2008

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Research Report No. 6
June 2008

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Bellingham, Washington
www.ac.wwu.edu/~bpri/

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This research was supported by the U.S. Department of Transportation, Office of the Secretary, grant no. DTOS59-05-G-00016.

This report is available at http://www.ac.wwu.edu/~bpri/

Cross Border Transportation Patterns at the Western Cascade Gateway and Trade Corridor: Implications for Mitigating the Impact of Delay on Regional Supply Chains

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Abstract

This report presents a commercial vehicle profile of transportation patterns and a commodity profile of the primary border crossing along the Western Cascade border region of southwest British Columbia, Canada, and northwest Washington, United States, in particular the corridor between the urban areas of Vancouver, British Columbia, and Seattle, Washington. Because of the larger trade volumes along the eastern portion of the U.S./Canadian border between Michigan, New York, and Ontario, trade research on the northern U.S. border has typically focused on trade along the eastern portion of the border between Michigan, New York, and Ontario, as well as on immigration and customs issues along the southern border with Mexico. As a result, less attention has been given to the western portion of the U.S./Canada border. This research begins to fill that gap with both a description of regional trade and a description of current delay patterns, consequences of delay, and causes of delay.

Using four data sources for comparison—a GPS freight carrier border delay data set, a commercial volume data set (BC MoT), a detailed border operations survey data set and manifest sampling (WCOG)—we consider the linkages among volume, delay, border operations, commercial vehicle origin/destination, and commodities carried to create a commercial vehicle profile at the Cascade Gateway. The data also allows us to demonstrate transportation patterns at this gateway and along the trade corridor, and to show that they are very regional in nature. This research will benefit both public and private stakeholders who are interested in understanding cross border commercial vehicle commodity flows and transportation patterns in the Cascade gateway and trade corridor, as well as the profile of delay experienced at the Pacific Highway commercial border crossing. Such an understanding can aid in the development of solutions to mitigate border delay and its impacts.

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1. Introduction

The Pacific Highway border crossing in Blaine, Washington, is the fourth busiest commercial crossing on the northern border and the most significant commercial crossing for Western Canada and the U.S. (USDOT/FHWA 2006). The primary commodities that flow across this border are agricultural/food, wood, and paper products (WCOG Manifest Data). These commodities are not viewed as particularly time critical, as they do not move in a strictly scheduled environment, although in fact a significant proportion of these goods are highly perishable. Both of these factors are significantly different than along the eastern portion of the northern border, where goods are flowing across the border in a time sensitive business environment that requires more precise delivery time estimates. These regional characteristics are important in understanding the current U.S. commercial vehicle transportation phenomenon and the impacts of delays, as well as in developing improvements and anticipating the consequences of change both at border crossings and within the Cascade border region as a whole.

The commodities that flow across the border at the Pacific Highway crossing are not typically under delivery time constraints, yet, in comparison to the eastern border region, a larger proportion of trips are made intra-regionally within the region known as Cascadia. In this report we also take into consideration border processing procedures and policies, and describe how these affect certain types of manufacturing supply chains and commercial carriers more than others. We argue that 'border readiness' or 'border preparedness' is an important factor in reducing border crossing times, and that historical data show that delay times are less strongly correlated with the volume of commercial vehicles arriving at the border for processing than might be expected.

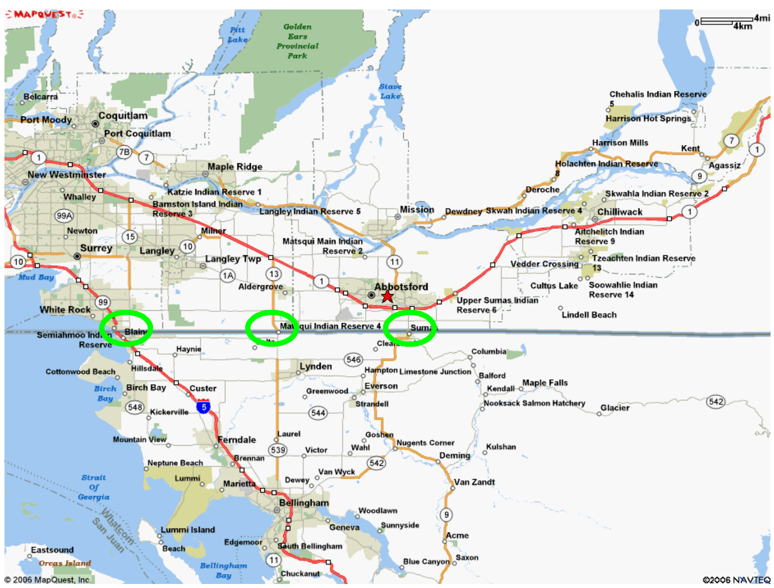
Very long border delays are particularly disruptive to the regional economy. Several studies document border delay (Belzer 2003). Previous research on border crossing time variability (Goodchild, *et al*, 2008) for Free and Secure Trade (FAST) approved commercial vehicle carriers at the Pacific Highway crossing show that most border crossing times are fairly consistent, with a standard deviation for southbound FAST approved vehicles of about 20 minutes. However, we also know that very long delays (defined as more than 2 hours) occur fairly frequently. In this report, we examine the distribution of very long delays by using a unique, 2.5 year data set, and provide insight into the relationship between delay and the volume of trucks arriving at the border, typically perceived to be the driver of delay. We are also able to differentiate some sources of delay into primary (or delay due to waiting in the queue and processing at the primary booth) and secondary (all other sources of delay; for example, secondary inspection or immigration) causes, demonstrating the significance of secondary delay to total border crossing time.

1.1 *The Pacific Highway Border Crossing*

The Pacific Highway crossing is the primary commercial crossing of the Cascade Gateway, the grouping of four Washington State-British Columbia border stations: two at Blaine-Peace Arch and Pacific Highway, one at Lynden/Aldergrove, and one at

Sumas/Huntingdon. The Peace Arch crossing is for passenger vehicles only, and Lynden has restricted commercial vehicle volume. The other two ports are open for both passenger and commercial vehicles. Map 1: The Cascade Gateway Border Crossings illustrates these crossings.

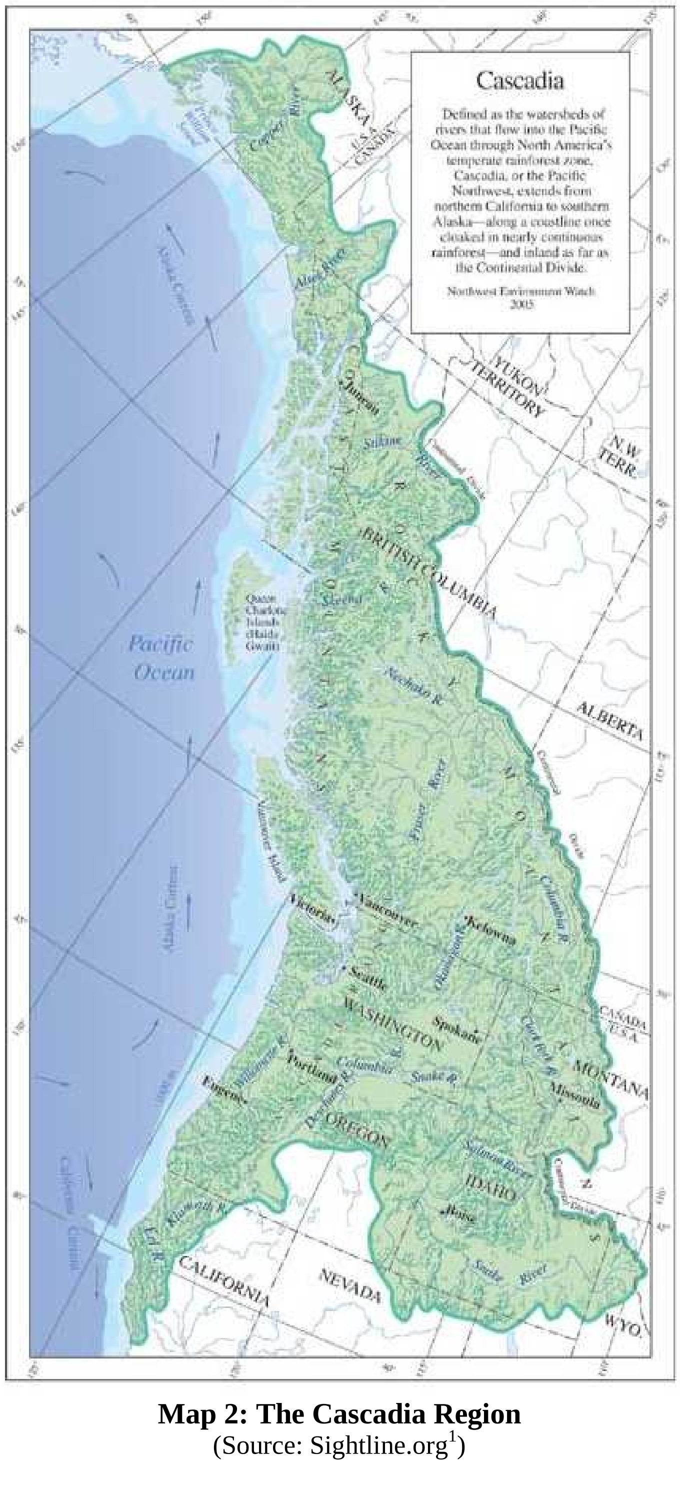
The Pacific Highway border crossing is the main commercial crossing between Whatcom County, Washington, and the Lower Mainland of British Columbia. It is the fourth busiest commercial crossing on the U.S.-Canada border and the busiest crossing on the Western portion (west of Detroit) of the border; it was used by more than 750,000 trucks in 2004 (HCI 2007). It is approximately 100 miles north of Seattle and 30 miles south of Vancouver, BC, on Washington State Route 543 and British Columbia Provincial Highway 15. The Pacific Highway crossing is the commercial crossing that directly serves Interstate 5, as Route 543 is a short spur that connects to Interstate 5 less than 1 mile from the border. About 11 miles to the east is the Lynden/Aldergrove crossing on British Columbia Provincial Highway 13 and Washington State Route 539 (used by 165,000 trucks in 2004). Another 10 miles to the east is the Sumas/Huntingdon crossing on Washington State Route 9 and British Columbia Provincial Highway 11 (used by 209,000 trucks in 2004). These border crossings connect the bi-national mega-region of Cascadia.



