEMs not to be preoccupied with day-to-day bottlenecks. One OEM noted that there is more of a preoccupation with “optimizing miles” in a network sense than going down to the level of the individual bottleneck.

For another OEM, these buffered circles relating to serving Ontario manufacturing operations were described as: 1 day within Ontario, 5-6 days for Texas, 7 days for Mexico and 6 weeks for anything needing to arrive from overseas. They suggested that as soon as the border is added into the equation, an extra day is added. The buffered time for Michigan was estimated as at least a day or as another said: “not as much as you might think.” For rail movements from Mexico a 12-day buffer was noted.

With some of the pandemic problems of the first part of this decade, it was stated that there has been a need to assume more conservative buffered time circles because travel variability has been higher. This has translated into holding more inventory and being less lean, which has cost money. A desire to get buffered times back to where they were before was noted.

3.14 How OEMs Monitor Trucking Performance

While OEMs are not too pre-occupied with long highway corridors per se, they are quite focused on how carriers are performing, or they designate a firm such as Penske to be pre-occupied for them. The emphasis is on how long it takes to get from Point A to Point B, as opposed to the time to traverse some road segment that lies somewhere between. Aspects such as on-time delivery, pick up and dwell times are measured very closely by many OEMs. Carriers are often rated on their on-time performance. However, one OEM stated that in their environment, shipments do not necessarily arrive at times that align with production. As such they had not focused on on-time performance and did not find it very meaningful.

A lot of tracking is done through GPS and telematics. This may include trucks and trailers being tracked separately in case drivers are being changed at the border and so forth. A third-party firm such as "Freight Verify" may be used for "track and trace" elements and individual carriers for a given OEM are required to facilitate the flow of their data through such a third party.

Geofences were referred to on multiple occasions. These can be set up at both ends of a trip between supplier and plant to allow trailers to be "checked in and checked out" as they move between locations. An OEM noted that geofences can be set up to flag the border or associated with switchyards. A geofence can even be set up in shorter term contexts, for example, around the path of a weather system. Insights might suggest employing expedited movements to pull inbound shipments ahead.

Electronic Data Interchange (EDI) was mentioned as being important for one OEM in terms of measuring door-to-door performance from the moment of departure to arrival, with EDI updates in the event of delays such as those caused by bad weather. No updates of this type were received by this OEM in terms of timing of actual border crossings.

3.15 Measuring Transborder Corridor Performance and how Government/Academia Could Help

With regard to potential roles that government or academia could play in helping to understand the performance of transborder corridors, there is a natural preference to want to employ real-time data. One OEM noted that the "closer to real time it [data] is, the better." Real time gives the potential for on-the-fly adaptations: if there is a back-up at Windsor, is it better to wait it out or divert up to Port Huron? It was speculated that this type of data could be valued also by Penske, which provides logistics services for many OEMs.

A deficiency was noted in having the data (whether real time or not) to know why certain crossings should be used at certain times. One OEM described "hearing crickets" when this type of question was posed internally. Typically, there can be a short period of time to react, so a better understanding is important. There was a stated desire to know more about which "big and compliant" carriers are doing the best job to ensure that they are not causing problems at the border crossings.

Borders themselves were a focus. During the sessions, most OEMs were provided with a description of the type of data on cross-border performance that is available from the federal government. It was noted from the McMaster side that there is precise measurement completed in the last decade or more on the border crossing times experienced by approximately 100,000 North American trucks. With that data, it is possible to assess the percentile distribution of crossing times and such distributions can be segmented by time buckets, weather conditions or other factors. The OEMs were not generally aware of the type of detail available.

This type of information was described as ideal by one OEM, noting that they tend to focus only on what materials are needed and when without consideration of whether it is a busy time of day or week at border crossings. Another noted that had not spent as much time as wanted on developing KPIs on "what they want to see" at the border. A third suggested that their standard allowance of "1 hour" for the border crossing was potentially off-target and more refined knowledge in this direction could help.

Cross-border detail was identified as "good to know" by one OEM based on upcoming changes to supply chains to support electrification. With electrification, it was suggested that even closer monitoring of certain aspects was to be expected. Depending on the types of segmentations that are available, the suggested cross-border data could prove very useful. For example, multiple OEMs noted that it would be very interesting to understand the difference in crossing times between FAST and non-FAST carriers.

Some observations were made in relation to non-border aspects of corridors. One noted that is quite worthwhile to know the true average duration or "proven historic performance" for certain corridors (a Virginia to southern Ontario example was given). If the true average is 14 hours rather than 16, then associated adjustments can save money. They noted that it could be better to pay premium logistics costs to cover abnormal events rather than a continuous payout for a corridor based on an over-estimate. Within southern Ontario, a better understanding of "constrained areas" along Hwy 401 and the QEW, among others, was seen as helpful if it could lead to a "smoothing out" of deliveries that in some cases arrive in bunches.

The use of data to provide enhanced measurement of the impacts of highway construction was noted as an aspect of interest. The tendency for construction projects to go on for a long time and past originally stated deadlines was seen as a pain point.

