Design and Development of a Methodology to Estimate Urban Container Truck Traffic

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Abstract

This paper describes a methodology to estimate container truck traffic volume to help understand the effects of this traffic on transportation engineering and planning issues in urban inland ports within the Canadian Prairie Region. The methodology is sensitive to the unique characteristics of container truck traffic and is intended to assist transportation engineers and planners reveal issues that should be considered in defining, evaluating, and choosing among alternative options to improve urban container freight transportation.

Despite the growth and importance of containers, transportation engineers and planners currently have insufficient tools to estimate container truck traffic volumes in their cities. Consequently they struggle to quantitatively evaluate the effect container truck traffic imposes on the urban transportation system. Regardless, there is an increasing demand for freight forecasts for long-term infrastructure planning; however, forecasts are weakened unless there is data representing current conditions. Therefore, methodologies are required to accurately estimate current container truck traffic volume.

The methodology discussed in this paper is based on research currently being conducted to develop a container truck model in Winnipeg using 348 hours of truck classification counts at various locations on the truck network. From this preliminary analysis three important findings are revealed: (1) container truck traffic exhibits different temporal characteristics than other articulated truck traffic; (2) geographic distribution of container truck traffic differs from other articulated truck traffic; and (3) there is a significant difference between the container truck and other articulated truck axle configurations.

INTRODUCTION

This paper describes a methodology to estimate container truck traffic volumes in medium-sized metropolitan inland ports within the Canadian Prairie Region. The methodology is sensitive to the unique characteristics of container truck traffic and is designed to assist transportation engineers and planners improve their understanding of the impacts of container trucking in their cities. It is anticipated that this broadened understanding will reveal issues to be considered in defining, evaluating, and choosing among alternative options to improve urban container freight transportation.

In this paper, medium-sized metropolitan areas are defined as cities with a population between 200,000 and 1,000,000. Inland ports are defined by the North American Inland Ports Network as "a site located away from traditional land, air and coastal borders with the vision to facilitate and process international trade through strategic investment in multi-modal transportation assets and by promoting value-added services as goods move through the supply chain.” The methodology described in this paper is developed for urban areas satisfying these definitions within the Canadian Prairie Region.

The paper presents the initial steps of designing and developing a container truck model for Canadian Prairie Region inland port cities. Preliminary results are attained using nearly 350 hours of visual truck classification counts at various locations on Winnipeg’s truck network.

BACKGROUND OF CONTAINER FREIGHT TRANSPORTATION

Containers are used to transfer freight seamlessly between transportation modes using standardized equipment (1). The interchangeable nature of containers reduces the cost and travel time of transporting freight long distances without sacrificing travel time reliability (2), and has introduced the concept of “just-in-time” (JIT) delivery. Shippers of both domestic and international freight have embraced this technology and in many cases are now dependent on containers to remain competitive (3). This is evident based on the growth of freight transported in international containers in Canada since the 1960’s as illustrated in Figure 1. Not shown in this figure are freight moved in domestic containers, which accounted for over 15 percent of total rail container movements in 2008 (4). This trend has been global as “most of the world’s non-bulk cargo travels from point of origin to final point of destination in standard marine shipping containers” (5) resulting in developed economic countries like Canada and the United States generating over 100 containers of trade annually for every 1,000 people (6). The demand for fast, on-time delivery of containers is exerting pressure on the transportation system to become increasingly efficient and reliable, and is imposing expectations on the transportation system to adapt harmoniously with fluctuating, and unpredictable, global market trends (7).

The exodus of North American manufacturing plants to Asia, commonly referred to as the “China effect,” is resulting in unprecedented volumes of containerized freight passing through West Coast ports and moving along continental coast-to-coast land bridges or port to inland destination mini-bridges (8). In 2006, Canada responded to the China effect by committing $1-billion dollars to the Asia-Pacific Gateway Corridor Initiative (APGCI).

The APGCI requires transportation engineers and planners to strategically design and construct infrastructure or improve operating conditions of the transportation system to support increased volumes of container freight. For inland ports, the infrastructure and operational designs primarily concern the urban road network. This is because trucks must pick-up or drop-off containers at rail intermodal terminals for customers located within the hinterland of the terminal (9). This activity is commonly known as drayage. Therefore, the volume of container truck traffic in cities grows proportionally with increases in freight transported by containers.

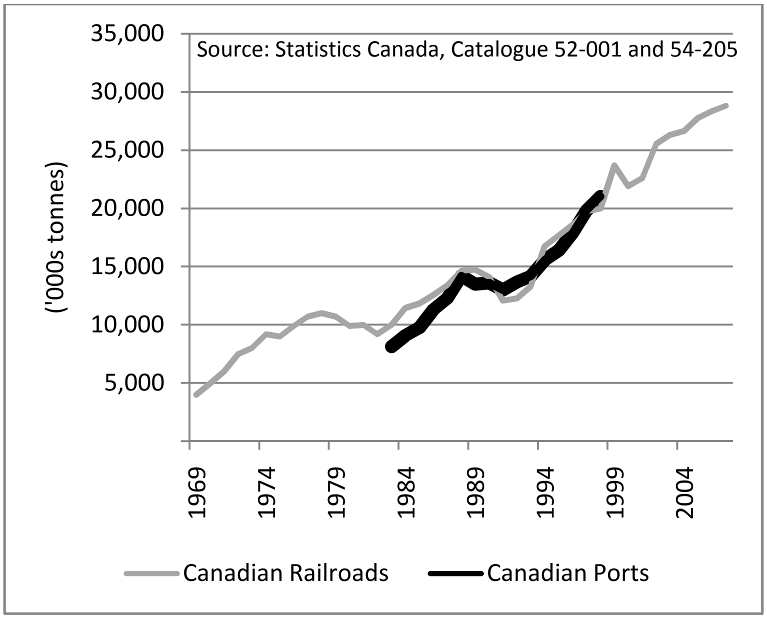

Figure 1: Freight Tonnage Handled in International Containers by Canadian Railroads and Ports from 1969 to 2008

Drayage occurs along intermodal connector routes and represents the "last mile" portion of the container freight transportation journey. According to the U.S. Department of Transportation (2000), these routes are usually local or city streets with lower design standards than the National Highway System (NHS). The last mile is where freight delivery companies have the least control in the delivery process and typically contributes to the longest delays (10) and up to half of the cost of an intermodal move (11). A one- or two-hour delay in a drayage movement can result in delays of up to a week for an international move (12). Since inland ports and their respective intermodal terminals are located in urban areas and every container requires a dray to and from a terminal, eventually every container will make its way onto the urban transportation network on a truck generating increased urban truck traffic (13; 8). This paper discusses a methodology to estimate container truck volumes in medium-sized metropolitan inland ports within the Canadian Prairie Region to assist transportation engineers and planners better understand the characteristics of truck traffic involved in container movement in these areas. This understanding can further assist in defining, evaluating and choosing among alternative options to improve urban container freight transportation.

CHARACTERISTICS OF DRAYAGE MOVEMENTS

Container trucks differ from other truck types in seven critical ways: operational, physical, competitive, legal, safety, ownership of containers, and traffic measurement and estimation characteristics (14). These differences must be considered in analyzing and modeling container truck volume and developing container-specific metrics such as container truck volumes on a road network (15). These differences are important because they allow for certain assumptions that are not applicable for general truck traffic. For example, the origins and destinations are assumed to be fixed at rail intermodal terminals and temporal characteristics of container trucks are assumed to follow those exhibited at terminal entrances.