Map 1: The Cascade Gateway Border Crossings
(Source: maps.google.com)

Cascadia is a large region; we focus on the area that stretches from Eugene, Oregon, to Vancouver, BC. It is a 400 mile corridor with 8 million residents. The five major cities are Vancouver, BC, Seattle and Tacoma, Washington, and Portland and Eugene, Oregon. The western border consists of the Pacific coast and a portion of the U.S. state of Alaska along the Canadian province of British Columbia and the U.S. states of Oregon and Washington. On the east, it borders the Canadian province of Alberta, and the borders of the U.S. states of Idaho and Montana. It stretches from 42° to 60° north latitude. The primary border crossings in the region are known as the Cascade Gateway. The Pacific

Highway crossing was selected for this study because it carries the largest volume of commercial vehicles in the region.



Map 2: The Cascadia Region
(Source: Sightline.org[1])

[1] www.sightline.org/maps/maps/cascadia_cs05m

Map 2: The Cascadia Region demonstrates the expanse of this region. Our focus of interest is primarily the Seattle-Vancouver corridor, of which the Cascade Gateway and the crossing at Pacific Highway are of utmost importance.

1.2 *Importance of the U.S.-Canada Relationship*

The U.S. and Canada are each others' largest trading partners, with the value of trade between the two the highest between any two countries worldwide. For the U.S., trade with Canada is larger than that with the European Union countries combined (U.S. DOT/FHWA 2002). Canada's international trade is strongly biased toward the U.S., which accounts for nearly 75 percent Canada's trade in goods (OCC 2005). The long land border favors surface modes of transport. In terms of total trade (north- and southbound combined), trucking is one of the most important modes of transport in terms of tonnage and value, with modal shares of truck transportation comprising almost 62 percent of total value, with a slightly over 35 percent share of weight (Bowen and Slack 2007).

Trade agreements opened a new era in the way that the two trade partners interact with each other, with regional cross border linkages playing an instrumental role in the process of North American integration generated by the North American Free Trade Agreement (NAFTA). Settlement and development of the U.S. and Canada largely occurred from east to west. As a result, the national transportation infrastructure of both countries remained heavily oriented toward east to west and west to east movements of goods and people involved in interregional trade and commerce. Then the Free Trade Agreement (FTA) and, more importantly, NAFTA, reduced tariff barriers and caused a set of logistical relationships to form around border regions and new freight distribution corridors, such that a north-south North American economy emerged. The liberalization of cross border trucking began in the late 1980s (Woudsma 1999), which in turn helped make the trade industry on both sides of the border more efficient. Both trucking and rail freight have been transformed by the 'continentalization' of the North American market (Heaver 1993). However, because both national transportation infrastructures were primarily developed for the east-west pattern of trade, the development of north-south trade corridors has strained the less developed infrastructure of the north-south corridors and gateways.

The increase in trade with Asia illustrates the need to think in continental terms. An integrated North American transportation strategy must meet the needs of an increasingly north-south continental economy (Blank 2007a). Goods flow across the border, not as finished goods but as part of a continental network of supply chains that cross national borders. For example, a quarter of the more than $1.25 billion of goods that cross the U.S.-Canada-Mexico borders daily is automotive. The economic partnership is described by the collaborative nature of the complex, cross border production systems and is considered to be of deeper significance than mere trading partners: "we don't sell cars to each other, we build them together" (Blank 2008). These North American economies are strongly integrated, and supply chains are bilateral and trilateral in scope and integration:

> The supply chains that span the U.S.-Canada border are unique in the global context. They are heavily reliant on land transportation that travels primarily through just a handful of key border crossings. Major shipments are routinely timed for delivery within hours, and sometimes to the minute (Webber 2005).

However, this just-in-time trade flow activity pertains to the eastern section of the border, where trade flows are concentrated at a small number of crossings. Over 60 percent of U.S.-Canada trade occurs at a small number of crossings at three Michigan/New York-Ontario crossings: Detroit-Windsor, Port Huron-Sarnia, and Buffalo-Fort Erie (Transport Canada 2005).

In contrast, the Western Cascadia border presents a different picture, with food/agricultural, wood, and paper products (20 percent of full commercial vehicles) being the primary commodities (WCOG Manifest Data). The majority of these goods are not operating under tight schedule constraints, nor are they flowing across the border as unfinished goods (for example, auto parts cross the Detroit-Windsor gateway a number of times during an assembly process that occurs on both sides of the border). Rather, finished goods and products requiring little or no assembly flow across the Cascadia Gateway on their way to market.

1.3 *Current Challenges*

North American freight distribution systems are adapting to global trends in economics and transport geography that are reducing costs and improving efficiency. However, while the liberalization of trade policies, internationalization of supply chains, and changes in transportation and information technologies have all contributed to an increase in freight movement, increased growth in trade has also placed greater pressure on international gateways. U.S.-Canada trade has grown by 152 percent since 1989 (growth in commercial traffic of 122.5 percent), with trucks moving over 70 percent of the value of exports to Canada (USDOT/BTS 2001). Between 1994 and 2000, U.S. trade with Canada grew by 8.9 percent (USDOT/BTS 2001). For the U.S. transportation system, the volume of freight is projected to increase by nearly 50 percent between 2005 and 2020 (USDOT/FHWA 2002c and 2006).

The increase in commercial vehicle traffic places added pressure on both border crossing facilities and U.S. and Canadian enforcement agencies, which in turn produces delays and long commercial vehicle queues. In addition, the events of 9/11 created increased awareness of national security, causing tougher scrutiny of incoming shipments and individuals, as well as a re-examination of policies and programs for border crossings. The resulting long queues and delays affect border crossing travel times at the Cascade Gateway (SAIC 2003). As a result, certain programs have been established, such as the Advance Electronic Presentation of Cargo Information (ACE) program, to resolve incorrect bond and customs paperwork and to increase goods shipment, tracking, and verification.

1.4 *Need for Freight Data and Cross Border Transportation Flow Data*

Effective freight transportation policy and planning that take into consideration how transportation infrastructure is affected are of utmost concern for the developing National Freight Transportation Policy.[2] As a result of better awareness of the movement of freight on systems of increasingly integrated supply chains and distribution networks the Washington State Department of Transportation (WSDOT) is developing a set of guiding principles for a policy framework regarding all aspects of freight transportation. These principles specifically target the facilitation of international NAFTA trade and commerce, the border crossings, and the north-south corridors that serve them.

However, policy must be developed with an understanding of its implications, and the implication of changes can be understood only with knowledge of regional economics, supply chains, and trade patterns. Without understanding of the current transportation patterns in the Cascadia region, we risk developing solutions (and there is some evidence that we have already developed some) for trade regions with characteristics of the eastern U.S./Canada border crossings. For example, one successful program, the Free and Secure Trade program, is very difficult for southern agricultural producers and shippers to join for the import of fruit and vegetables from Mexico into the U.S.

The importance of data that quantify North American cross border commercial vehicle transportation derives from the benefits of trade. NAFTA trade is predominantly cross border, with truck and rail significant. While increasing attention is being paid to the importance of developing North American freight flows, the events of 9/11 resulted in a heightened level of concern about border infrastructure capacity, and an awareness that security issues overwhelm and possibly impede further growth in trade and therefore limit the benefits of trade between NAFTA countries. What is needed is information on cross border trade activity that is comprehensive in coverage (not limited to one geographic area or transportation mode) and consistently available. Such data can help alleviate challenges such as deteriorating travel times and delivery time reliability, increased complexity of supply chains, and increased impacts of border gateway activity on border communities and trade corridors (TRB 2007).

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[2] http://ostpxweb.dot.gov/policy/data/national%20freight%20transportation%20policy%20statement.pdf

2. Contributions

The primary contributions of this research can be described as follows:

1. We describe the patterns of southbound border crossing times experienced by FAST approved vehicles at the Pacific Highway border crossing, the main Cascadia U.S./Canada commercial border crossing. With our unique long term data set we describe observed seasonal, daily, and time-of-day patterns, including the average and variability of delay. This also includes a description of the frequency and distribution of very long delays (defined as delays of more than 2 hours).
2. We provide a lower bound for the magnitude of secondary delay. This is delay other than that spent waiting in a queue and being processed at the primary booth. This is a significant source of delay and should inform policy solutions for reducing border crossing times.
3. We demonstrate that observed crossing times are weakly correlated with arrival volumes. Common understanding is that border crossing times are primarily driven by arrival volumes, but historical patterns and empirical crossing time observations suggest that other factors contribute significantly to border crossing time.
4. We describe regional trade patterns observed at the Pacific Highway crossing, including commodity type, origin and destination, arrival patterns, and delay patterns, providing a context for understanding the impacts of future change and the costs of current delay.

These results will provide a context for understanding the impacts of the border on regional supply chains and facilitate the discussion of strategies designed to reduce the cost of border crossings to regional trade.