3.16 Concern over CARM

Multiple OEMs expressed concern with the implications of the CBSA Assessment and Revenue Management (CARM) project that is revamping many of the processes involved for firms to import goods into Canada. One OEM noted that the perceived need for the revamp came out of the Auditors General report that showed a lot of duties to be collected were being lost in the legacy system. Ultimately, there is concern that CARM will cause difficulties at the border. It was noted that the consultation surrounding CARM has been good but that there have been problems with achieving targeted implementation dates and there are worries about creating additional time barriers at the border.

A second OEM described the CARM implementation as “very challenging” and noted that from their perspective, CARM is supposed to be an accounting system that does not affect the release of trucks. But it was their concern that certain privileges available to an importer of their stature would be lost. At times this OEM brings vehicles across the border for testing or to support the development of marketing material or for other reasons, and this can be done at no cost in relation to these privileges. There is concern that these capabilities could be lost. There was also concern that the new portal would not be able to manage their EDI feeds and the 120,000 transactions per month generated by this OEM.

4

Benchmarking Aspects of the Current Situation

This brief chapter displays some empirical data that is associated with the performance of key transborder corridors. The outputs capture the Canadian side currently but can be generalized in the future subject to securing the appropriate data. The two themes covered are the average speeds along key corridors and market penetration of electric vehicles. These are discussed in further detail below.

4.1 Average Speeds Along Key Canadian Corridors

Transport Canada hosts data from HERE Technologies which records the speeds that monitored vehicles achieve every hour of each day of each year over thousands of road links. Data was provided for this project that covered all the days and hours of 2022 for all Class 1, 2 and 3 road links in the relevant regions of Ontario. Some speed data has apparently been provided for US states as well, but further efforts would be required to assess the coverage of this very large data source. For the current version of this report, we focus on the performance of major Ontario highways that were identified in the engagements as critical. These include Hwy 401, 402 and

403 and we also offer an overview of how major highways in the Greater Toronto Hamilton area were performing in 2022.

In all maps, the focus is on average weekday speed per link, direction, and hour for the 2022 calendar year. To achieve this, we examined the calendar for 2022 and identified all dates that were non-holiday weekdays in Ontario. The week between Christmas and the end of the calendar year was excluded entirely. Essentially, we attempted to isolate workdays, and in the end tabulated 249 such days that entered the calculation. The ultimate averages (means) per hour/link/direction that were tabulated appropriately took account of the number of observations that had been collected (these would vary over time).

The results for these summary calculations for the relevant days of 2022 are displayed below. Figures 4-1 to 4-4 deal with corridors between the key border crossings and the western Greater Toronto Hamilton Area (GTHA). Figures 4-5 and 4-6 show the average performance of the main GTHA highways and also the performance of the Hwy 401 corridor east of Toronto towards Kingston. In 4-5 and 4-6, results for northbound and eastbound signposted highway directions are shown in the top panel and results for southbound and westbound signposted highway directions are shown in the bottom panel.

The figures can be reviewed in detail for specific bottlenecks, but the main overall takeaway is that important Southern Ontario highway corridors on average performed at a high level in 2022. There are long stretches of highway where average speeds of over 100km/h were supported even at peak times. The GTHA is the largest source of corridor problems, but 2022 levels of congestion appear less severe than what has been seen in pre-pandemic times. Of course, a lot of automotive manufacturing activity is centred west or north of the GTHA. Of note, engagements revealed that Honda's carriers tend to use backroads instead of primary GTHA highways to reach the main facility in Alliston shown on 4-5 and 4-6.