Operational Differences

Unique origin-destination patterns exhibited by containers owing to each container originating or terminating at a rail intermodal terminal (16) change the routing patterns of goods in metropolitan areas. Container trucks operate almost exclusively as urban drayage movements (17), which are different than other tractor semi-trailer general freight operations that function as medium- or long-haul movements. Container trucks make multiple intra-city trips per day between shippers and terminals and are especially susceptible to urban congestion (11). Drayage movements contribute to high proportions of trucks entering or exiting terminals without a container and increase volumes of bobtail traffic to the urban road network (18).

Tightly defined rail intermodal terminal schedules in response to just-in-time delivery demands dictate when containers must be picked-up and delivered (11; 14). These schedules, along with the location of intermodal terminals, can directly impact the temporal characteristics of container trucks (13) and influence the efficiency and cost of drayage operations (19). These operational differences affect how container truck traffic is modeled and can potentially alter truck traffic characteristics in the event of an intermodal terminal relocation.

Physical Differences

Container trucks are physically different than other truck types in terms of length, tare weight, structural integrity, and chassis connection to truck tractors. International containers have lengths conforming to International Organization for Standardization (ISO) standards of 20 and 40 feet (and sometimes 45 and 48 feet), which are unlike traditional trailer and domestic container lengths typically of 53 feet. Despite shorter lengths, international container tare weights are typically higher than traditional trailers and domestic containers since a stronger construction is necessary for stacking on ships (8) and sustaining severe environmental conditions during ocean voyages. Containers are primarily carried by truck tractors using a special purpose tridem axle chassis which interchanges between truck tractors, extends to carry different lengths of containers, and increases the maximum allowable payload of the unit (9). This is important for pavement design engineers because container trucks increase the proportion of tridem axle configurations and can influence pavement design inputs.

Competitive Differences

Container freight transportation operates in a globally competitive environment that is linked to external factors typically outside of the transportation engineer's domain. Factors such as business patterns of ocean carriers, leasing and repositioning costs of containers, and trade deficits directly affect urban container freight transportation operational and planning issues (18). In Canada, the establishment of the Port of Prince Rupert was accomplished without input from cities like Winnipeg, yet this development will directly impact Winnipeg's transportation system. Further, disruptions including labour strikes at ports or railway incidents threaten the temporal characteristics of container freight (20) and ultimately affect urban container truck traffic. Nevertheless, transportation engineers and planners are expected to proactively respond to current and future changes in the system and ensure their jurisdictions remain relevant to shippers and carriers.

Modally, container freight typically does not compete; ships are used for the oceanic component, rail is used for the land bridge movement, and trucks are used for the urban drayage operation (16). However, strong intra-modal competition to capture freight within each movement exists. Containers have also created or intensified other competitive forces. Coastal ports and canals compete to attract containerships and ocean freight; rail lines compete to attract containers on the land bridge movement; and cities compete to attract container freight through establishing inland ports. Understanding the competitive environment of container freight transportation is important for engineers and planners to ensure this type of traffic is explicitly considered in design.

Legislative Differences

International container freight transportation is subject to legislative and regulatory restrictions not applicable to traditional trucking operations. For example, cabotage regulations govern permitted triangulation movements and length of time international containers can reside within a country. These regulations have direct impacts on the land bridge routing of containers and consequently impact container trucking in urban areas.

Safety-related Differences

The safety performance of container truck chassis is an on-going debate. Rail lines, who own many chassis used by third-party trucking companies, argue that trucking companies are responsible for the safety performance of the chassis once it is secured to a truck. Trucking companies argue that chassis owners are responsible for providing chassis in a condition that will pass a safety inspection. Standard industry contracts (i.e., the uniform intermodal interchange agreement) are clarifying this issue; however, these contracts are not mandatory. Nonetheless, the mechanical fitness of chassis affect the safety performance of the transportation system.

Ownership of Containers

International containers are primarily owned by ocean carriers or leasing companies (21), while domestic containers are typically owned by truck and rail carriers. Ownership impacts container routing, particularly international, due to the governing interests of the owners. Ocean carriers are concerned with the expedient return of containers from North America to Asia since the majority of their revenue is generated from the Asian head-haul (20). Conversely, leasing companies offer increased flexibility through lease options that enable carriers to leave containers at trip destinations if there is no backhaul opportunity (21). Transloading freight from international containers to domestic containers is a common practice to expedite the return of containers to Asia. However, transload facilities add another location for trucks to pick-up and drop-off containers and hence these facilities have similar effects of rail intermodal terminals on the temporal and routing characteristics of container trucks.

Traffic Measurement and Estimation Differences

Container truck volume is difficult to measure because detection of containers requires precise body type identification systems. Current technologies that automatically measure truck volume use in-pavement sensors or optical detection using cameras. In-pavement sensors provide vehicle length, axle spacing, and weight data but cannot capture body type characteristics. Cameras are becoming increasingly sophisticated in their ability to identify different body types of trucks; however, this technology is still unable to sufficiently differentiate containers and traditional trailer types (22). Advanced tracking systems that monitor containers from origin to destination (such as radio frequency identification tags) are commonly used by ocean carriers (21), although this information is classified and not readily-available for modeling container trucks in urban areas. Similarly, truck companies are deploying geographic positioning systems (GPS) to monitor their fleets; however, most companies track containers through an in-house dispatch system and telephone communication with drivers (21) that is also not readily-available for modeling purposes. The absence of container truck traffic data on urban street networks is a direct result of insufficient technologies to monitor this traffic. The data collection procedure described in this paper provides urban container truck traffic data and is vital for estimating container truck volume.

NEED FOR CONTAINER TRUCK VOLUME ESTIMATES

Due to the economic importance of containers, the rapid increase of container freight in recent decades, the presence of containers in urban areas, insufficient tools to quantitatively analyze urban container trucking (23), and the lack of technology to measure and estimate container truck traffic (17), there is a need to develop a methodology to acquire container truck traffic data for the purpose of modeling container truck volume (24). Few sources of container truck data are available in North America (21). Sources of container freight data available for modeling container trucking in the Canadian Prairie Region are Statistics Canada (Trucking Commodity Origin and Destination Survey), Transport Canada (National Roadside Survey), and the U.S. Bureau of Transportation Statistics (Transborder Surface Freight Dataset). These databases are either aggregated at national or provincial levels or provide inadequate geographic detail for modeling urban container trucking.

Some of the reasons why container truck volume estimates are important are they:

- help transportation engineers and planners understand urban container truck traffic characteristics;
- assist with scenario-based analyses;
- serve as a baseline for developing forecasting models;
- can be used as inputs for transportation system performance measures; and
- feed pavement designs (25).

Without sufficient tools to objectively assess container freight in urban environments, transportation engineers and planners struggle to strategically provide adequate infrastructure to maintain and enhance the competitiveness of the transportation system to improve efficiency, safety, productivity, and economic growth (26). Given that Canadian Prairie Region cities are supporting inland ports, major railroads are considering the development of large value-added intermodal hubs outside metropolitan areas, and the importance of the last mile for intermodal freight transport, it is critical for transportation engineers and planners to understand container truck flows in urban areas to design and operate transportation infrastructure to facilitate these movements.