3. Literature Review

3.1 *Border Delay Studies: Costs and Impacts*

International border delay is perceived as a major problem. The province of Ontario has carried out a significant amount of work in an attempt to quantify the impacts of border delay on its economy (Belzer 2003). Ontario and the states surrounding the Great Lakes have formed a regionally integrated economy that is very dependent on the ability to move goods across the border. With future trade expected to grow by 180 percent by 2015, without investments in cross border trade, Ontario will suffer economic and social costs. Because of this, Ontario has deemed it important that its border remain free from delays (OCC 2004). However, U.S. border security has changed border transit and security processes, and it has been estimated that up to 1.5 hours have been added to the average freight transit border crossing time, with an estimated annual cost of security measures on the Canadian trucking industry of between $179 to $406 million U.S. dollars (Transport Canada 2005).

A study on the effects of post 9/11 security at border crossings noted that increased security has had economic ramifications for Canadian exporters. In particular, increased security has meant that shipping goods across the border can lead to unexpected delays and increased costs for Canadian exporters. However the carriers have largely absorbed the added costs of border delays so that there has been little transfer of higher costs to companies, and the study did not find any evidence that tighter border security measures have had an effect on the volume of Canada's exports to the U.S. (Goldfarb 2007). However, another study on the impact of 9/11 on U.S./Canada trade found that bilateral trade flows in the post 9/11 period fell far short of "expected" levels, and that the Pacific Highway port experienced significant shortfalls (differences across land ports were identified, with shortfalls not uniform) (Globerman and Storer 2006).

A study on service time variability at the Pacific Highway border crossing and the impacts on regional supply chains also found limited immediate economic consequences of additional delays imposed on the system by border security, primarily because of the current flexibility in regional delivery schedules. However, regional schedules are flexible, in part, because of the inability to predict border crossing times. With a more reliable transportation system, logistics efficiencies would certainly be improved. This study found that the primary border crossing strategy carriers regularly use is to increase the amount of time needed to accommodate longer than average crossing times. This strategy, increasing buffer times, is the most common response to the variability in border crossing times. While the average crossing time southbound for non-FAST vehicles is 1 hour and 23 minutes, most carriers give 2 hours accommodation in border crossing time, thereby building in 37 minutes to accommodate longer than average crossing times. FAST vehicles typically allow 1 hour for border crossing, presenting, on average, 40 minutes of lost time per trip (Goodchild, *et al*, 2008).

3.2 *Border Delay Studies: Modeling and Queuing Analysis*

Government agencies on both sides of the border have made efforts to quantify border delay. A detailed study was undertaken in the summer of 2001 on traffic at the four major U.S.-Canada and the three major U.S.-Mexico border crossings. The northern crossings included the Pacific Highway crossing, as well as the Windsor-Ambassador Bridge crossing between Windsor and Detroit (the largest northern border crossing), the Peace Bridge between Niagara and Fort Erie in upstate New York, and the Blue Water Bridge crossing in Michigan. For each location the study computed a zero congestion time for both northbound and southbound border traffic. Pacific Highway crossing travel times were computed over a single three-day period. Actual travel times are defined as starting from the first queuing point before the actual border crossing and end when the vehicle is released from inspection at the border. Data used include crossings per day, average delay per trip, and a buffer index (the difference between the average crossing time and the 95th percentile crossing time). The study shows a correlation between delays and the number of customs/immigration booths open—the greater the number of booths open, the shorter the delay. The data also suggests that staffing at a number of crossings is not responsive to traffic buildup in peak periods (USDOT/FHWA 2002a and b).

A similar border operations survey was undertaken in June 2006 specifically at the Pacific Highway crossing to collect southbound data to evaluate commercial vehicle operations and compare conditions with data from the study described above. During the four-day southbound survey, 2,292 truck trips were recorded, an average of approximately 570 vehicles per day, representing a decrease of approximately 23 percent in comparison to the 2001 survey. The average arrival rate (a key contributor to travel time and delay time) is approximately 65 commercial vehicles per hour, with variation by hour and from day to day. Neither FAST nor non-FAST traffic demonstrate an "average" daily profile. The average travel time for a FAST vehicle is between 16 and 45 minutes; while non-FAST vehicles take over 90 minutes to make the crossing, with an average travel time of greater than 2 hours observed during some times of day (HCI 2007). We use this survey data for this research report and describe the data more fully in the *Data Analysis* section below. In order to distinguish the 2006 survey from the 2001 study, we label this the 2006 survey data "WCOG," as the study was prepared for the Whatcom Council of Governments (WCOG).

An early study on vehicular delay for motorists (noncommercial vehicles) at the Peace Arch/Blaine crossing (separate from the Pacific Highway/Blaine commercial crossing) was conducted over a two day period for 18 hours between September 4, 1991, and September 5, 1991, during the hours of 10:00 AM to 8:00 PM and 8:00 AM to 4:00 PM, respectively (Paselk and Mannering 1994). This study on congestion mitigation used duration models and I-5 loop detectors capable of recording 5-minute averages to focus on how long a motorist could expect to wait upon arriving at the back of the queue at the border (and not on how long a motorist had waited in line). Of the 910 vehicles that were tracked through the system, the average wait time was 20.19 minutes, with a standard deviation of 11.76 minutes. The maximum time was 59 minutes; 50 percent of vehicles waited less than 18 minutes, 75 percent less than 28 minutes, and 90 percent less than 38 minutes. During the study period, 8,085 northbound vehicles crossed at the Peace

Arch/Blaine, with 857 vehicles using the PACE[3] lane (the precursor of FAST, it also provided expedited processing times for pre-authorized travelers).

3.3 *A Border Region: The Cascade Gateway and Trade Corridor*

The idea of a Cascadia region emerged during the 1990s. It is a bi-national region that encompasses British Columbia, Washington, and Oregon and has at its core the Vancouver-Seattle "bio-region." The name 'Cascadia' derives from the lower region of the Rocky Mountains that bridges both countries. A number of trans-national and trans-governmental organizations assisted in the growth and transformation of what is now recognized as a trans-national regime. This regime is particularly noted in the transportation and environmental sectors, which often have region-specific needs that require cooperation of a trans-regional and trans-national nature. For example, the Cascadia regime is considered to have stronger linkages in the transportation sector than the U.S.-Canadian border regions of Niagara and Windsor-Detroit (Brunet-Jailly 2006).

In this report, we consider the multidimensional linkages that are taking hold at the regional level between adjacent and nearby areas along the border. A cross border region is a group of states and provinces that straddle the border and share a certain level of economic and organizational linkages as well as socio-cultural similarities. Geography, history, demography, and transportation corridors all play a crucial role in shaping cross-border regional linkages, the level of trade, and recent growth in trade (PRI 2006). Examples of these organizations in Cascadia include the following:

- the International Mobility and Trade Corridor Project (IMTC), a group of stakeholders working to improve mobility though the Cascade Gateway that includes both U.S. and Canadian *transportation agencies* such as Transport Canada, the British Columbia Ministry of Transportation (BC MoT), the WSDOT, USDOT, and WCOG), as well as *inspection agencies* such as the Canada Border Services Agency (CBSA) and U.S. Customs and Border Protection (CBP)
- other organizations such as the Puget Sound Regional Council (PSRC) and PSRC Freight Roundtable, the Pacific Northwest Economic Region (PNWER), and the West Coast Corridor Coalition.

Efficient transportation flows across the U.S. and Canadian border are necessary for continued economic stability and growth in both countries. By knowing the potential for growth and increases in commodity flows across border crossing locations, policy makers can better adapt border ports to allow continued and increasing efficiency in commercial vehicle crossings. Ports have commodity and trade profiles that affect usage, operations, efficiency, and infrastructure—they are not just physical and geographic locations. The Pacific Highway border crossing at Blaine has the most diversity in commodities (of the border ports across the state), with a heavy emphasis on food and agriculture products, which combine to account for almost one-fifth of the northbound commercial crossings

[3] The Peace Arch Crossing Entry (PACE) project, begun in May 1991, was a joint U.S.-Canadian project that entitled pre-approved motorists to use a separate lane for quicker processing at border crossings (Paselk and Mannering 1992).

and one-tenth of the southbound crossings, translating to over 66,000 northbound and 41,000 southbound crossings in 2005. Washington is a significant generator of food and agriculture trade with British Columbia, with 43 percent of northbound crossings and 50 percent of southbound crossings revolving around the Washington economy. Profiles of both crossings are as follows: northbound crossings are dominated by produce, followed by fish, seafood, and beverages, while southbound crossings have a large number of farm products, such as cattle, feed, and meal, followed by fruit and fish (Galloway, *et al*, 2007).

4. Data Sources

The Pacific Highway border crossing (southbound) operates three gates for commercial vehicle crossings, including one FAST lane when it is available.[4] The FAST program offers expedited crossing times for commercial vehicles and increased information about drivers and shipments for the CBP (Bonsor 2004). The term "FAST" is used here to refer to any vehicle using the FAST lane when transiting the border. The FAST lane offers faster customs and immigration processing for approved commercial vehicle drivers, carriers, and importers, who all must be pre-approved through a background and business process evaluation. Approval requires citizenship or permanent residency within the U.S. or Canada, with a minimum age of 18 and a valid driver's license. Commercial carriers must supply employment and address history, a full set of fingerprints, and payment of fee every 5 year period. The requirements also apply to all passengers in the commercial vehicles.

In addition, the importer of the goods being carried must be approved by the Customs Trade Partnership Against Terrorism (C-TPAT) program. C-TPAT is a voluntary program in which companies must comply with a variety of security measures designed to increase the level of trust between the importer of the goods and the CBP. The benefits of this program include a reduced number of CBP inspections, which reduces border delay times, and priority processing for CBP inspections (front of line processing for inspections when possible) in order to secure and maintain security of the supply chain.