Figure 4-1: Eastbound Hwy 401, 402, 403 Corridors Average Speed – AM Peak Times

Figure 4-2: Eastbound Hwy 401, 402, 403 Corridors Average Speed – PM Peak Times

Figure 4-3: Westbound Hwy 401,402, 403 Corridors Average Speed – AM Peak Times

Figure 4-4: Westbound Hwy 401,402, 403 Corridors Average Speed – PM Peak Times

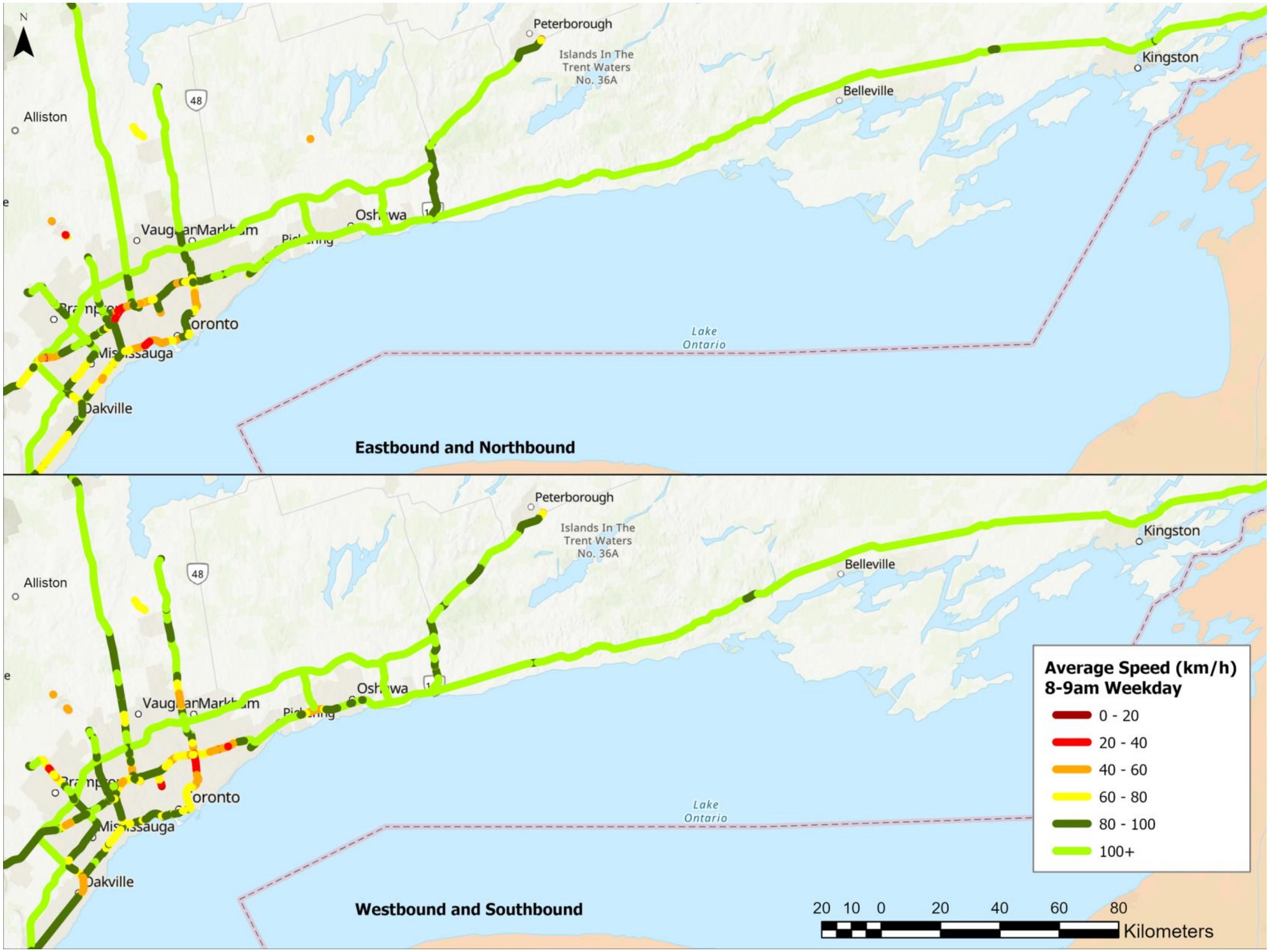

Figure 4-5: GTHA Highways and the Hwy 401 Eastern Corridor – AM Peak

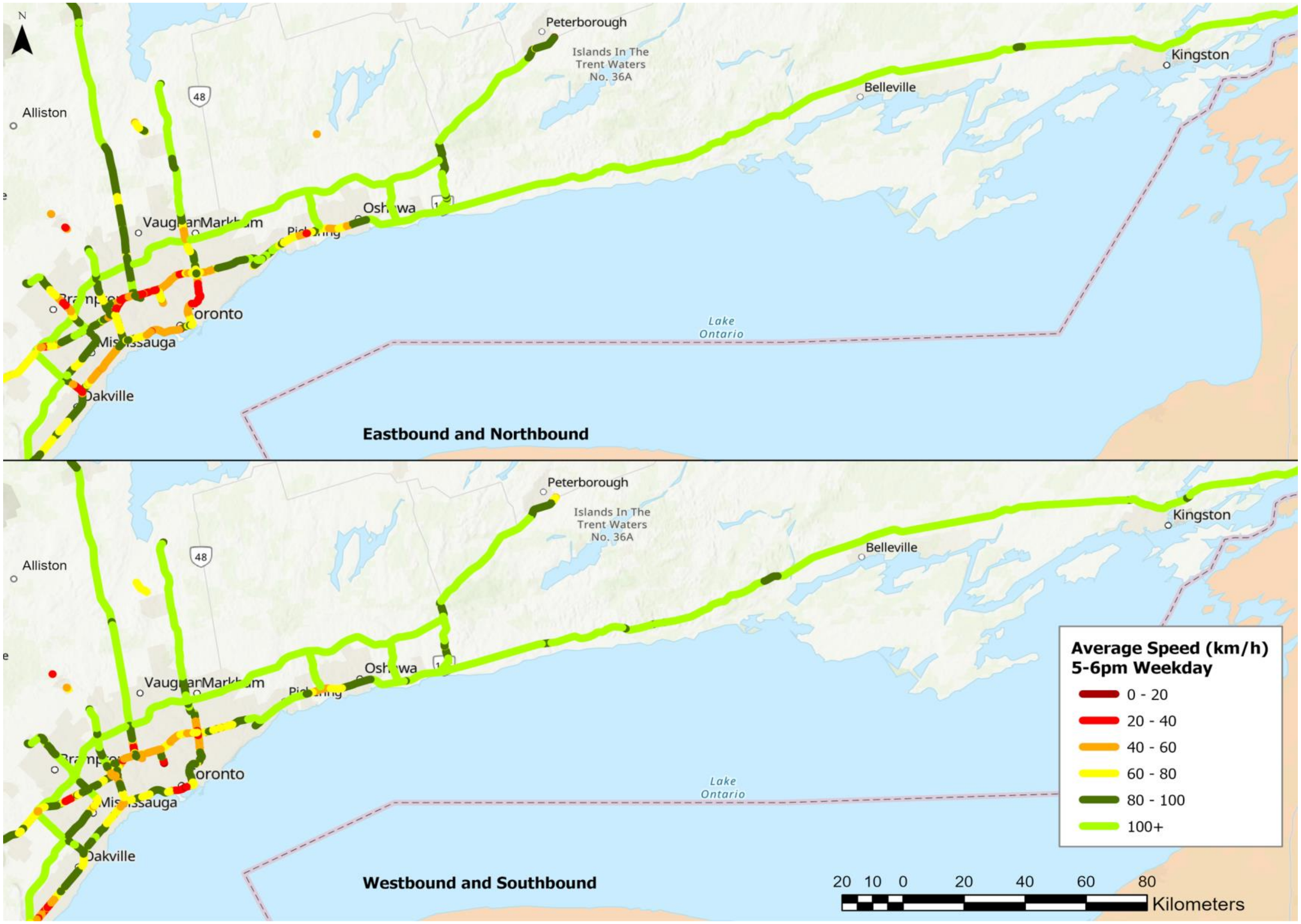

Figure 4-6: GTHA Highways and the Hwy 401 Eastern Corridor – PM Peak

4.2 Market and Corridor Penetration of Light, Medium, and Heavy-Duty Electric Vehicles

With electrification being a major new theme in vehicle manufacturing that will link to transborder corridors, it makes sense to benchmark the overall adoption trend of electric vehicles. The following two figures show a summary of new motor vehicle registrations in Canada, reported on a quarterly basis, looking at all vehicle and fuel types currently on the market (Statistics Canada, 2021). Results are shown for light duty vehicles, for which electrification is more advanced. Electrification of medium- and heavy-duty vehicles has progressed less to this point but is a major issue since larger trucks are big emitters. Trucks are typically commercial registrations as opposed to retail/household registrations.