The literature reveals that the influence of container trucks on the transportation system is complex and significant and that research specific to this unique freight transportation environment is undeveloped and warrants special attention (14; 26). The literature also calls for increased operational research using strong quantitative approaches to obtain understanding of the dynamic relationship between terminal schedules and drayage movements (23). Currently, "there is no methodology aimed specifically at the analysis and planning of freight movements within the city" (27). This paper addresses the need to develop a methodology to estimate container truck traffic volume that recognizes the unique characteristics of container trucks and overcomes the traffic measurement and estimation technology limitations.

METHODOLOGY TO ESTIMATE CONTAINER TRUCK TRAFFIC

The methodology to estimate container truck traffic is currently under development; however progress on some components has advanced enough to report preliminary findings. The methodology to estimate container truck traffic in urban areas requires the following:

1. Understanding who the major container freight players are and the magnitude of their container generation;
2. A defined container truck road network;

3. Data sources for estimating container truck traffic volumes;
4. A process to analyze the data to estimate container truck traffic volumes; and
5. A process to validate the reasonableness of the container truck estimates.

This section discusses how each of these needs was obtained for this research; however the focus of this paper deals with numbers 4 and 5.

1. Understanding Major Container Freight Players

Interviews with shippers and carriers were combined with field investigations and internet searches to identify major container freight players and the magnitude of their container truck operations. Field investigations involved observing and identifying truck companies carrying containers and identifying companies with containers on their premises by traveling to industrial and commercial areas of Winnipeg. This investigation provided a basic list of potential container freight carriers to survey. This list was shared with the Manitoba Trucking Association to validate and add carriers that may have been omitted.

An internet search of Industry Canada's website supplemented the list of potential container businesses identified in the field investigation. This site contains the Canadian Importers Database that identifies major importers (those representing the top 80 percent of all imports by value for each Canadian city) and their location. This site also provides the following company information: commodities, number of employees, involvement in international trade, trade volumes by value, and contact information.

The final list contains industrial and commercial sector companies and truck carriers. Telephone contact was made with each company to determine if they use containers for transporting freight, the magnitude of container generation by day, month, or year, which rail intermodal terminal the company uses, and truck routes used for transportation. In most cases, companies were only able to provide information about some of these issues. Using the results of this survey, major container players were identified, their geographic location in the city was determined, and preferred container truck routes were revealed. To protect the confidentiality of each survey respondent, container land use zones were developed that aggregate individual land use zones and the number of containers generated by each company at the zonal level.

2. Defining a Container Truck Network

The truck network, as defined by the City, was the initial starting point for developing a container truck network. Survey results, discussions with transportation engineering government officials, and general transportation engineering judgement were used to reduce the truck network to the container truck network. For example, roads connecting areas of the city where containers are not generated were generally discarded as container truck network routes. The exception was if the road is used as a through route. In these instances discussions with government officials and engineering judgement was used.

Segments on this network were classified based on the types of data applicable to each.

- Type I segments are those with container truck traffic data,
- Type II segments are those with container truck traffic data estimated through intersection flow balancing,
- Type III are segments with articulated truck traffic data but no container data, and
- Type IV segments are those with no truck data.

Figure 2 shows each segment type for Winnipeg. The data source for each segment class is discussed in the following section.

3. Data Sources for Estimating Container Truck Traffic Volume

Seven data sources were used to estimate container truck traffic volume on the new container truck network. Each provides a different data type as shown in Table 1. Every data source, except for the NRS, was used to estimate container truck traffic volume in this paper.

Table 1: Data Sources

Data Source	**Data Provided**
UMTIG (U Counts)	Articulated truck turning movements with body types on container truck network
City of Winnipeg (W Counts)	Articulated truck turning movements without body types on container truck network
MHTIS (M Counts)	Annual Average Daily Truck Traffic (AADTT) without body types on container truck network
NRS	Articulated truck data on highway routes connected to the container truck network
BTS	Rail intermodal traffic between Manitoba and the United States, by month
Statistics Canada	Rail intermodal traffic in Canada, by month
Shipper/Carrier Survey	Container truck traffic handled by shippers and carriers in Winnipeg

UMTIG (University of Manitoba Transport Information Group), MHTIS (Manitoba Highway Traffic Information System), NRS (National Roadside Survey), BTS (U.S. Bureau of Transportation Statistics)

The following sections discuss the methodology used to either collect or obtain container truck data from the different sources.

U Count Data

Container truck data for estimating volumes on urban road networks were unavailable; therefore data had to be collected at different locations on this network. Since technologies to automatically obtain container truck data do not exist, manual counts were required. A schedule of intersection turning movement counts of articulated trucks by body type at various locations on the container truck network was developed. This schedule was designed to capture geographic and temporal characteristics of container truck traffic. These counts were conducted by the University of Manitoba Transport Information Group (UMTIG) and are referred to as "U Counts" in this paper. U Counts are the data source for Type I road segments. Based on the shipper and carrier survey, areas in the city with high levels of container activity were identified, and intersection count stations were located in these areas.

There are four tiers of U Count stations defined by the number of hours counted: fixed, control, sub-control, and coverage. Table 2 shows the number of stations, count hours, and day-of-week distribution for each tier. There are 17 count stations with a total of 240 hours of data. The number of stations, hours of data collection, and day-of-week coverage shown in Table 2 were chosen to maximize geographic and temporal coverage of the count data. Fixed stations are located at rail intermodal terminal entrances. Each fixed station obtains a total of 24 hours of data (from 00:00 to 24:00). Counts are conducted for each day of the week.