We use four data sources for this study. The three data sets listed below are used to calculate border delay times, variability in border crossing times, commercial vehicle volumes and service times at the primary inspection booth. The three data sets are as follows:

1. Fixed Vehicle Count Loop Detector Data (southbound only) from the British Columbia Ministry of Transportation (BC MoT)
2. GPS Freight Carrier Border Delay Data Set (both south and northbound) obtained from a private truck fleet
3. Pacific Highway Port-of-Entry Commercial Vehicle Operations Survey (southbound only) from the Whatcom Council of Governments (WCOG).

[4] The FAST lane is available M-F 8:00 AM—8:00 PM.

The fourth data source is used to create a commercial vehicle profile in order to illustrate transportation patterns and a commercial commodity profile for the Western Cascadia Gateway and Trade Corridor. This data source is:

4. Cascade Gateway Commercial Carrier Origin and Destination and Commodity Manifest Data (bi-national) from the WCOG.

The three data sets are described more fully below, while the fourth data source is described in section five, *The Western Cascade Gateway and Trade Corridor,* which discusses border operations and the inspection process and analyzes the regional characteristics of the carriers and commodities that primarily use this border crossing.

4.1 *British Columbia Ministry of Transportation (BC MoT) Fixed Vehicle Count Loop Detector Data (southbound only)*

The commercial vehicle volume data set (BC MoT) is used to understand the pattern of truck arrivals at the southbound crossing (obtained from the Border Data Warehouse).[5] It contains commercial vehicle volume data, collected by a series of loop detectors on the approach to the border, that have been accumulating data since November 13, 2006. Each observation represents the number of vehicles crossing over double loop detectors (doubled[6] to record speed, spaced 16.4 feet apart) in a 5 minute period. Observations contain information regarding the volume (total number of vehicles), average occupancy (percentage), average speed (kilometers per hour), and average length (meters). We focus on five pairs of loop detectors on Highway 15 at specific distances from the primary booth processing center to 8th street. The total number of observations for FAST vehicles is 328,450. Map 3: Southbound BC MoT Location Loop shows where the detectors are located; the numbers are the names of the loops, which are placed at 100 feet, 600 feet, 1500 feet, 2000 feet, and 6000 feet from the primary booth (with the last loop being the farthest north and not included in this photo).

[5] http://www.cascadegatewaydata.com/
[6] An upstream (U) loop and a downstream (D) loop.

Map 3: Southbound BC MoT Location Loop Detectors
(Source: CascadeGatewayData.com)

Each lane of traffic, including the FAST lane, has a separate set of loop detectors. Thus, FAST vehicle volumes can be identified in the lane dedicated to FAST vehicles during FAST hours of operation (8:00 AM to 8:00 PM). The loop detectors closer to the border often measure congested traffic. The loop detectors farther from the border are often free of congestion, but observations farther from the border may measure traffic with destinations other than the border itself.

Typically, the vehicle volume builds in the early morning, peaking at 8:00 AM, leveling off[7] slightly during the middle of the day, and dropping off about 4:00 PM in the afternoon. Figure 1: Average Arrival Volume at Loop 15-905 U is an example of southbound commercial vehicles for all 2007 Monday through Friday observations.

[7] Loop 905 still shows the arrival pattern slowly decreasing rather than leveling off, but the phrase "leveling off" may still describe this arrival rate in comparison to loop 907.

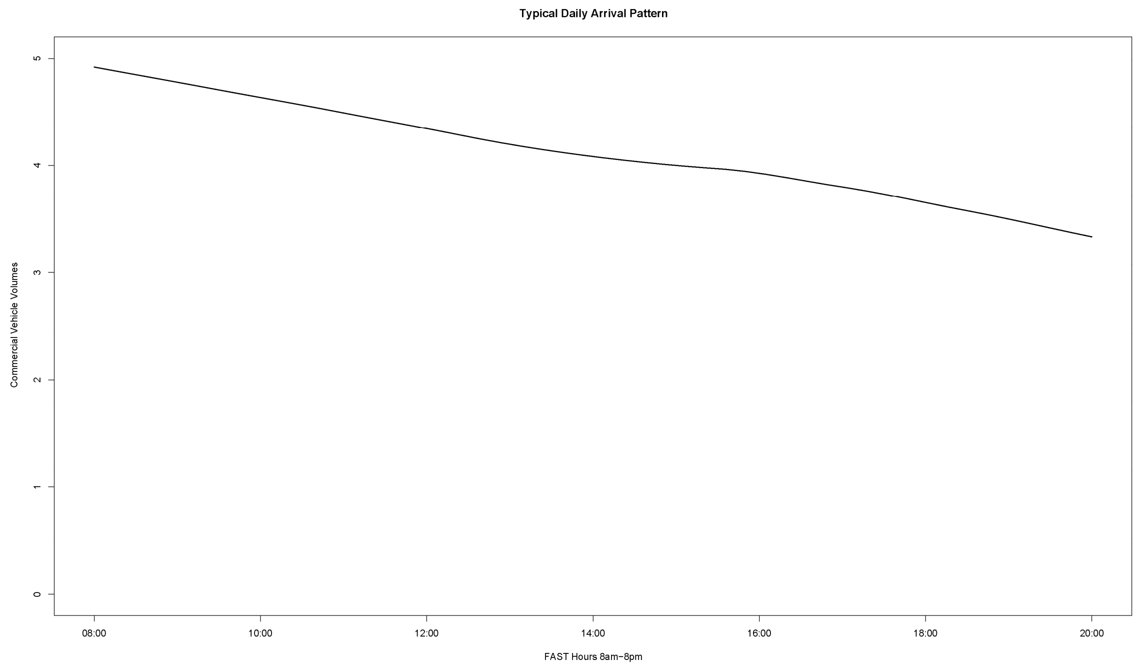

Figure 1: Average Arrival Volume at Loop 15-905 U
All Monday through Friday 2007 observations
(Source: CascadeGatewayData.com)

Appendix 1 shows the locations of the loop detectors and includes the 8^{TH} Ave detector map, Pacific Highway detector map, and port of entry detector map. Volume data was obtained directly from CascadeGatewayData.com and required no data cleaning. If a loop detector was not functional, it does not store a volume count (a "zero" count). To capture the pattern of arrivals, a loop detector was selected that was as close to the border as possible but outside of the typically congested range. This is because the arrival pattern cannot be observed within the congested range, as arrival times are determined by the state of congestion, not the vehicle's preferred arrival time. This location was identified by comparing speed and occupancy data for all loops approaching the border.

4.2 *GPS Freight Carrier Border Delay Data Set (both south- and northbound)*

This data is collected by a fleet of private vehicles that cross the border approximately every 30 minutes. A data sharing agreement was reached between the company operating this fleet and the researchers. Drivers are paid by the hour and work for a fuel company that transports fuel from a Washington state refinery to the Vancouver International Airport, crossing the border full northbound and returning southbound empty. Upon arrival at this border, drivers self-report their arrival time at the back of the queue and departure time from the border. Drivers are required to report these times, but their remuneration is not dependent on border delay. This data is collected for company management and planning. This company and its drivers are FAST approved and use the FAST lane whenever possible (the FAST lane is only open Monday through Friday 8:00 AM to 8:00 PM).

A complete description of this data set and the data cleaning processes can be found in Appendix 2. The freight carrier border delay data set covers July 11, 2005, to May 5, 2008, and contains 43,912 observations.[8] It is summarized in the table below.

Table 1: GPS Freight Carrier Descriptive Statistics for Border Crossing Times

Data Set	*Observations*	*Mean*	*Standard Deviation*
GPS: Southbound (All Hours)	19,729	00:21:57	00:22:54
GPS: Southbound (FAST Hours)	11,281	00:17:09	00:18:28
GPS: Northbound	24,184	00:21:50	00:18:35

These data allows us to consider the delay to FAST vehicles at the Pacific Highway crossing over a long period of time, thereby allowing analysis of seasonal and temporal variation. Further analysis is provided in section 5.

4.3 *Pacific Highway Port-of-Entry Commercial Vehicle Operations Survey (southbound only) Whatcom Council of Governments (WCOG)*

The WCOG and Halcrow Consulting undertook a border operations survey in June 2006 to evaluate the commercial vehicle operations at the Pacific Highway border crossing (HCI 2007). The objective of this study: to track commercial vehicle movements and travel times at key decision points on the approach to the primary inspection booths and to observe processing times at these booths, as well as to compare the border conditions to those observed during a similar border operations survey several years previously (USDOT/FHWA 2002a and b).[9] To distinguish the 2006 survey from the previous study, we label the survey data "WCOG" as the study was prepared for the Whatcom Council of Governments.[10]

The WCOG data was collected for southbound commercial vehicles at the Pacific Highway crossing between 8:00 AM and 5:00 PM from Monday, June 5, through Thursday June 8, 2006, by using handheld personal digital assistants (PDAs) to capture when trucks arrived in the queue and entered and exited processing. The usable data set includes 579 FAST observations over three days (one day was removed as the FAST lane was open to all traffic that day[11]), and 1,480 non-FAST observations.

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[8] This is for the cleaned data set (cleaned as explained in the appendix). If the data set had not been cleaned, it would be a grand total of 57,018 observations.

[9] Both studies surveyed border operations between 8:00am to 5:00pm over four days in June (USDOT/FHWA 2002a & b; HCI 2007).