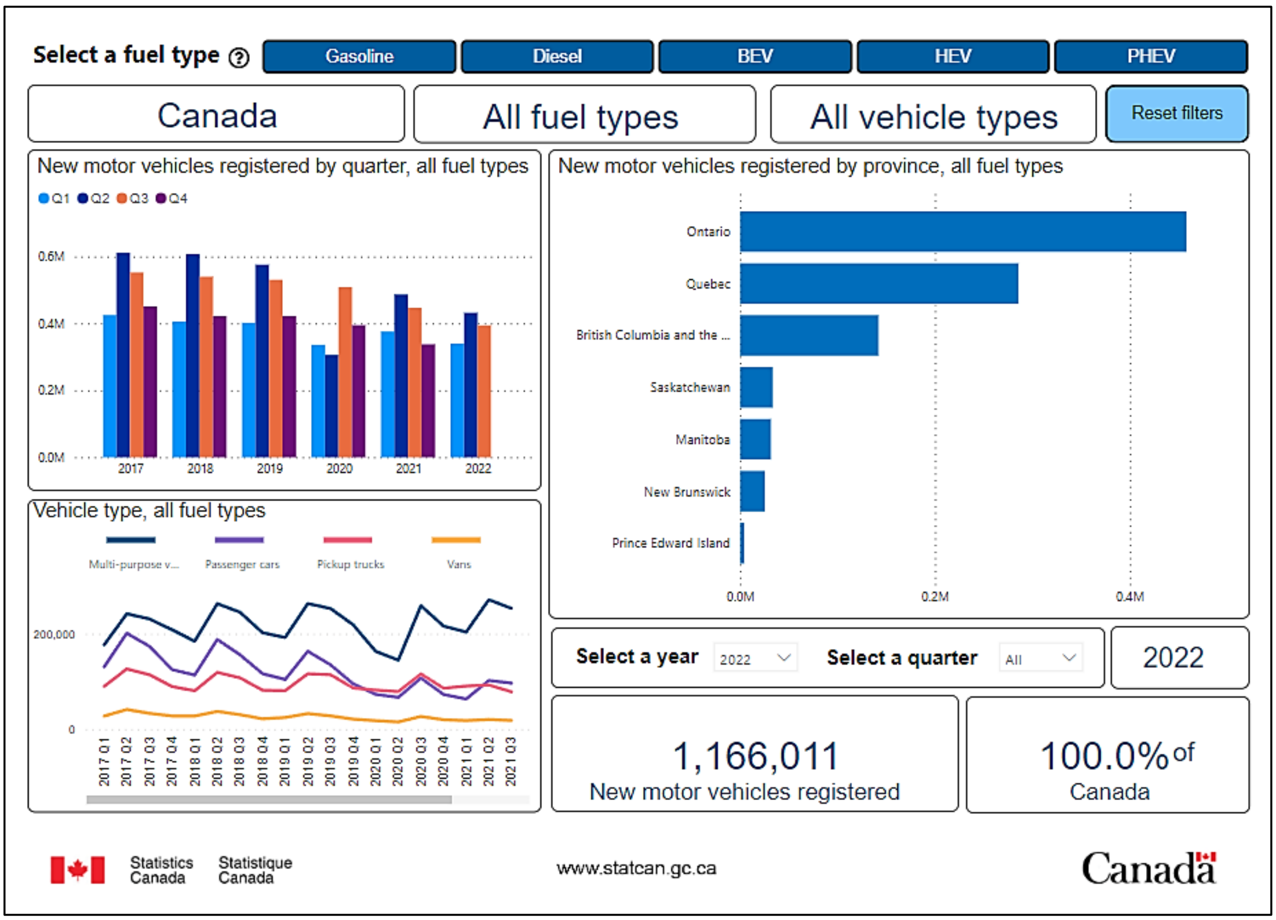

Figure 4-7: Statistics Canada New Motor Vehicle Registration visualization tool: All vehicle and fuel types

Figure 4-7 shows an overview of the light-duty vehicle spectrum. It exhibits some quarterly cyclicality. A decline is apparent in the pandemic years that is attributable to chip shortages, general lack of supply and high prices. Figure 4-8 permits a view of newly registered electric vehicles in isolation (including the three main fuel types – battery electric, hybrid electric, and plug-in hybrid). A clear upward trend over the past five years is apparent. Results suggest that 13.2% of newly registered light duty vehicles in 2022 were electric vehicles. Though not shown here, battery electric vehicles are rising in relative prominence compared to hybrid forms of EVs.