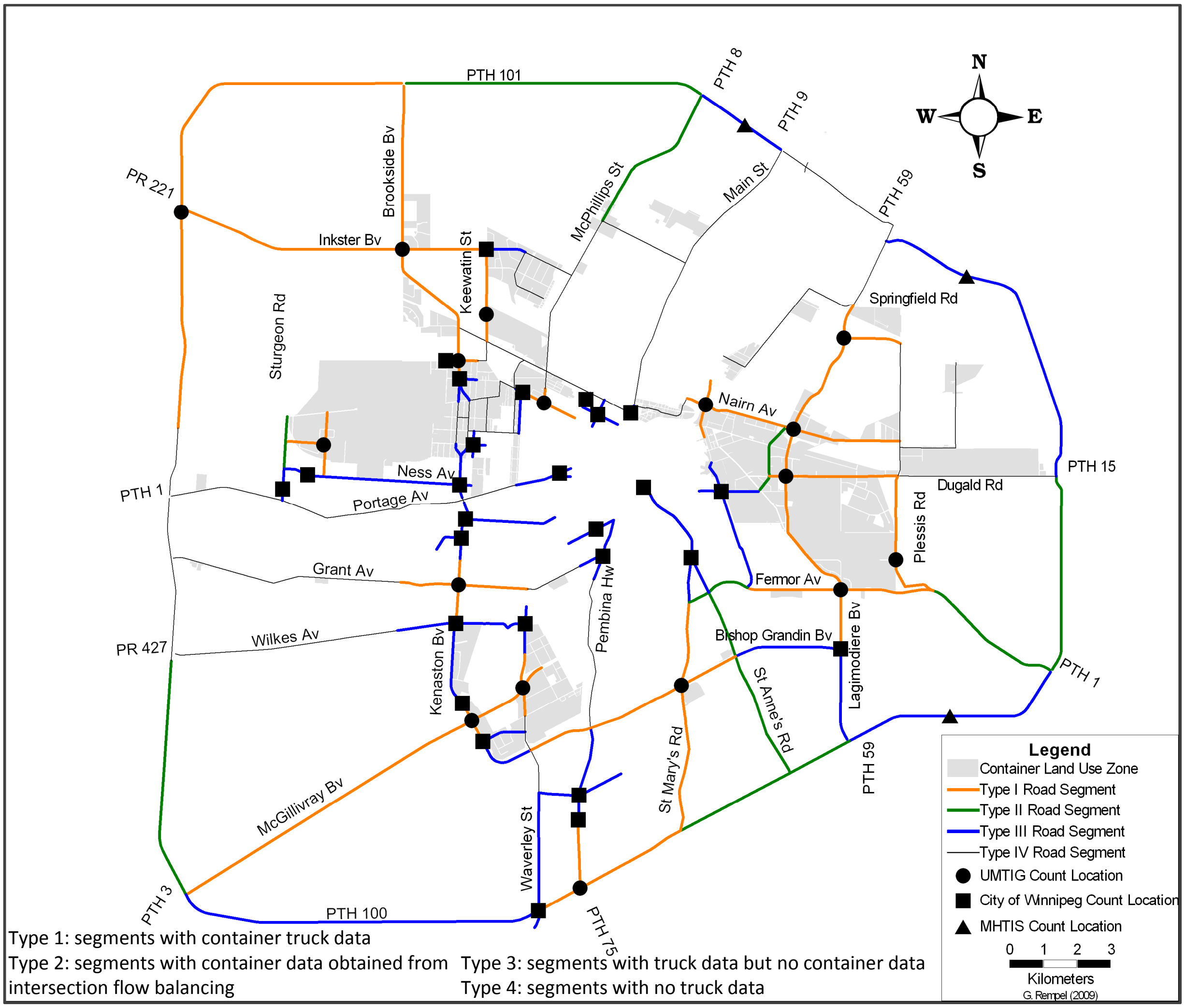

Figure 2: Winnipeg Container Truck Network and Count Locations

Control stations are located at major intersections on the container truck network. Each station collects a total of 18 hours of data for four days of the week. Sub-control stations are located at minor intersections on the container truck network. Each station collects 12 hours of data for three days of the week. Coverage stations are located at intersections where there are high volumes of articulated traffic but it is unknown from the survey whether containers are present. Data from coverage count stations help determine if the intersecting routes should maintain their container truck route status. Overall, counts are distributed for all hours of the day and days of the week.

Table 2: U Count Station Tiers

Station Tier	Number of Stations	Total Hours of Data for Each Station	Day-of-Week Coverage (out of 7)
Fixed	2	24	7
Control	4	18	4
Sub-control	8	12	3
Coverage	3	8	2

W Count Data

The City of Winnipeg conducts manual intersection turning movement counts at various locations along the entire street network each year. These counts classify vehicles as cars, single unit truck, semi trailer, and semi combination. There are five types of counts defined by their duration: 6, 8, 11, 12, and 15 hour counts. These counts all occur between 07:00 and 22:00 on all days except Sunday. The City of Winnipeg supplied these counts for this research and are the data source for Type III segments.

M Count Data

The Manitoba Highway Traffic Information System (MHTIS) maintains traffic data for highways in Manitoba. MHTIS data (M Counts) are collected using Automatic Vehicle Classifiers (AVC) which are automated permanent count stations that provide continuous traffic data for the entire year. M Count data classifies vehicles by axle configuration using the Federal Highway Administrations 13 class system; however, body type data is not available. M Counts were used as another data source for Type III segments.

Since this research is not scheduled to be completed until 2010, a complete dataset from the U, W, and M Counts is unavailable for this paper. Therefore, the container truck traffic estimates discussed in this paper were calculated using a portion of the total planned number of counts discussed in the previous sections. Table 3 shows characteristics of the count data used in this paper to estimate container truck traffic volume, and Figure 2 shows the locations of U, W, and M Count stations.

Table 3: Data Source Characteristics for this Paper

Data Source	Number of Hours of Data	Number of Count Locations	Total Articulated Trucks	Number of Container Truck Network Centreline Km (out of 367 km)
U Count	200	15	16,120	117
W Count	148	19	6,493	90
M Count	8,760	3	1,816,195	19

Note: M Count data is collected using permanent count technologies (automatic vehicle classifiers) while U and W Counts are manual intersection turning movement counts.

4. Data Analysis Process to Estimate Container Truck Traffic Volume

This methodology estimates container truck traffic in four stages.

- Stage 1 calculates temporal adjustment factors for container truck traffic and expansion factors for other articulated truck traffic. Temporal factors for container trucks use fixed count data from U Counts and rail intermodal data from BTS and Statistics Canada. Expansion factors for other articulated trucks are calculated from U, W, and M Count data.

- Stage 2 estimates container truck traffic volumes on Type I segments using U Count data and temporal adjustment factors for container trucks from Stage 1.

- Stage 3 estimates container truck traffic volumes on Type III segments using U, W, and M Count data and expansion factors for other articulated trucks and temporal adjustment factors for container trucks from Stage 1, and

- Stage 4 estimates container truck traffic volumes on Type II segments by performing intersection flow balancing analyses.

The general process for estimating container truck traffic volume is to calculate average hourly truck traffic for road segments using sample data from each count station. Temporal adjustment factors (monthly, day-of-week, and hour-of-day) are applied to the raw count averages to obtain hourly truck estimates for each month, day, and hour. Where possible, container truck traffic volumes are balanced at intersections. These estimates are applied to segments without container or articulated truck traffic data (Type II segments). The goal of this methodology is to estimate hour-of-day, day-of-week, and monthly container truck traffic on Type I, II, and III road segments. This methodology does not estimate container truck traffic for road segments without truck data (Type IV segments).

5. Validation

Two validation procedures are developed and will be applied upon completion of data collection: one to assess the accuracy of rail intermodal terminal container truck traffic generation estimates and another to check container truck traffic volume estimates on individual road segments. The first validation procedure sums container truck traffic volumes generated by rail intermodal terminals using U Count data and compares this value to the total number of containers originating and terminating in the province by rail, using CN and CP intermodal terminal container traffic data supplied by each terminal. The purpose of this validation procedure is to ensure that the estimates for the largest generators of container truck traffic are reasonable.

The second procedure uses shipper and carrier survey results for conducting reasonableness checks to validate container truck traffic volume estimates on individual road segments. Each survey respondent is part of an industrial or commercial land use zoning group. These land use zones are aggregated to create a container traffic analysis zone which simplifies the validation process and ensures confidentiality of individual survey data. The purpose of this validation procedure is to ensure that volume estimates are appropriate and avoid obvious inaccuracies rather than determine if the estimates are within a statistically significant range.

The container truck volumes near container traffic analysis zones should approach the number of containers generated by the zone. Container truck volumes on the network must be greater than the sum of containers generated by surveyed shippers and carriers since the survey only represents a portion of all players. Figure 3 shows the magnitude of container activity for each container traffic analysis zone and container truck route.