[10] http://www.wcog.org/

[11] Because of an international incident in Iraq on June 6th the security level was increased, a high proportion of traffic directed to the Vehicle and Cargo Inspection System (VACIS), and the FAST lane was opened to all traffic for the entire day. While booth inspection times were not significantly different, delays of vehicles from the VACIS queue caused vehicle blockages at the booth, thereby lowering the processing rate. For these reasons, June 6, 2006 does not represent average border conditions (HCI 2007).

The WCOG data does not contain data from a long enough period to consider variations across day, week, and hour, but it does contain non-FAST vehicles. The average crossing time for FAST vehicles is 22 minutes, with a standard deviation of 21 minutes. Over a three day period the average arrival rate per southbound lane is the same for the FAST and non-FAST lanes (21.5 vehicles per hour), but FAST service rates are shorter (86 seconds in comparison to 119 seconds and 121 seconds for the two non-FAST lanes). This means that differences in crossing times were due to differences in service rates rather than differences in arrival rates. Table 2: WCOG Descriptive Statistics for Border Crossing summarizes the descriptive statistics for this data set.

Table 2: WCOG Descriptive Statistics for Border Crossing Times

Data Set	*Observations*	*Mean*	*Standard Deviation*	*Arrival Rate*	*Average Service Time*
WCOG FAST *(one lane)*	579	22 minutes	21 minutes	21.5 vehicles per hour	86 seconds
WCOG non-FAST *(two lanes)*	1480	1 hour 23 minutes	26 minutes	21.5 vehicles per hour	119 seconds and 121 seconds

4.4 *Data Usability*

All data sets have limitations in their usability. Typically a trade-off must be made between level of detail and level of scope. For example, the WCOG data set provides fine resolution or detail in terms of each vehicle's border crossing experience, but because this information is expensive to collect, it presents only a very limited temporal observation. The GPS data set, on the other hand, provides the opportunity to make comparisons across season and day of the week but does not provide detail in terms of the border crossing experience for each vehicle. The major limitations of our data sets are described here. These limitations were considered in our analysis, and we were conscious of these limitations when considering the methodology used in our analysis and the ability to make conclusions based on these limitations.

British Columbia Ministry of Transportation (BC MoT) Fixed Vehicle Count Loop Detector Data:
In congested phases, loop detectors can undercount vehicle volumes due to high density of traffic and the loop's inability to differentiate vehicles. When measuring volume, we use the loop that was as close as possible to the border while being typically outside of the congested region. If loop detectors failed, they provided a zero volume count.

GPS Freight Carrier Border Delay Data Set:
Arrival at the back of the queue and departure from the border are self reported. This introduces the possibility of human error; for example, if drivers forget to report or report more than once. In our data cleaning processes (described in Appendix 2), we took several steps to try to identify errors without removing true

observations. We have no reason to believe this occurred with significant frequency, and we believe that our data set is large enough to absorb any remaining errors without significant consequence. Drivers have no financial incentive to report longer wait times at the border because this does not affect their level of remuneration.

Pacific Highway Port-of-Entry Commercial Vehicle Operations Survey:
We are not aware of any limitations of this data set other than the limited time period.

4.5 *Need for Clear Definition of Border Delay Metrics*

Although many studies of border delay have been undertaken, a consistent method of measuring and presenting border delay has not been developed. Lack of an accepted methodology for measuring and calculating border delay has limited the discussion of this topic by making comparative studies more difficult. One metric that is commonly used in transportation system performance is Travel Time Reliability, which is generally measured according to the Buffer Time and Buffer Time Index. Buffer Time is calculated by ranking the crossing times of individual vehicles at each port of entry. It is the difference between, for example, the 95^{th} percentile time (any percentile can be used) and the average time for all vehicles. It represents the 'extra time' a driver must budget to cross the border over the average time with a 95 percent certainty. The Buffer Index is the buffer time expressed as a percentage of average time. This is the measure that will be most comparable on an annual basis and between crossings as it standardizes the measure. For commercial vehicles, significant variations in travel time can impact inventory planning and the efficient use of transportation infrastructure, particularly for time sensitive goods because of value, perishability, or business characteristics such as just-in-time operations (USDOT/FHWA 2002a and b).

Although Travel Time Reliability has been clearly defined, Travel Time is more difficult to clearly define. Should border crossing time include time for secondary screening, given that all vehicles do not experience a secondary screening? While issues related to commercial values of time are somewhat similar to passenger values of time, they differ in important aspects. For example, travel time savings for passenger vehicles may be a direct or indirect function of the importance of time as a resource constraint on travel decisions. For commercial vehicles this is an indirect value—time is a resource used in a production function. Commercial vehicles operations also involve several actors (company, driver, importer), making it more difficult to identify a single decision maker and the actual agent who will take advantage of time savings. Another challenge is that reliable and complete data on commercial transport are not available. Given these constraints, the commercial vehicle value of time is typically calculated by using the following three variables:

- value of time savings for the driver
- savings of vehicle operating costs
- value of time savings to the goods, or freight, carried.

Unfortunately these estimates ignore the dynamic environment of commercial transportation in which variability in delay might cost companies through lost business opportunities, late fees, schedule changes, or changes to their logistics structure. It is generally agreed that a thorough classification of the impacts, or an estimate of their value, and the measurement of time delay and its associated costs for commercial vehicles needs further refinement and rigorous analysis (USDOT/FHWA 2006).

In this report, we present **border crossing time** as the time from arrival at the back of the queue until departure from the border and its associated processes. We chose this metric because it most accurately presents the user's perspective on the time it takes to cross the border. This time includes the time in the queue, the time at all stages of processing, and any transition time between stages of processing.

In other studies it is common to use travel time between fixed physical locations (TTI/BMI 2002). This is driven primarily by ease of data collection, as measurement devices can be located at specific points, while other data devices, such as GPS units, provide specific and precise location information yet are costly to install for every vehicle. However, the location of the back of the queue changes because in peak border crossing times the end of the queue can be up to 2 miles from the border, whereas during non-peak times the end of the queue is generally much closer to the border. This presents a data collection challenge when fixed data devices such as loop detectors are used because the location of these devices cannot be adjusted.

In this study, we refer to border crossing time rather than delay time. Delay implies a wait time *in addition to* the required processing time. In a recent study on border delay, the term is defined as the difference between actual crossing time and low-traffic-volume crossing time. However, this study does not include processing time (TTI/BMI 2002). On the basis of this concept, the travel time index has been introduced, which is defined as the observed truck travel time divided by the free flow travel time (USDOT/FHWA 2002a and b). While this definition more clearly presents the congestion related delay, it is more difficult to calculate, as each truck does not experience the same number or intensity of inspections.

In most cases, the primary inspection is enough to confirm that a vehicle is cleared to cross the border. However, in some cases extra attention is required for inspection of the driver, the vehicle, and the contents. Also, some trucks can cross using the FAST lane, while others cannot. There are additional complexities. For example, should delay to a truck due to poor documentation be included in border delay?

Depending on the method of data collection, it can be difficult to identify the details of the inspection process in order to separate delay from processing time. Therefore, for this research we chose to take the perspective of the user of the vehicle processing facility (i.e., the users' perspective at the border crossing facility), thus capturing the entire time a vehicle takes to cross. The measurement of this time, together with border delay time and border processing time, results in a combined total time measurement of these activities. In our analysis, however, to the extent possible, we do separate sources of delay.

5. The Western Cascade Gateway and Trade Corridor

The Cascade Gateway and Trade Corridor is a geographic area, or trade corridor contained within the Pacific corridor, which is a larger trade corridor that includes the entire geographic band formed by the Rocky Mountain range and the Pacific Coast. The traffic in the Pacific corridor mainly uses Interstate 5 in the United States, which joins together the major cities along the Pacific coast. At the northern border, Washington State and British Columbia have established the U.S.-Canada International Mobility and Trade Corridor (IMTC) project, a coalition of business and government entities focused on improving mobility in the Cascade Gateway by investing in and supporting road, rail, and border facility improvements, including "de-congesting" the border, in order to facilitate cross border trade at the four Washington-BC border crossings (Blank 2006).

The area is more commonly known as Cascadia and is also part of a trade corridor that links the major urban regions of Southwestern BC and the Puget Sound. This region includes major maritime transportation facilities (the ports of Seattle, Tacoma, and Vancouver), a major north-south highway (I-5/99), two east-west highway facilities (I-90 and the TransCanada highway), and two east-west rail corridors (U.S./Canada). Trade corridors are defined not only in terms of physical highways but also as an exchange between firms seeking to build greater efficiencies into their production systems and supply chains (Blank 2006). They are also defined as any pathway that facilitates the movement of goods between two or more gateway cities. Gateways can be seen as hubs in supply chains, creating value through the efficient transfer of goods and information between modes and by linking different geographical areas along corridors. In this era of expanding global supply chains, gateways and corridors are becoming sources of competitive advantage for many firms, and new gateways and corridors are changing the competitive framework for transportation in North America (Parsons, *et al*, 2007.

The road network that serves the Cascade Gateway is more a north-south system than an east-west system. It is the set of four land border ports of entry that connect Western Washington State and the lower mainland of British Columbia. In this bi-national region, local trade and travel are served by the major highway routes that transit this region, such as U.S. Interstate 5, BC Highway 99, and the TransCanada 1 highway. The Pacific Highway crossing at Blaine is the main commercial crossing between Whatcom County, Washington, and the lower mainland of British Columbia. It is the fourth busiest commercial crossing on the U.S.-Canadian border and the most significant commercial crossing for Western Canada and the United States (USDOT/FHWA 2002a and b).
The crossing is 100 miles north of Seattle and 30 miles south of Vancouver, BC, on Washington State Route 543 and British Columbia Provincial Highway 15. The approximate distance between the greater Vancouver region and the Puget Sound region is 150 miles, with a 300 mile round trip. Accounting for the border crossing, congestion, travel speed, and a drop-off and pick-up, this trip can be completed in one full day of work. In previous research on variability in border crossing times we found that most of the commercial vehicle carriers employed regional truckers who live within the region

and want to be able to complete a run and return to their home base on the same day (Goodchild, *et al*, 2008).

