SIMULATING THE IMPACTS OF RFID LANES AT THE CANADA-US BORDER: AN APPLICATION TO THE WINDSOR- DETROIT CORRIDOR

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Introduction

Efficient and secure movement of goods and people across the Canada-US border is vital to support the economies on both sides of the border. Nearly 30% of Canada-US road trade passes through the existing four lane Ambassador Bridge between Windsor, Ontario and Detroit, Michigan with nearly 8,000 trucks crossings every day (PBOA, 2015). The bridge is ranked as the largest land border crossing for commercial vehicle volumes (CBSA, 2016). The enormous movement of commercial vehicles through this corridor is sometimes subjected to extended delays resulting in significant economic losses. In order to meet increased long-term travel demand and reduce the likelihood of disruption in moving surface trade between the two countries, Gordie Howe International Bridge (GHIB), a new six-lane bridge across the Detroit River is being constructed. The new bridge will provide a much needed additional border crossing option in this busy trade corridor.

While the development of a new infrastructure such as the GHIB provides system resilience, its introduction should be accompanied with emerging Intelligent Transportation System (ITS) technologies. An example of the latter is the use of Radio Frequency Identification (RFID) technology at border crossing facilities. This technology is believed to improve the performance and throughput of these facilities. RFID enabled documents have a radio chip embedded, which allows them to communicate with a ground station that is typically 10 to 15 feet away from the card. Such touchless technology is believed to reduce the time it normally takes border custom agents to process passenger vehicles crossing the border. Vehicles in this situation will have to go through RFID enabled lanes. Travelers only need to hold the RFID enabled document by the windshield of their vehicle to enable the computer system in front of the primary inspection booth to automatically display the traveler's personal information on the officer's computer screen.

The benefits of implementing RFID technology are highly dependent on the proportion of vehicles that are able to take advantage of the RFID equipped lanes. This, in turn depends on the number of drivers, both passenger and commercial who have acquired RFID enabled documents such as Nexus and or/ enhanced drivers licenses (EDLs) and the Free and Secure Trade (FAST) cards. The choice by travellers to acquire these processing documents is not independent of the number of lanes in the Canada Border Services Agency (CBSA) plazas that are equipped with RFID in that the more lanes there are, the greater the benefit of these travel documents.

This paper provides a framework for simulating the potential benefits of using RFID technology at an existing border crossing (the Ambassador Bridge) under various RFID adoption scenarios. The objective is to examine the incremental increases in the number of RFID equipped lanes, RFID enabled documents or combinations of the two. The movement of individual passenger and commercial vehicles, the interactions among them, and their passage through primary service booths at the existing Ambassador Bridge will be simulated in the VISSIM micro simulation traffic software (PTV America, 2016). The conducted analysis will enable us to evaluate the efficacy of using RFID technology to achieve a reduction in crossing time.

Transportation simulation models are powerful tools widely used by transportation practitioners to model travel behavior, traffic flows and to evaluate the impacts of new public transport and highway infrastructure projects. Microsimulation models are more detailed and focus on microscopic movements of vehicles in a traffic stream. Since these models simulate the movement and interaction of individual vehicles, they are more computationally intensive (Nguyen et al., 2012). Furthermore, the successful application of microscopic simulations is often limited to parts of the urban network. Constructing and calibrating a large scale network at the microscopic level is usually very time consuming and non-trivial (Kitamura and Kuwahara, 2005). The application of micro-simulation models to assess the impacts of various measures of effectiveness in queuing facilities is well documented in the literature (see for example Ceballos and Curtis, 2004; Al-Deek et al. 2005; Khan, 2010; Brijmohan and Khan, 2011; and Aksoya et al. 2014).

Application of Radio Frequency Identification (RFID) Technology in Transportation

Over the last few decades the use of Radio Frequency Identification (RFID), in terms of optimizing transportation and logistics operations, has gained considerable credibility. The conducted research points to the fact the benefits of implementing and managing RFID based transportation facilities outweigh the cost deterrents given the improvement in system performance. RFID has broad range of application in various forms of transportation, including surface, air and marine transportation. For example, RFID is commonly used in processing flows at toll and inspection plazas, automated baggage handling and container tracking.

The first significant application of RFID in the trucking industry was the implementation of weigh-in-motion system to allow trucks to bypass as they approach a weight station (Engineering.com 2016). The system would read the RFID tag of the approaching vehicle and based on the information/data received from the vehicle, it would transmit a bypass or no bypass signal to the vehicle. This resulted in an overall significant processing time savings for all the stake holders involved. However, as in the case of any emerging technology, implementing of RIFD in transportation also faces many challenges. These include but not limited to: cost of implementation, transaction security and privacy issues and compliance with jurisdictional regulations.