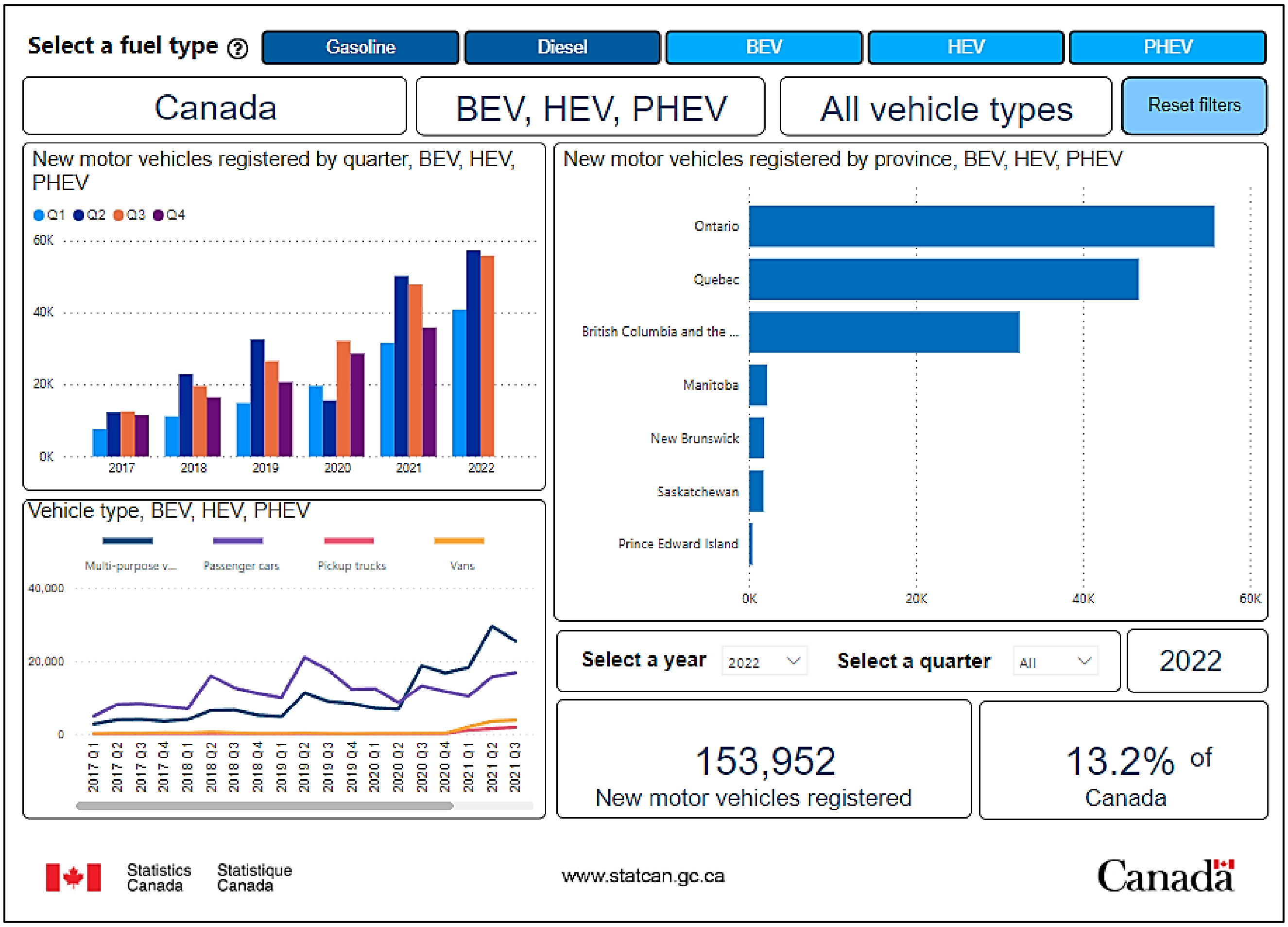

Figure 4-8: Statistics Canada New Motor Vehicle Registration visualization tool: Electric vehicles

5

Conclusions

This study has combined an in-depth literature review, detailed automotive stakeholder engagements, and analysis of extensive highway speed data to derive some important conclusions on the topic of transborder corridors in support of automotive supply chains. These insights are derived in a period of dynamic change in the automotive sector as electrification is beginning to take hold.

5.1 Engagement Takeaways

One important takeaway from this research was the excellent participation of the primary automobile manufacturers and what it signified. The OEMs took the request to engage quite seriously, and the majority arranged groups of high-ranking representatives to participate. In multiple cases, participants from both sides of the border participated for a given OEM. While the engagements had been conceptualized along the lines of better understanding the performance of longer-distance trucking corridors that crossed the border, the biggest drawing card for the OEMs appeared to be concerns that were focused more specifically on maintaining the fluidity of goods movement at the border.

Rising electrification in the years ahead does not appear poised to reduce a high dependence on the relatively seamless movement of parts and components across the border in both directions. Ultimately, the primary Ontario-Michigan bridge crossings are viewed as "existential" for OEMs and in particular automotive manufacturing in southern Ontario. It is noteworthy that the February 2022 Ambassador Bridge protest shut down certain production sites on both sides of the border, not just in Ontario. Consider that important supplier flows move in both directions.

Hybrid electric vehicles (HEVs) and plug-in hybrid vehicles (PHEVs) were not viewed as impactful in reducing the high diversity of parts and components that are needed to run automotive supply chains. Even battery electric vehicles (BEVs), noted for their relative mechanical simplicity, were identified as retaining a lot of the same parts and components. It was stated that some components for combustion vehicles are big and bulky and have poor cubic efficiency for shipping (e.g., fuel tanks). BEVs are effective in removing some of these "awkward" components from supply chains that presently tend to be sourced locally and not far from assembly plants. The implication for corridors was that many existing longer-distance transborder flows, of the type that would apply also to BEV's, would be retained in the future (perhaps with some swapping out of the old and swapping in of the new) but changes might be likely in more localized contexts. There was no stated evidence of a lesser expected connection between Southern Ontario and the US Midwest due to electrification.

With the rise of electrification, the manufacturing of Cathode Active Material (CAM) is a significant theme for Quebec and Eastern Ontario – jurisdictions that have been less prominent in automotive supply chains. Whether CAM will move along Hwy 401 towards Toronto is yet to be determined as there is a case for rail (if not marine). CAM is in the earlier stages of battery supply chains and is not a "just-in-time" input.

Trucking appears to have a promising future as a continuing "driving force" in automotive supply chains. The United States-Mexico-Canada Agreement (USMCA) and the implementation of the US Inflation Reduction Act are consistent with the localization of various supply chain aspects. A more localized supply base, with a lot of it concentrated in the US Midwest and Ontario, means more miles driven by truck and a continuing crucial role for leading highway corridors. This was noted as a trend of the last several years that had preceded important new legislation but is further fueled by the new rules. Moreover, the aim for all the leading OEMs to be as lean as possible argues strongly for the continuing dominance of trucking.

Non-trucking modes were not mentioned prominently in the engagement. Marine was mentioned in the context of shipping from overseas. Rail was mentioned as a prominent mode for the long-distance shipping of finished vehicles. The potential role for rail to move Cathode Active Material was identified. Air was mentioned in the context of premium/expedited logistics to keep supply chains running. It was noted by one OEM that "nothing is ever planned to fly."

The extension of automotive supply chains to the south including Texas and Mexico could mean a greater role for rail but the mode was not described as suitable to support just-in-time contexts.

While the leading OEMs generate an enormous amount of trucking activity, this is almost all outsourced. In addition, most of the OEMs deal with carriers through a 3rd party, often Penske Logistics. This separation of the OEMs from many of the day-to-day aspects of transportation likely contributes to some detachment from the evaluation of specific highway corridors. There is more focus instead on buffered time durations that are required to guarantee that parts and components will reach the assembly sites in time and often on whether carriers are delivering as scheduled. In this context, the prevailing image is more one of radiating travel time circles (e.g., allow 4 days if something is coming from Texas) than it is of details and components of specific travel corridors. Actual border bridge crossings, mainly two of them that join Ontario to Michigan, are corridors with which all OEMs are very familiar.