5.1 *Border Operations and Programs*

The border crossing process from Canada to the U.S. at Blaine, Washington, is described in Graph 1: Land Port Border Booth Inspection Procedure. The northbound crossing into Canada is similar but does not have a Radiation Portal Monitor (RPM) or Vehicle and Cargo Inspection System (VACIS) inspection for all vehicles. The VACIS is a gamma ray imaging system that uses radiographic images to help inspectors examine the contents of all types of vehicles for hidden compartments. Originally developed to detect narcotics contraband, it is now also used to detect human smuggling.

In both the northbound and southbound directions there are primary and secondary inspections. All southbound vehicles (entering into the U.S.) typically arrive first at the back of the queue of vehicles waiting to cross the border. Then they travel through a Radiation Portal Monitor (RPM) (northbound does not have an RPM). Prior to this, they may experience some delay while waiting in the queue, and in fact, this is generally the largest source of delay.

The FAST (Free and Secure Trade) program, a joint U.S.-Canada initiative[12] allows users to use dedicated border crossing lanes in Canada and the U.S. when available, and offers accelerated customs and immigration processing for all vehicles, goods, carriers, and importers that have been pre-approved. The average crossing time for all trips, both northbound and southbound, is significantly quicker for those drivers, vehicles, goods, and carriers who are FAST approved. A recent study (HCI 2007) showed that the average FAST primary inspection time is approximately 30 seconds per vehicle faster than at non-FAST booths, with a 1-hour reduction in crossing time per vehicle in comparison to non-FAST crossing times. Crossing times can be more variable southbound because Canadian staffing policy at the northbound gates is more demand responsive (i.e., staffing requirements at the northbound gates are more flexible because of more liberal Canadian labor laws).

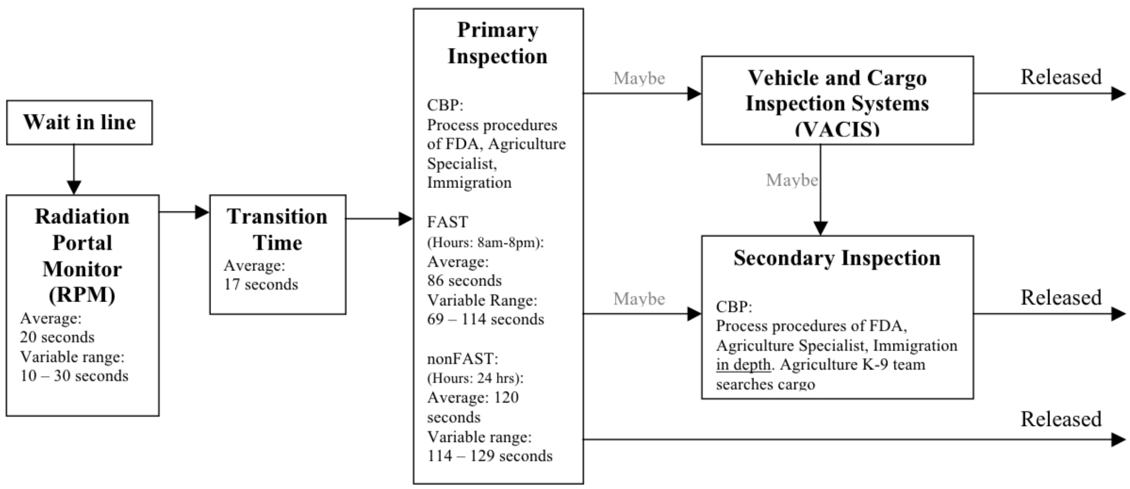
It is important to note that the FAST lane is not always available for FAST traffic (thus reducing the incentive to become FAST approved). Southbound hours of operation for the FAST lanes are Monday through Friday 8:00 AM to 8:00 PM; the northbound lane (into Canada) has similar hours of operation but is substantially shorter at 30 feet long. In addition, a current practice at the Pacific Highway crossing is to open the FAST lane to *all traffic* when significant delays occur.

It is clear from comparing the WCOG and GPS data that FAST provides significant benefit to carriers. Primary booth times are significantly reduced, and wait times are almost an hour shorter. Unfortunately, FAST has not been widely adopted, and anecdotal

[12] The FAST program is a joint U.S.-Canada initiative comprising the Canada Border Services Agency (CBSA) and U.S. Customs and Border Protection (CBP).

evidence suggests that carriers of agricultural products, which dominate trade in Cascadia, are even less likely to enroll.

After the RPM, vehicles move to primary inspection, where they are reviewed by CBP, Immigration, and a Food and Drug Administration (FDA) Agricultural Specialist. Southbound vehicles then travel through the VACIS. Some vehicles are required to go through a secondary inspection before being released. There are various reasons for a secondary inspection. A vehicle may be flagged by the electronic system or chosen by the booth agent for further inspection.



Graph 1: Land Port Border Booth Inspection Procedure[13,14]

Because of the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, the FDA requires advance notice of arrival to import food into the United States. The advance information assists the FDA in determining whether the types of imported food and agricultural products will require further inspection (examples include larvae, banned insects, snails). It is important to note that a shipment does not need to contain only food or agricultural products to be of interest to FDA inspection. For example, containers with wood packing or pallets, especially of untreated wood, may contain larvae in the untreated wood that could cause an infestation in the U.S. Also, auto parts or generators may harbor wood-born insects; all dirt must be thoroughly cleaned off any equipment, as all foreign soil is a banned substance.

Imported food shipments can comply by using the CBP's Automated Broker Interface of the Automated Commercial System (ABI/ACS) and advance notice can be submitted either through the ABI/ACS or the FDA's Prior Notice (PN) System Interface. For arrival by land, advance notice must be submitted electronically and confirmed by the FDA no more than five days and no fewer than 2 hours before arrival. Information submitted must include the identification of the submitter, transmitter, manufacturer, grower, shipper, importer, and carrier; entry type and CBP identifier; the country from

[13] TTI/BMI, 2002.

[14] U.S. Customs and Border Protection: “Assessing the Impact of the ACE Truck e-Manifest System in Trucking Operations,” “Customs-Trade Partnership Against Terrorism Cost/Benefit Survey,” “Advance Electronic Presentation of Cargo Information,” and “Free and Secure Trade Program.”

which the article of food is shipped; anticipated arrival information; and the FDA country of production. The FDA Agricultural Specialist is available between 7:00 AM and 11:00 PM Pacific Standard Time and technical assistance is available between 7:00 AM and 11:00 PM U.S. Eastern Time.

5.2 *Current Patterns of GPS Freight Carrier Border Delay and Volume*

It is approximately 150 miles between Vancouver, BC, and Seattle, Washington. As mentioned previously, the regional or greater Vancouver to greater Puget Sound trips (about 35 percent of the total) are served by drivers based in the region, who, given the distances, can reasonably make one round trip from their home, to origin, destination, and return, in one working day and not exceed hours of service regulations. However, they cannot make two trips. This creates the arrival pattern we see in Figure 1, with a sharper peak in the morning (as is typical with demand for transportation services), a low point in the mid-day when the regional drivers are at their destination, and a more spread peak in the afternoon, when variances in travel times and wait times spread the demand across a greater period than in the morning.

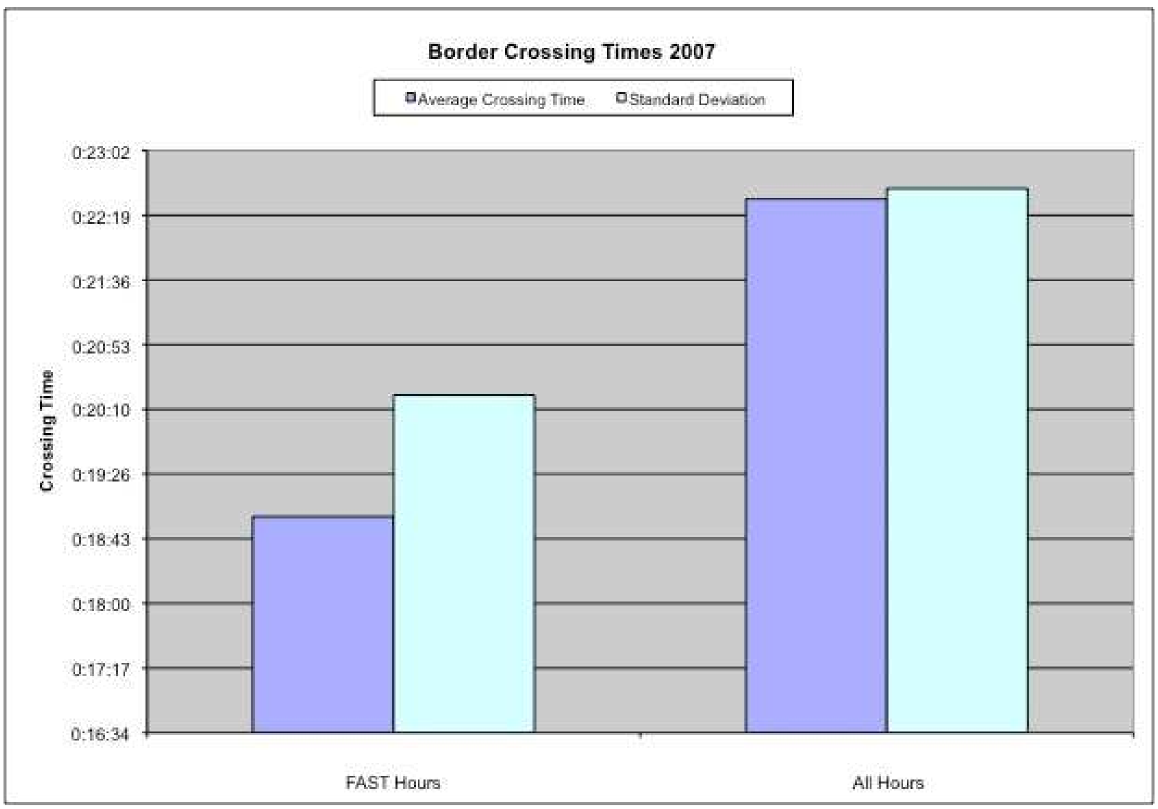


Figure 2: Average and Standard Deviation of Crossing Times (All Hours)