Modeling Approach

In this paper, a microsimulation traffic model is used to reproduce as accurately as possible the flow of heavy commercial vehicles through the conventional primary inspection lanes of the CBSA Plaza of the Ambassador Bridge. In this type of model, the movement of individual vehicles, the interactions among them, and their passage through inspection stations are digitally represented in a near-continuous time sequence. The model simulates the exact lane configurations of the existing CBSA inspection plaza. We calibrate the microsimulation model (that is define model parameters that reproduce actual primary inspection lane performance) based on available data. This included several tests of different vehicle arrival rates and inspection times at the primary booths to produce the same throughput observed from Remote Traffic Monitor Sensor (RTMS) System. As for the physical capacities of the Canadian Custom Plaza at the Ambassador Bridge, there are currently 13 and 10 lanes available for passenger and commercial vehicles, respectively (CBSA 2016). Two of the passenger's lanes are designed for NEXUS travellers and one of the commercial vehicle lane is designated for trucks using the FAST program. The framework for micro-simulation modeling is presented in Figure 1.

For any given increase in the number of RFID equipped lanes, RFID enabled documents or combinations of the two, it is be possible to calculate the estimated reduction in wait time (defined as the time interval from when a vehicle joins a queue to when it is released from the primary inspection booths). This reduction can be disaggregated into time savings accruing to vehicles with RFID enabled documents and vehicles without them (there is a positive externality effect at work here, whereby the wait times of all drivers decrease as the proportion of drivers with RFID enabled documents increases.) The times savings will be translated into money terms for cost-benefit assessments using value of time estimates.