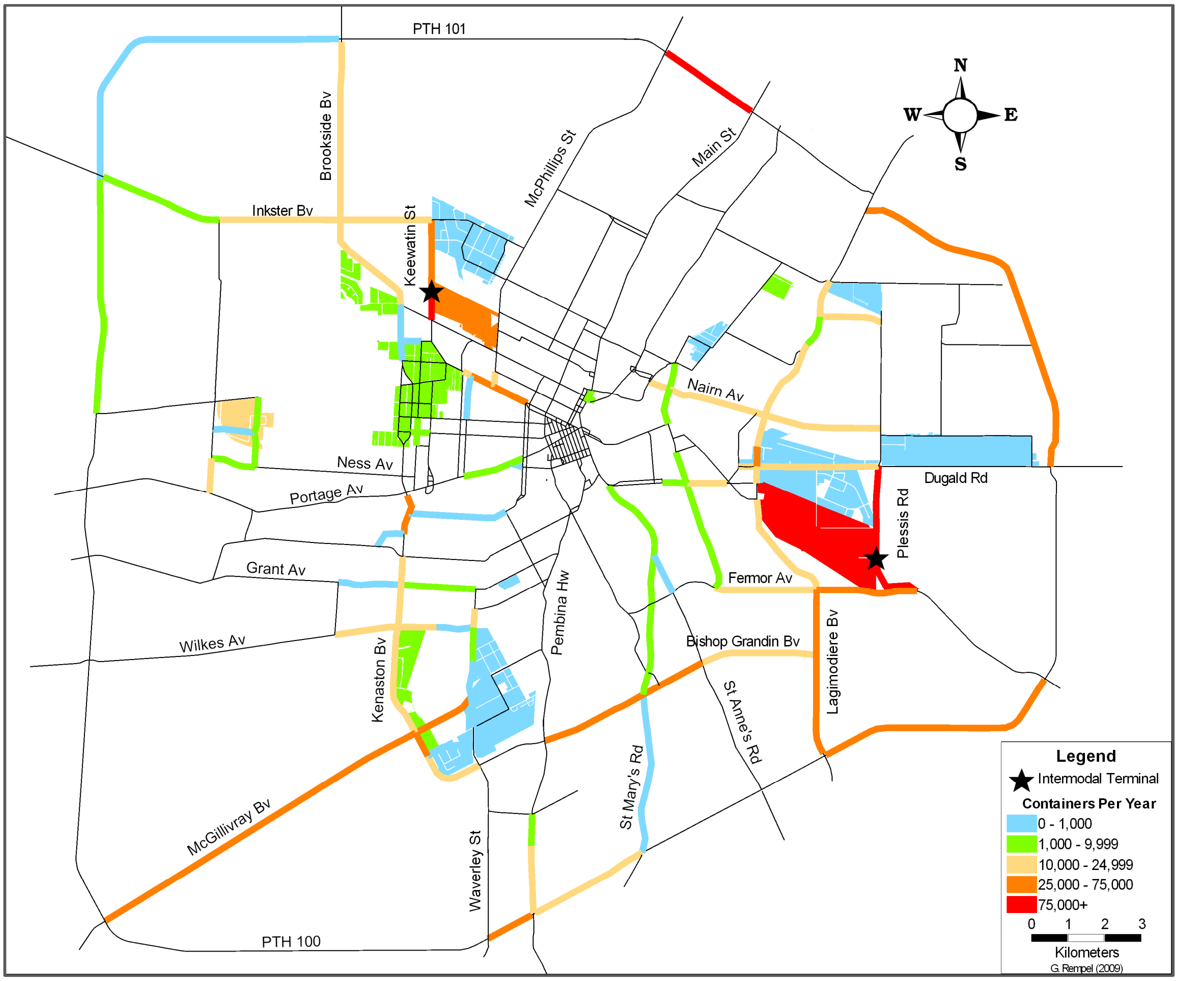

Figure 3: Container Activity for Container Land Use Zones and Container Truck Network Segments

RESULTS AND FINDINGS

Based on analysis of preliminary data, three major findings related to temporal, geographical, and physical characteristics of container trucks compared to other articulated trucks are identified.

Temporal Differences

Container truck traffic differs temporally from other articulated truck traffic in terms of hour-of-day, day-of-week, and month. Figure 4, Figure 5, and Figure 6 show average daily container and articulated truck traffic in Winnipeg by hour, day, and month, respectively. On an hourly basis, container trucks and other articulated trucks behave similarly with one exception. Other articulated trucks exhibit a peak in volumes between 08:00 and 10:00 and 13:00 and 16:00. Container trucks exhibit more activity in the early hours of the day but also peak at the same time as other articulated trucks.