In terms of how OEMs were seeing electrification, the mechanism was mostly expected to be through battery electric vehicles. There was minimal mention of hybrid vehicles, whether plug-in or not. Hydrogen fuel cell vehicles were mentioned once upon prompting, but the concept was dismissed as something that was not happening anytime soon. It seems clear that the operation of battery supply chains on a very large scale, with all that this entails, is front and centre for OEMs.

5.2 Corridor Performance Measurement

Our review of performance measures along highway corridors shows that certain of these measures appear quite well established and accepted. In the vast majority of cases, deployment has been in the context of domestic corridors as opposed to transborder corridors. In principle, there is no reason that these same measures cannot be adapted and applied in transborder contexts. Data collection can be more onerous when there is a need to assemble data from more than one country, but this is a resolvable aspect. Discussions in the course of this work with entities such as the Federal Highway Administration and the Texas Transportation Institute, showed potential for rapid progress on this topic on the US side. Interestingly, the automotive OEMs did not specifically mention any of these existing measures during engagement processes. However, conceptual frameworks that were discussed had a lot in common with the Buffer and Planning Time Indices described in Chapter 2.

Concerning measurement of transborder corridors on the Canadian side, the Canadian Centre on Transportation Data (CCTD), could be an avenue for development. The centre is a joint initiative between Transport Canada and Statistics Canada to collect and share new data, performance indicators, analysis and research on transportation in Canada.

Stated objectives of the CCTD are to:

- build new partnerships with the transportation industry, transportation users, researchers and other levels of government,
- make available better data, analysis and information about the national transportation system,
- develop new tools and applications to promote the flow of transportation-related information and knowledge and enhance understanding and decision-making.

Considering the extent to which the Canadian economy is integrated with the US economy (with there being no better example than the automotive sector), a strong emphasis on cross-border data integration by the CCTD would seem well-placed and in Canada's best interests.

To actually characterize the performance of transborder corridors, data is clearly needed to do it. The question is: what should be the source for this data? The Ontario COMPASS system, for example, which measures real-time travel performance along some of the busiest intra-metropolitan corridors in the province, and is quite effective in this regard, depends on fixed and expensive infrastructure. With major investments, this type of approach could be employed on a large scale, that covers long distances along key highways, on both sides of the border. Alternatively, GPS sources relating to truck movements are becoming more and more plentiful and do a good job of characterizing how a given corridor performs at all times of the day, week or year. GPS information from passenger vehicle movements have validity in informing on the performance of the traversed corridors as well, even for goods movement purposes.

An important consideration that arose from engagement processes is that the OEMs are not focused day-to-day on the particulars of how lengthy transborder highway corridors are performing. To the extent that there is concern with these matters, it appears to be "sub-contracted" to the truck carriers or logistics providers such as Penske. Also, the engagements detected no expressed displeasure with how these third parties were performing. Whether truck carriers or logistic providers would have a different take on the particulars of transborder corridor performance is potentially a question for the future.

There were some key aspects that OEMs <u>are</u> focused on. Clearly, they are quite determined that required materials reach assembly plants within their pre-determined time buffers. Even in that context, the use of premium/expedited logistics to deal with one-off problems encountered through the multitude of suppliers is an accepted part of the daily fabric. Secondly, there is focus on disruptions caused by extended duration of construction projects on key corridors. Thirdly, there was stated interest in understanding more about congestion patterns on major highways.

This was more in relation to the 400-series highways in Ontario than on the US side, perhaps because Canadian assembly was well-represented in the engagements.

By far though, engagements revealed that the biggest transborder corridor concern, especially given the dominant role of trucking in automotive contexts, was the border bridge crossings that join Michigan to Southern Ontario. It became clear that these crossings have attained the status of "existential infrastructure" as it concerns the operation of cross-border automotive supply chains. There are detours and workarounds for most any other highway bottleneck but if the bridge crossings seize up, for whatever reason, automotive plants will shut down sooner or later. The Port Huron-Sarnia bridge crossing stayed open in February of 2022, during the problems at the Ambassador Bridge, but this remaining safety valve was not sufficient to avoid shutdowns for multiple OEMs that affected manufacturing on both sides of the border.

5.3 Overall Conclusion

Overall, the key border bridge crossings require the most attention, compared to other elements of transborder corridors, in terms of the collection of timely data and making it actionable. The current context for GPS data, at border crossings or otherwise, is more historical at present as opposed to being real-time or near real-time. Government entities or academia tend to receive data with significant time lags (up to a month or more). For example, the Canadian Centre on Transportation Data reports monthly crossing time statistics based on truck GPS data. Even for this lagged information, some OEMs were not aware of its availability and expressed an interest to learn more. For example, breakdowns of the performance of FAST lanes versus Non-FAST lanes at bridge crossings was a stated topic of interest even if analytics depended on recent historic data.