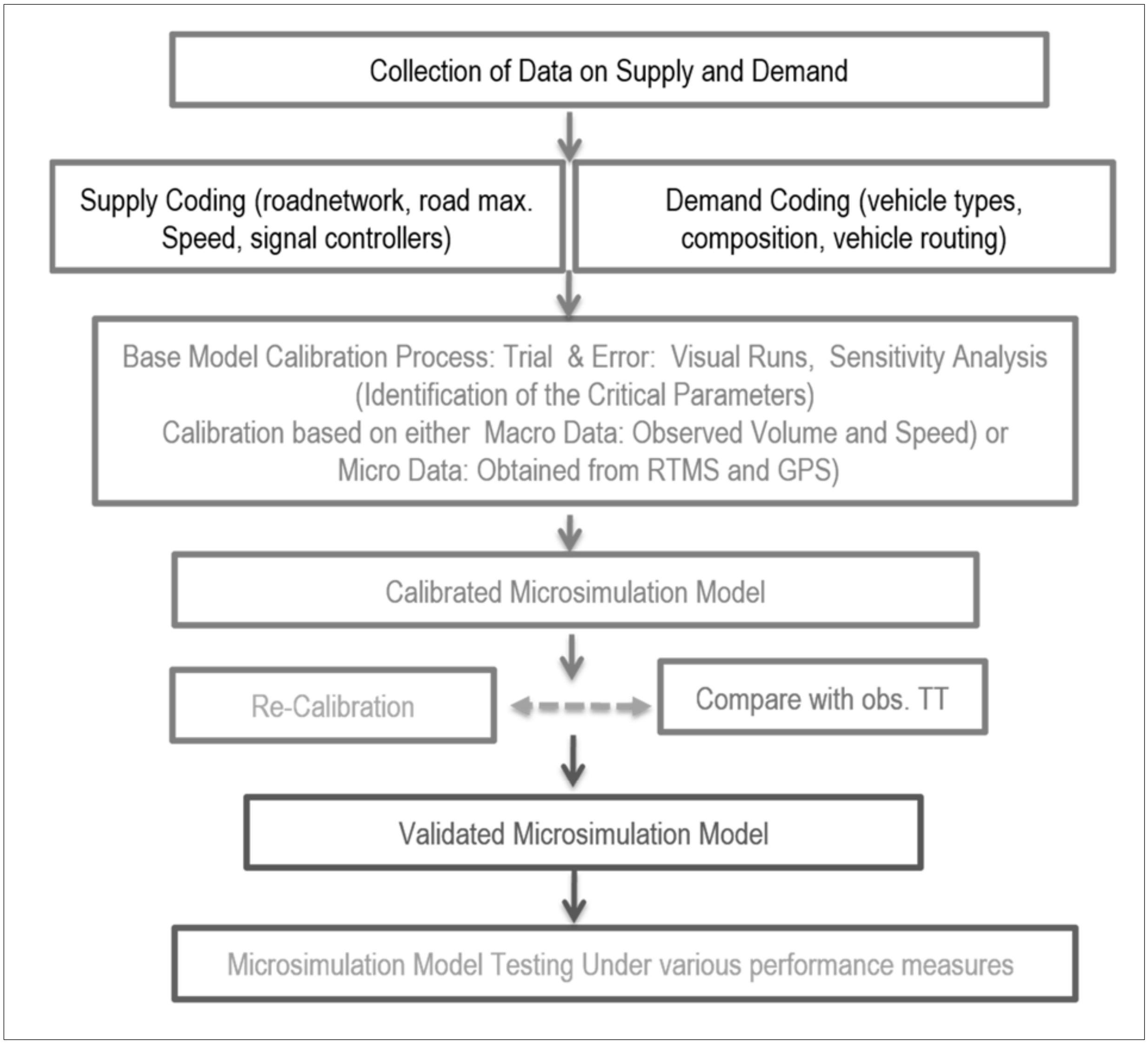

Figure 1. Framework for developing a calibrated Micro-Simulation Model

Our approach to assessing the effect of RFID technology on border crossing wait times starts by defining different inspection time distributions (taking account of both mean times and the variability across times) separately for RFID enabled and conventional inspection lanes for commercial vehicles, mainly heavy duty trucks. We hypothesis that RFID enabled lanes will have clearance times with lower mean and standard deviation compared to non-RFID clearance times. The microsimulation model gives us great flexibility to model not only the length of queues for each service booth, but also the traffic dynamics in the plaza including the distribution of vehicles from one, two or three lanes on an approach road to a larger number of queues in the plaza; and the interactions of vehicles in the plaza. The inspection time is defined as the time interval between one vehicle releases from a booth servicing a given lane to the next vehicle's release in that lane.

Once we have a microsimulation model that is capable of reproducing the performance of the inspection plaza under the RFID and conventional inspection lane cases, we can test a number of scenarios to assess the effect of increased presence of RFID technology. For commercial vehicles, the scenarios are defined on the following basis:

- The number of RFID lanes and non-RFID lanes
- The proportion of vehicles passing through the plaza in which all drivers have RFID enabled documents
- Rules of operations, such as whether lanes with RFID readers are open to all vehicles or exclusive to vehicles with RFID enabled documents only.

Through this simulation structure and as a proof of concept, we are able to quantify the reduction in crossing times for the commercial vehicles with respect to: 1) the status quo scenario 2) increased RFID enabled lanes.

Data

This research makes use of traffic count data from various sources. First, data collected via a RTMS system that was deployed by the Cross-Border Institute, University of Windsor, in May 2015 are used to estimate the volume of the Canada bound commercial and passenger traffic entering Canada (i.e. south bound traffic). Figure 2 presents the locations of the sensors forming the RTMS System.