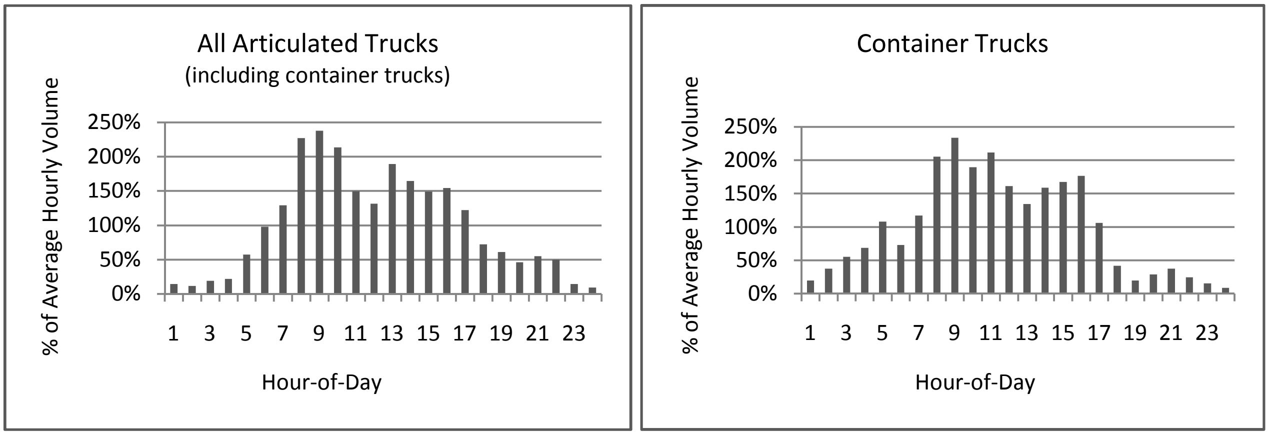

Figure 4: Hour-of-Day Volumes for Container and Other Articulated Trucks

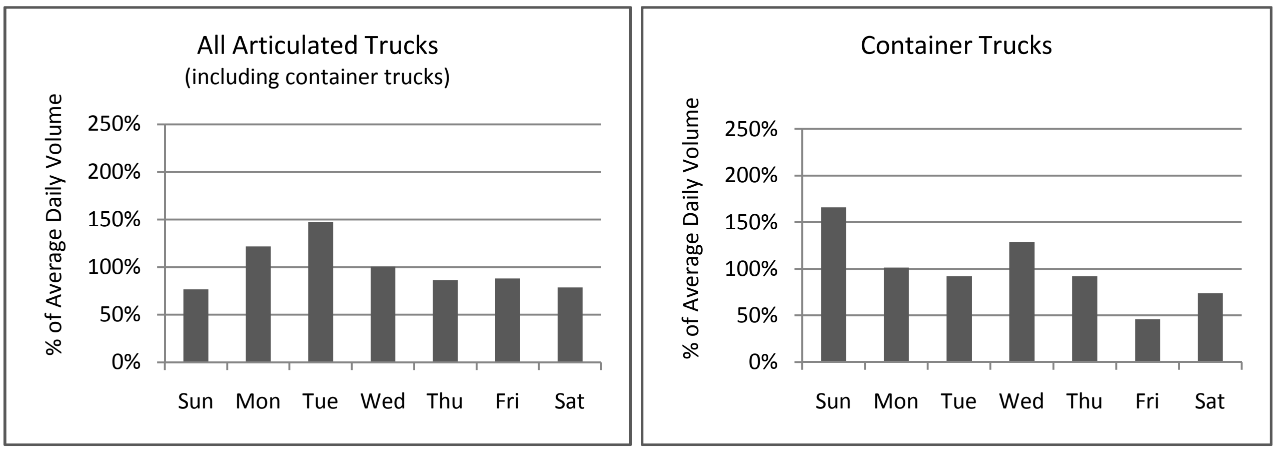

Figure 5: Day-of-Week Volumes for Container and Other Articulated Trucks

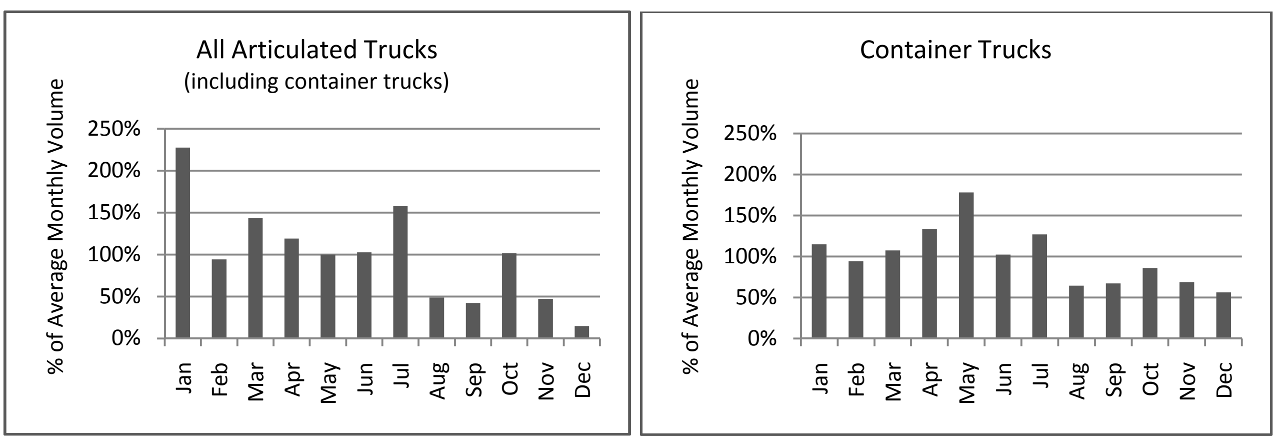

Figure 6: Monthly Volumes for Container and Other Articulated Trucks

On a daily basis, discrepancies exist between container and other articulated truck traffic. Articulated truck traffic follows a normal distribution skewed towards the beginning of the week, while container truck traffic appears to have two peaks, one on Sunday and another on Wednesday. Generally it is expected that urban truck traffic will decrease on weekends, which is observed with other articulated trucks; however, container truck volumes are highest on Sunday, which is a significant difference to general expectations. Further, the variation of container trucks is greater than other articulated trucks;

ranging between 45 percent to 160 percent of the average daily volume for containers and 75 percent to 145 percent for other articulated trucks.

Regarding monthly distribution, container and other articulated truck traffic exhibit different peaking characteristics, but generally follow the same monthly pattern. Articulated truck volumes peak in January while container trucks peak in May. Both truck types show large decreases in volume between August and December with October volumes approaching average.

Geographic Distribution Differences

Figure 8 and Figure 9 show average daily container and articulated truck traffic volumes, respectively. The purpose of these figures is to illustrate the differences in geographic distribution between container trucks and articulated trucks and not to compare volumes; therefore the scale of Figure 9 has been increased by a factor of 10 for clarity. There are seven road segments that illustrate the difference in geographic distribution: Inkster Blvd, Brookside Blvd, Keewatin St, Bishop Grandin Blvd, Fermor Ave, Plessis Rd, and Nairn Ave.

There are two rail intermodal terminals in Winnipeg, one on Keewatin St and the other on Plessis Rd. As expected, the most noticeable differences occur in the vicinity of these terminals. Brookside Blvd, Lagimodiere Blvd, and Nairn Ave carry relatively large volumes of articulated trucks; however, these same segments carry relatively few container trucks. Conversely, Keewatin St and Plessis Rd are carry relatively large volumes of container trucks but relatively few articulated trucks. This difference is important because making improvements to major articulated truck routes may not translate into benefits for container trucks.

Physical Differences

The axle configuration distributions of container trucks are opposite than those of other articulated trucks. As shown in Figure 7 the proportion of 3S2 and 3S3 axle configurations is 68 and 32 percent, respectively for articulated trucks. For container trucks, the proportion of 3S2 and 3S3 axle configurations is 20 and 80 percent, respectively. This difference is important for pavement design engineers who use axle configuration data as pavement design inputs.

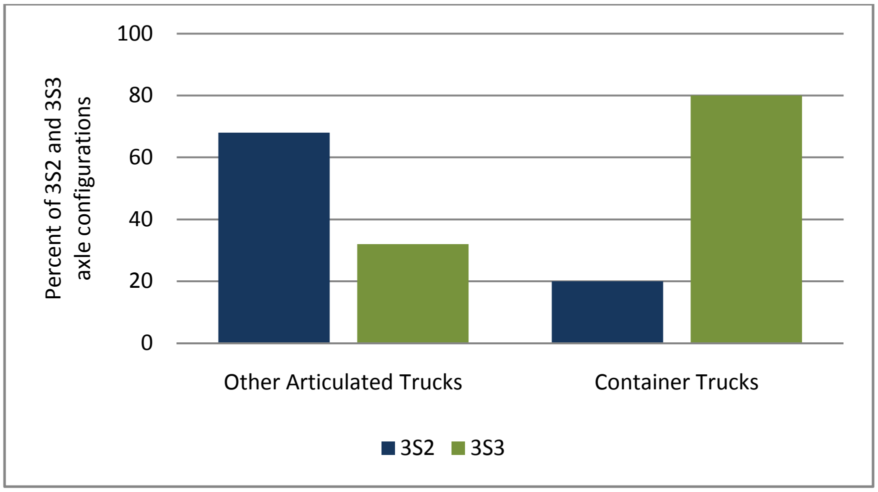

Figure 7: Axle Configuration Distribution of Container and Other Articulated Trucks