While there may be potential for more direct linkages to data providers in the future, an alternative to lagged GPS sources is to equip bridges with new technologies that collect traffic flows specifically for trucks and which can support on-the-fly calculation of the types of metrics outlined in this report. What the Cross-Border Institute has been prototyping on the Ambassador Bridge (see section 2-5) with a sensor-based approach could be adapted/extended for the Gordie Howe Bridge. MTO COMPASS information collected by camera at bridges could assist as well. Overall, there is significant interest from OEMs in data/indicators for bridge crossings by truck that are near real time at minimum.

For the non-border components of transborder corridors, it appears that the on-going progression and development of GPS data from vendors will be adequate, despite time lags, to support the moderate level of insight and detail that is required by the automotive sector. As shown in Chapter 4, the analysis of Ontario HERE traffic speed GPS data for thousands of individual road links along key highway corridors revealed that most stretches of these corridors were performing at a high level in 2022 with some exceptions at border locations or in the heavily populated areas of the Greater Toronto & Hamilton Area.

In closing, an approach to transborder corridors that prioritizes timely measurement at road border crossings should translate well to other locations along the Canada-US border, and in support of other economic sectors of the economy. If such an approach is sufficient for cross-border automotive supply chains in the economic heartland of North America, it should be sufficient elsewhere for other sectoral contexts as well.

6

Appendix

The text below shows the background, instructions and list of questions that were provided to the participants in the engagement process of this research project. The actual format of the circulated PDF file was slightly different but the content below is identical.

Towards Performance Measurement of Transborder Trucking Corridors: The Case of Automotive Supply Chains

Background

Canada's federal government (specifically Transport Canada) has tasked the Institute for Transportation and Logistics at McMaster University (MITL) and the Cross-Border Institute at the University of Windsor with examining performance issues along Canada-US transborder surface corridors The purpose of this collaborative project is to better understand requirements for accurately measuring the end-to-end performance of strategic transborder trucking corridors on an ongoing basis. Specifically, this is geared to the changes in the automotive supply chains with the production of the new generation of vehicles that will be brought about by Canada's commitment to climate change. The current period is one of unprecedented disruption in automotive manufacturing as transport becomes increasingly electrified. Significant shifts are expected in how associated supply chains operate, including with respect to the central role of batteries. Given the significant secular shifts under way and the increased emphasis on supply chain resilience, the proposed project is viewed as a timely one in support of key transborder strategic corridors that span the Great Lakes region and beyond.

Your organization is a central stakeholder in the current and future performance of such corridors. Accordingly, we are inviting you to a brief session, of likely no more than 45 minutes, conducted by Dr. Mark Ferguson and Mr. Louis-Paul Tardif, both representing the McMaster Institute for Transportation and Logistics. The session will be conducted by Zoom or Teams, depending on your preference. With your consent, the session would be recorded for the sole purpose of compiling high-quality notes. The recordings will not be shared outside the research group at McMaster.

The proposed work is taking place in a compressed time frame at the request of Transport Canada. As such, if you agree to participate, we would like to schedule a session with you as soon as possible.

Instructions

Below you will find a list of questions that are intended to guide the discussion. Ultimately, we are trying to get a sense of how your firm's operations depend on regional transborder trucking corridors and how upcoming secular changes may influence the nature of this reliance. Your answers to such questions will help us assess important aspects relating to future performance measurement of strategic corridors.

The questions listed below form the basic structure for a discussion that should run for no more than 45 minutes. Answers provided may naturally lead to follow-up questions that will arise in the flow of the dialogue. The discussion will be held over Zoom/Teams or by telephone if preferred. One or more representatives of your organization may wish to participate in the session. With your consent, the session would be recorded for the sole purpose of compiling high-quality notes. The recordings will not be shared outside the research group at McMaster and will be stored securely.

Your identity will be kept confidential throughout this process, including any reporting on results/findings. If preferred, the name of your organization can also be kept confidential. Should there be a desire to use a quotation from our session in reporting overview consultation results, this would be done only with your consent. Ultimately, MITL will prepare a report that will summarize the important results of the engagement process.

In responding to the questions below, please seek to provide answers that are consistent with your organization's stance on these topics to the best of your knowledge. Please refrain from providing personal opinions as separate from the thinking/values/direction of your organization. You do not need to answer any questions with which you are not comfortable.

The answers to the questions below may not be immediately clear and may require some deliberation. If time permits, we encourage you to evaluate the questions in advance of the consultation.

List of Questions

1. Please describe some of the prominent changes that vehicle electrification is having/is expected to have on your firm's manufacturing supply chains? Can you comment on supply chains related to batteries in particular
2. Can you comment on the importance of trans-border highway corridors to the current and future operations of your firm? Are there certain of these corridors that are particularly strategic to your firm's operations or are expected to become so? Are there particular bottlenecks of concern that affect transit times, costs or predictability?
3. Can you elaborate on identities of some of the important origins and destinations that define emerging transborder corridors? Are most truck movements direct between these origins and destinations or are intermediate facilities involved (e.g., warehousing)?
4. Does your firm systematically measure operational performance over road corridors whether trans-border or not? If so, what types of metrics are employed?
5. Would 3rd party efforts (including by governments) to measure the on-going performance of transborder corridors be considered valuable to your firm? If so, what key elements would be needed to make such an effort successful? What obstacles do you foresee?

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