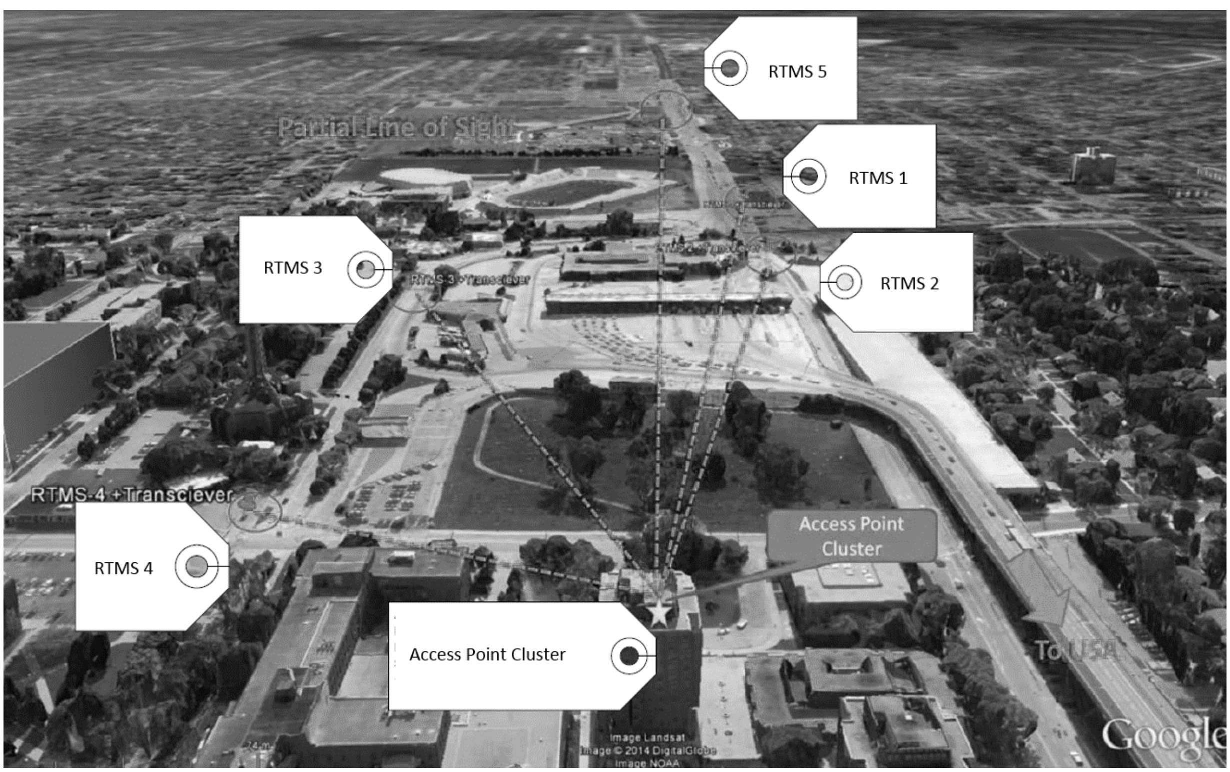

Figure 2. RTMS Data Acquisition System at the Ambassador Bridge (*Base Image Source: Google Map*)

The collected data consists of minute to minute vehicle count for six vehicle classes (based on length) that enter from US into Canada. This data, which was observed by RTMS unit #2 for the period June 8 – 14, 2015, form the basis for calibrating the micro-simulation model used to generate aggregate statistics as a starting point. The exact location of the RTMS sensor recording the count of vehicle exiting from the Canada custom Plaza is shown in Figure 3.

Figure 3. RTMS Monitoring Station at the Exit of the Canadian Custom Plaza at the Ambassador Bridge
(*Base Image Source: Google Map*)

A summary of the volume of Commercial vehicles used to calibrate the model are presented in Table 1. These volumes are calibrated against an average crossing time of approximately 17.50 minutes obtained from analyzing the crossing time of 10,827 commercial vehicles that crossed the Ambassador Bridge in June, 2013 (Gingerich et al. 2016). The crossing time was estimated by geocoding GPS pings generated by commercial carriers within a geo-fence (total length of 2.5 Km) located on both sides of the Canada US border at the Ambassador Bridge, as shown in Figure 4 (Gingerich et al. 2016). These data were used to generate a crossing time distribution for trucks entering Canada from the US, as shown in Figure 5. The distribution formed the basis for developing a processing/dwell time cumulative distribution function in our simulations.

Table 1. Count of Trucks Crossing the Ambassador Bridge to Canada, June 8 – 14, 2015

Day	Trucks
Monday	3,571
Tuesday	4,204
Wednesday	4,270
Thursday	4,328
Friday	4,243
Saturday	2,503
Sunday	1,283