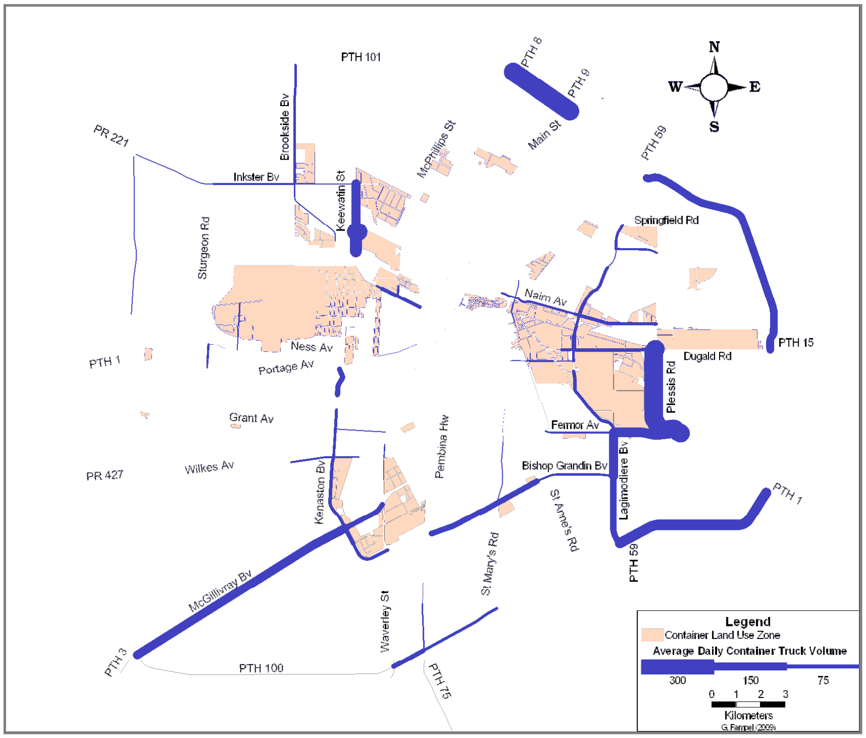

Figure 8: Average Daily Container Truck Traffic

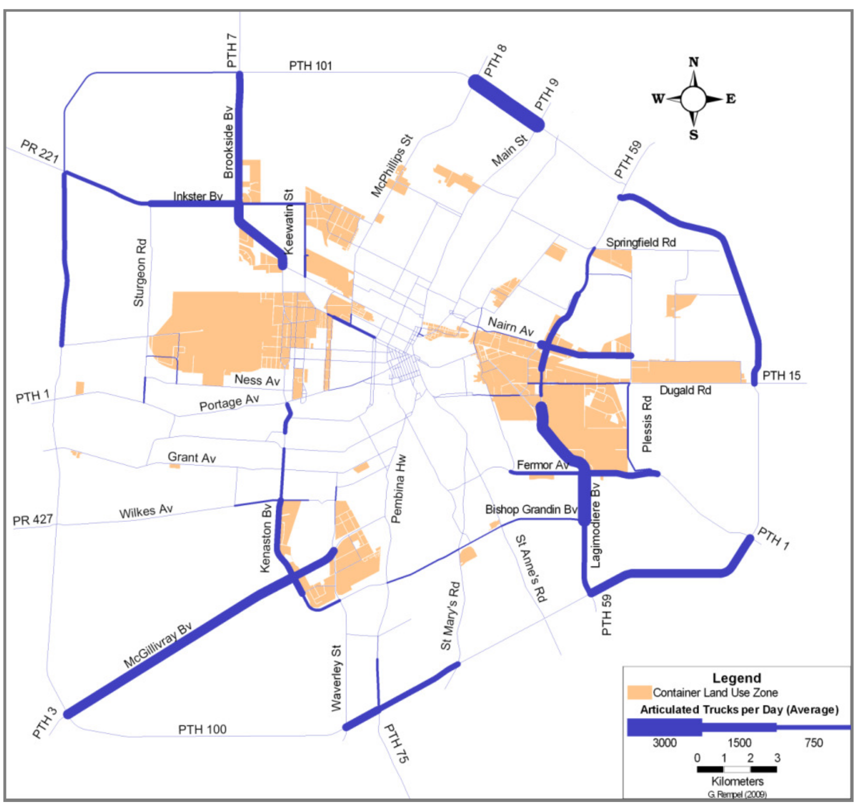

Figure 9: Average Daily Articulated Truck Traffic (including Container Trucks)

DISCUSSION

This section discusses issues and challenges related to estimating container truck traffic in urban areas.

Understanding Major Container Freight Players

The two major difficulties with this component were identifying potential container freight players and generating responses from commercial and rail establishments. Performing a field investigation to observe companies with containers on their premises was the most effective method to identify container players. The next most effective method was consulting the Canadian Importer Database from Industry Canada to identify the top importers in Winnipeg. Other than these two methods, calls to industrial and commercial headquarters inquiring about their involvement with containers was the only other way to obtain this data. Currently there are no data sources listing all container freight players in Winnipeg, therefore it is unknown what the population of container freight players is and what proportion have been surveyed.

The other major challenge was receiving cooperation from commercial and railroad establishments. Commercial entities cited confidentiality concerns as the main reason for not disclosing information while rail intermodal terminals were non-responsive to requests for data. Industrial companies were generally willing to discuss their shipping and receiving operations under confidential terms. Contact with company executives returned marginal responses, therefore direct communication with shipping and receiving personnel was pursued instead. This approach significantly increased response rates. Despite higher response rates, it was common to encounter individuals who had difficulty understanding the difference between a container and a van trailer or the difference between a domestic and international container.

Container Truck Network

Defining a container truck network prior to data collection is difficult. Understanding areas of the city that generate containers and the magnitude of container volumes helps develop a skeleton network between origins and destinations. However, identifying container routes is challenging without traffic data. Defining these routes relies on transportation engineering judgement and industry intelligence. As data is collected, the definition of the container truck network changes and matures. Therefore, the container network is expected to continue to evolve.

Another challenge with defining a container truck network is establishing criteria that define these routes. For example, any segment that carries a container can be classified as a container network segment; however, it is expected, or at least it is reasonable to expect, that every segment of the truck network will accommodate a container at least once. Therefore, different criteria must be established. For this research, a truck route segment will be defined as part of the container truck network if it carries a threshold percent of average daily container truck traffic. For example, if the threshold percentage is 50 percent, and the average daily container truck traffic volume for Winnipeg is 100, then all segments carrying 50 container trucks per day or more would be part of the container truck network. The threshold percentage is not yet determined for this research since a complete data set has not yet been acquired.

Data Sources for Estimating Container Truck Traffic Volume

Data availability or lack thereof, is the largest challenge for estimating container truck traffic in urban areas. Few data sources of truck data incorporating hour-of-day, day-of-week, monthly, axle configuration, and body type truck characteristics exist. Permanent vehicle classification technologies are ill-suited for urban traffic conditions due to variable speeds and short headways; therefore available truck data is typically sample data from intersection turning movement counts. In Winnipeg, as in most cities, this data does not cover seasonality or night time truck characteristics well and does not provide body type data. Data sources with container data (i.e., BTS and Statistics Canada), provide container volumes on an aggregated geographic and temporal level and poorly reflect container trucks. For example, container volumes are typically provided at provincial or national levels and do not provide hour-of-day or day-of-week detail.