Figure 2: Average and Standard Deviation of Crossing Times shows the average and standard deviation of crossing times for southbound FAST vehicles for all observations in 2007. We can see that when the FAST lane is available (M-F 8:00 AM to 8:00 PM) to

FAST approved vehicles the average crossing time is less than 19 minutes. Outside of FAST hours, crossing times are on average just over 22 minutes. The crossing times are larger outside of FAST hours despite the reduced volumes of vehicles. The crossing times were quite variable, with a standard deviation of about 20 minutes in the FAST hours and 22 minutes outside of FAST hours. Notice that the standard deviation is approximately equal to the mean, which is what we would expect with a random process, suggesting that the arrival distribution could be modeled by a Poison distribution. Figures 3 and 4 show how the average and standard deviation of FAST crossing times varies over the seasons for our entire data set. Figure 3: Average and Standard Deviation of Delay over Seasons shows the average and standard deviation for all hours, and Figure 4: Average and Standard Deviation of Delay over Seasons shows the average and standard deviation for FAST hours only. From these figures we can make the following observations:

1) There is not a strong seasonal pattern for observed delay during the period.
2) Crossing times do appear to have a decreasing trend in the observation period.

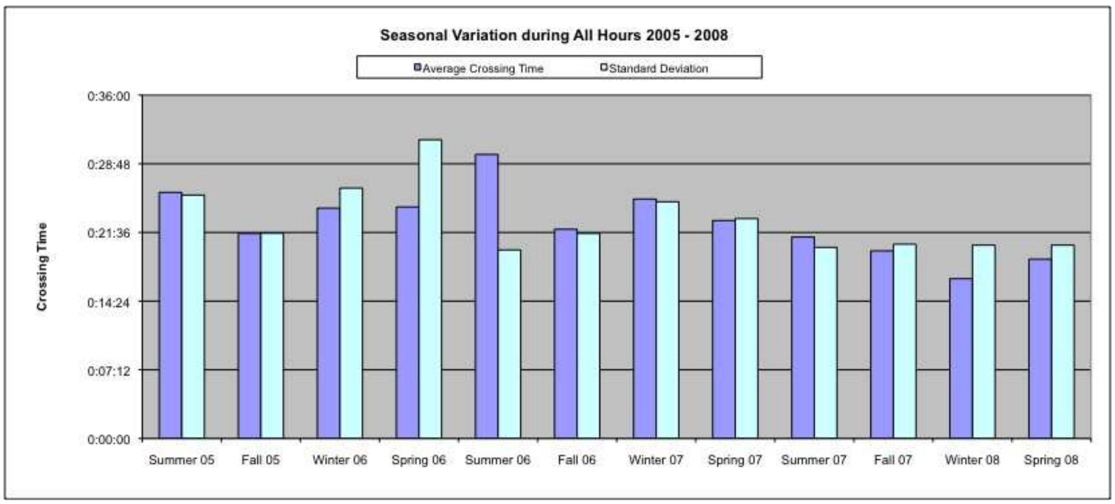


Figure 3: Average and Standard Deviation of Delay over Seasons (All Hours)

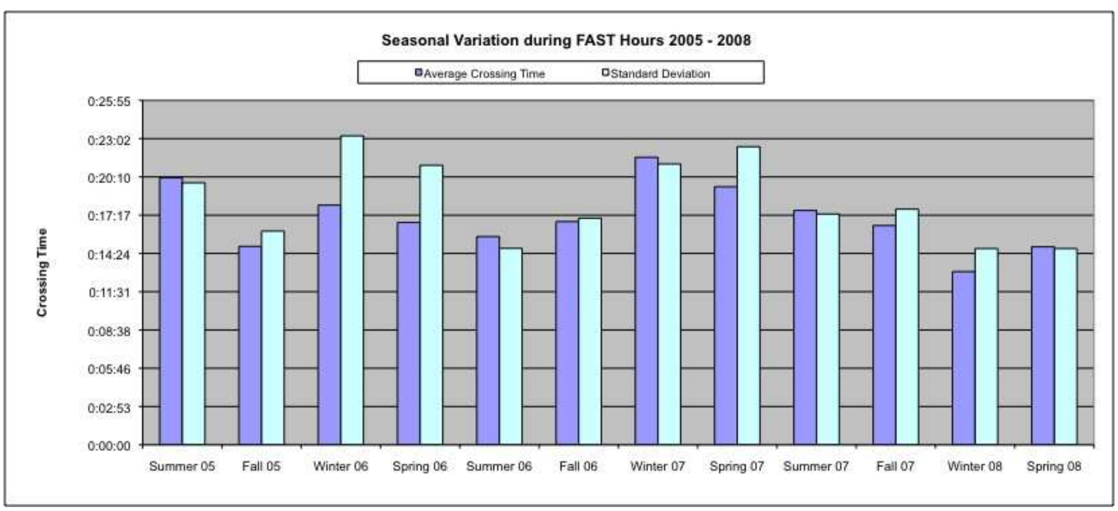


Figure 4: Average and Standard Deviation of Delay over Seasons (FAST Hours)

Figure 5: Weekly Average and Standard Deviation (All Hours) and Figure 6: Weekly Average and Standard Deviation (FAST Hours) show the average and standard deviation in crossing times for each day of the week (Monday through Friday) for 2006 and 2007. We limit our analysis to 2006 and 2007 because we do not have a complete data set for 2005 and 2008. Again, we do not observe a strong or consistent delay pattern, with Mondays in 2006 having a lower average crossing time but Mondays in 2007 having a higher crossing time.

As discussed in previous research on service time variability and its impact on regional supply chains (Goodchild, *et al*, 2008), crossing times within 2 standard deviations of the mean are anticipated by frequent crossers and internalized into their scheduling and planning; however, very long delays (defined here as more than 2 hours) are much more problematic. Figure 7: Frequency of >2-Hour Delays by Month for All Hours and Figure 8: Frequency of >2-Hour Delays by Month show the frequency of days for FAST hours in which at least one observation of a delay of more than 2 hours was made. Within FAST hours it is uncommon for a FAST approved vehicle to experience a delay of more than 2 hours, whereas these delays are more common within the entire 24-hour period. This indicates that very long delays occur more frequently off hours, between 8:00 PM and 8:00 AM. During this time period, if problems are encountered, resources such as brokers and FDA representatives are limited for resolving problems.

Although the observed delay patterns consistently show longer delays outside of FAST hours, between Monday and Friday, 8:00 PM to 8:00 AM, they show surprisingly little consistency in terms of day of week and seasonal crossing time.

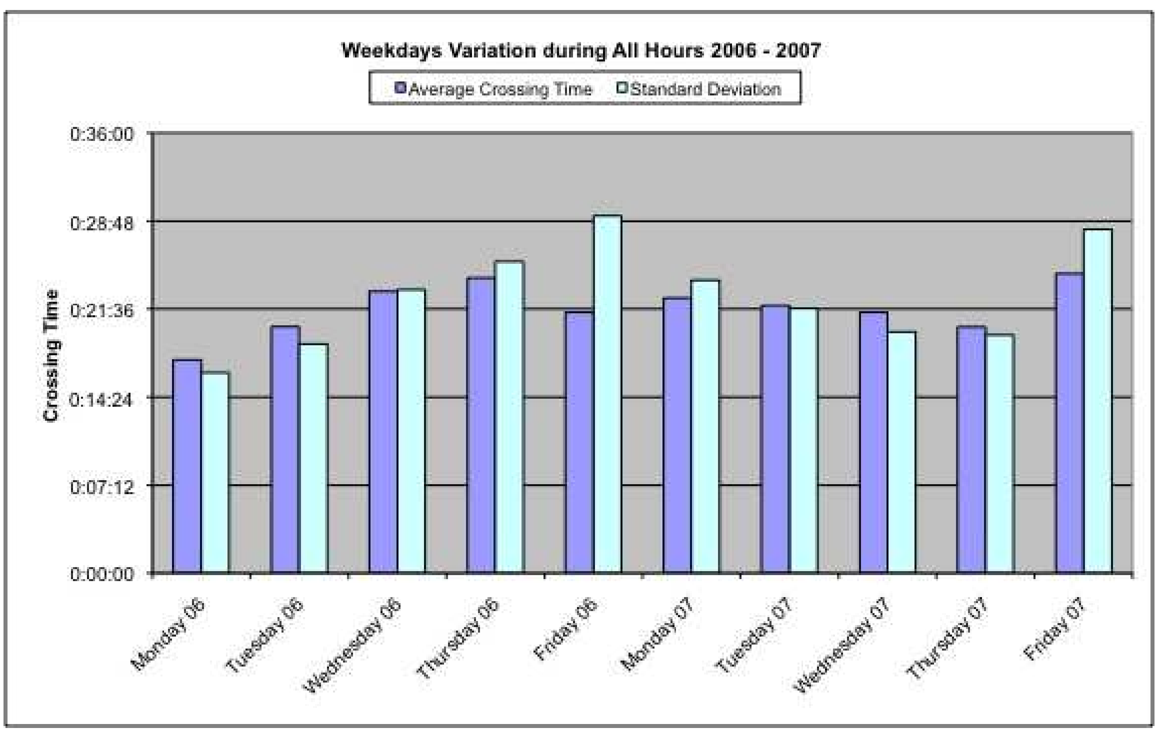


Figure 5: Weekly Average and Standard Deviation (All Hours)