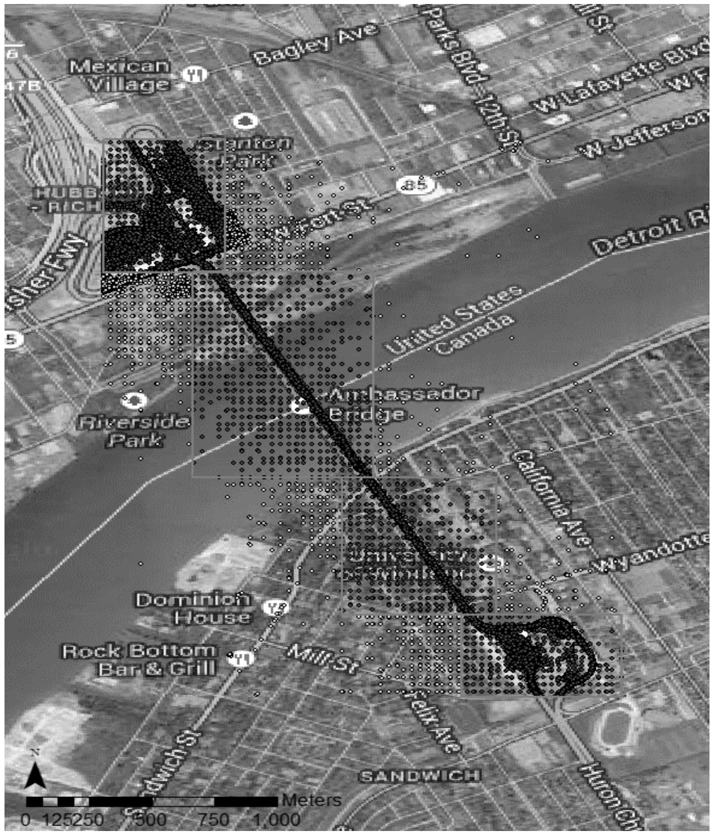

Figure 4. Geo-fence tracking GPS pings of commercial vehicles across the Ambassador Bridge (Source: Gingerich et al. 2016)

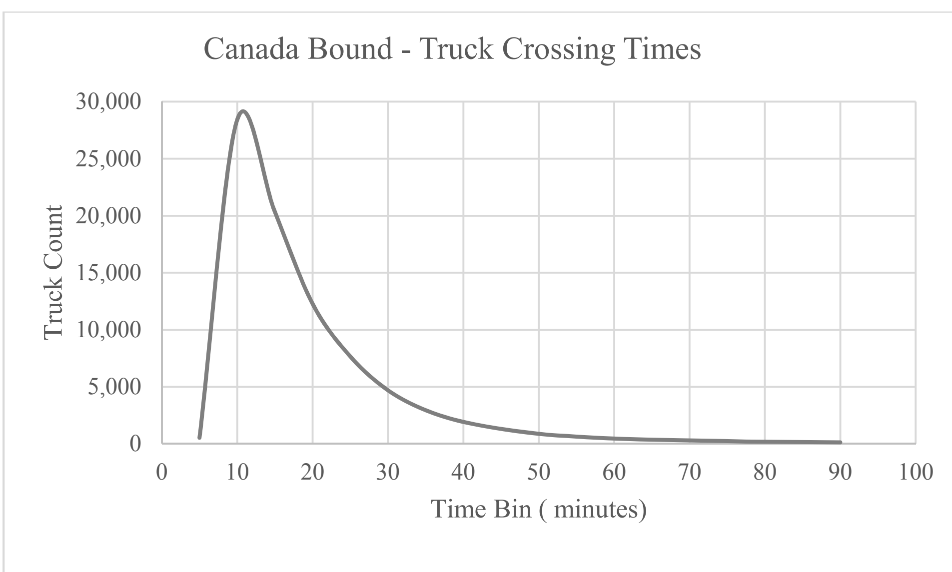

Figure 5. Crossing Time Distribution Adapted in VISSIM Simulation (Source: Gingerich et al. 2016)

Preliminary Results

The preliminary results pertaining to the microsimulation model calibrated for commercial vehicles are presented in Table 2. The RFID lane is represented by a processing time distribution that ranges between 60 sec -180 sec whereas the conventional primary inspection lanes (Non-RFID) feature a processing time ranging from 120 sec – 300 sec. A total of 10 lanes were simulated including one RFID lane. The model resulted in an average simulated crossing time of 18.65 minutes with close to 93% predictive ability for the system.

Table 2. Preliminary Results of the Calibrated Microsimulation Model for Commercial Vehicles

Conventional Inspection Lane	RFID Enabled Lane	Avg. Observed Crossing Time (min)	Simulated Avg. Crossing Time (min)	Percent Difference
9	1	17.50	18.65	6.57%

Conclusions and Future work

A microsimulation model is calibrated to assess the reduction in processing times by implementing increased RFID based processing lanes for commercial vehicles at the Canadian Inspection Plaza of the Ambassador Bridge. The calibrated model is able to simulate the existing performance of the Canadian Inspection Plaza for commercial vehicles. The data used in model calibration is obtained from various sources including an in-house developed RTMS data acquisition system and GPS ping records for a very large number of Canadian trucks. The calibrated microsimulation method offers a great flexibility to simulate various configurations featuring RFID and conventional inspection lanes for commercial carriers and assess the savings that can be realized by implementing more RFID enabled lanes. For future work, the model calibration will include passenger traffic and implementation of increased availability of RFID based lanes. Following that, the framework can be extended to include the new Gordie Howe Bridge to assess the impact of RFID enabled lanes for both passenger and commercial traffic.

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