Other issues with existing data sources are inconsistencies in the year of data and the structure and definitions of the databases. For example, BTS maintains data as recent as the current year while Statistics Canada data is one or two years behind the current year. To overcome this difference when attempting to analyze these databases, older BTS data must be used or growth factors must be applied to Statistics Canada data to facilitate comparisons on the same time scale. The structure of databases can also differ. An example is the difference between U Count and W Count databases. U Counts collect body type data for articulated trucks by occurrence; W Counts collect vehicle type data for all vehicles in 15-minute bins. Therefore, fields in these databases must be collapsed to allow the joining of this data for analysis. Finally, definitional differences are frequent between databases, particularly when dealing with container freight. To date, a clear and universally accepted definition of intermodal has not been established. Confusion still arises between professionals when deciding whether intermodal freight is synonymous with containers or whether containers are a component of intermodal freight. Therefore, databases that report intermodal movements cannot be assumed to be reporting the same statistics as those reporting container movements.

Developing a container truck count schedule for U Counts is challenging due to human resource constraints, physical conditions at potential count locations, and duration of counts. These challenges lead to complicated scheduling and management of the counts, relocation of count stations, and undesirable count durations, respectively. Human resource issues arose since automatic vehicle classification technologies that identify containers do not exist and therefore manual counts are required. The schedule of counts is demanding, often requiring data collectors to work through the night and on weekends. This introduces difficulty in recruiting data collectors and coordinating their schedules with the count schedule. At some count locations, construction, road geometry, adjacent land use, or snow prohibited the collection of data. Therefore, some stations were relocated. This is a significant challenge because count stations are carefully and strategically chosen at locations that maximize the data collected (i.e., at the intersection of major container truck segments). Continuous counters provide best data for determining the population of traffic volumes on a road segment. Manual counts can only provide samples and according to the U.S. Traffic Monitoring Guide (2001), manual counts should not be much longer than three hours. This is recommended since experiments have shown that fatigue increases and concentration decreases around this time when conducting counts and there is a significant increase in errors. The count duration for this research recognizes this issue and ranges from 3 to 4.5 hours, although a duration of at least 12 hours is desirable.

Balancing the number and types of counts was challenging. This balance is a typical example of quality of data versus quantity of data. For example, conducting more Control counts improves the quality of data at individual intersections (assuming that more data translates into more reliable data); however, the trade-off is reducing the number of Sub-control and Coverage counts and achieving less geographic coverage.

Data Analysis Process to Estimate Container Truck Traffic Volume

Issues with the data analysis concern the four assumptions used to estimate container truck traffic. These assumptions are based on the eight critical differences between container trucks and other articulated trucks as discussed earlier in this paper. The first assumption is that the origin and destination of all containers in a city is a rail intermodal terminal. This assumption is reasonable when considering the ultimate start and end points of a container in a city. However, literature reveals that container drayage operations can involve other trips between the final origin and destination. For example, trucks may transport containers to their depots or a container storage yard for temporary storage before delivery. Carriers may also use containers for deliveries between local shippers. The potential for this type of movement is especially available for truck companies who own their own containers, which are domestic containers.

The second assumption is that the temporal characteristics of container trucks entering and leaving rail intermodal terminals govern the temporal characteristics of container trucks on the rest of the network. This assumption builds on the previous one where all containers and container trucks originate and terminate at rail intermodal terminals. Temporal characteristics of container trucks that transport containers to and from depots or storage yards are not expected to follow these same patterns. At this point in the research, it is unknown how many container truck trips engage in movements to storage yards as opposed to direct point-to-point movements between terminals and shippers. One way to improve this assumption is to discuss this issue with container truck carriers to determine whether they pick up and deliver containers at storage yards and the magnitude of this activity.

The third assumption is that container truck volumes are proportional to other articulated truck volumes on all road segments without container data. The two flow maps shown in Figure 8 and Figure 9 illustrate that this is not the case and that some links carry large volumes of containers and small volumes of articulated trucks and vice versa. This assumption can be strengthened with additional truck body type data collection efforts.

The fourth assumption is that the monthly distribution of rail intermodal terminal container traffic generated by a province from BTS and Statistics Canada represents the monthly distribution of container trucks in cities. Further, this assumption uses container tonnage data to represent container volumes. This assumption also builds on the first one where all containers being trucked in a city enter and exit a rail intermodal terminal. Again, additional truck body type data collection efforts conducted for each month can help validate the reasonableness of this assumption.

Validation

Validating the results of the container truck traffic volume estimates is difficult because the only data available for validation is the same data used to produce the estimates. Traffic volume estimates are commonly validated in two ways, one for estimates produced by traffic data (vehicle-based estimates) and another for traffic estimates produced from demand models (commodity-based estimates). Vehicle-based validation produces an traffic estimate using sample data and then compares the estimate to an estimate produced using the population. Commodity-based validation estimates traffic volumes using demand modeling methods and compares the volume estimate to known traffic volumes obtained from traffic counts.

Quantitative validation of container truck traffic volumes is achievable at the rail intermodal terminal entrances because CN and CP publish annual containers generated by their terminals. Assuming that each container requires a truck, the number of containers generated by terminals represents the number of container truck trips generated by these facilities. Therefore the container truck estimate produced from U Count data should be similar to the number of containers generated by the terminal. Qualitative reasonableness checks are used for validating container truck traffic volumes on individual network segments. This validation procedure ensures that land use zones that attract large quantities of containers are connected by road segments that also carry large quantities of container trucks. Judgement is used to validate the through movement routes and the quantities of container trucks on these segments. The validation process will be improved upon completion of this research by discussing the results with industry experts and gather their input into the reasonableness of the geographic and temporal distribution of container trucks.

CONCLUSION

This paper describes a methodology to estimate container truck traffic volume to help understand the effects of this traffic on transportation engineering and planning issues in urban inland ports within the Canadian Prairie Region. The methodology is sensitive to the unique characteristics of container truck traffic and is intended to assist transportation engineers and planners reveal issues that should be considered in defining, evaluating, and choosing among alternative options to improve urban container freight transportation.

Growth and maturation of the global container freight transportation system, competitive conditions between Northwest Pacific coast ports and land bridges, and increasing demand for truck drayage operations influence container trucking in Canadian Prairie Region cities. Increasingly, container trucks are becoming a larger component of urban truck traffic, yet the volumes, routing patterns, and impacts of rail intermodal terminal locations are largely unknown. Transportation engineers and planners must be knowledgeable about each of these influences to proactively approach container freight issues. Container truck drayage and the location of intermodal terminals can potentially alter the volumes and travel patterns of urban truck traffic and impact transportation engineering and planning issues. Container truck traffic volume estimates are important data inputs that feed analyses concerning: corridor analysis and design, land use planning, environmental effects, transportation system performance measures, pavement design, asset management programs, infrastructure prioritization, traffic operations, and safety performance.

Despite the growth and importance of containers, transportation engineers and planners currently have insufficient tools to estimate container truck traffic volume in their cities. Consequently they struggle to quantitatively evaluate the effect container truck traffic imposes on the urban transportation system. Regardless, there is an increasing demand for freight forecasts for long-term infrastructure planning; however, forecasts are weakened unless there is data representing current conditions. Therefore, methodologies are required to accurately estimate current container truck traffic volumes.

The methodology discussed in this paper is based on research currently being conducted to develop a container truck model in Winnipeg using 348 hours of truck classification counts at various locations on the truck network. From this preliminary analysis three important findings are revealed: (1) container truck traffic exhibits different temporal characteristics than other articulated truck traffic; (2) geographic distribution of container truck traffic differs from other articulated truck traffic; and (3) there is a significant difference between the container truck and other articulated truck axle configurations.

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