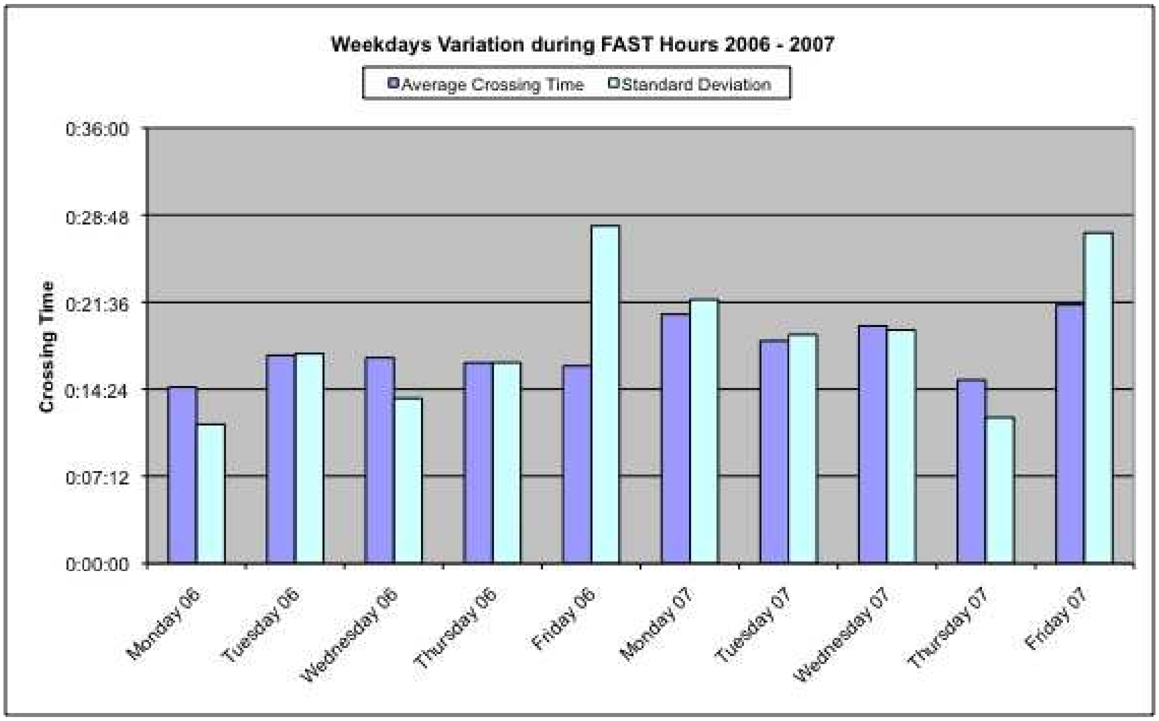


Figure 6: Weekly Average and Standard Deviation (FAST Hours)

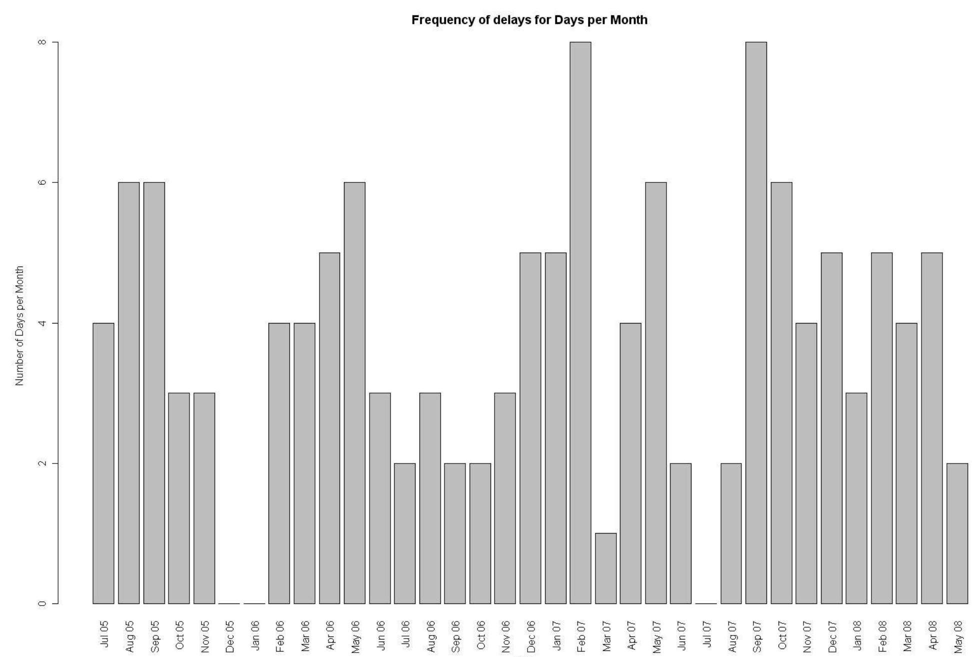


Figure 7: Frequency of >2 Hour Delays by Month (All Hours)

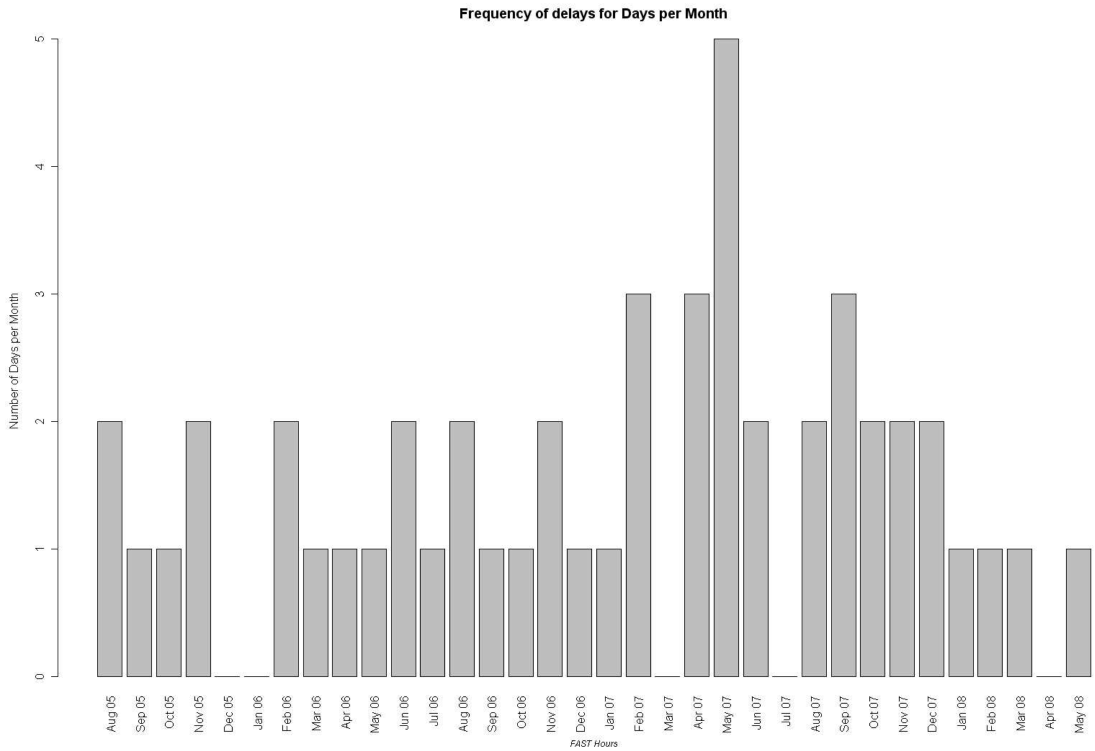


Figure 8: Frequency of >2 Hour Delays by Month (FAST Hours)

5.3 *Unique Characteristics of the Cascade Gateway and Trade Corridor*

Other sources of delay affect travel times and border delay. For example, variability in travel time due to congestion in major regional cities (Vancouver, Seattle, Portland) will overwhelm variability in border crossing times. However, companies regularly build buffer times into logistical planning in order to accommodate mean travel time, plus 2 standard deviations (Goodchild, *et al*, 2008). Although the ability to predict crossing times would reduce this buffer, the typical distances in the region would still prevent drivers from making another complete trip. Therefore, trucking companies have little incentive to improve scheduling or eliminate the existence of slack capacity in the transportation supply chain at least until travel times are much more reliable. The economic consequences of very long delays, however, are much more significant, as they may cause a loss in product value, contract specifications, or sales opportunities.

The commodities crossing the Cascade Gateway are not operating in a tightly scheduled manufacturing environment. Unlike the Eastern Border, where unfinished goods are moving between factories on either side of the border, or the Southern Border, where it is difficult to become FAST approved and C-TPAT certified (it is difficult to secure the supply chains for fruits and vegetables, especially for small and medium producers) (Villa and Vázquez 2008), goods crossing the Cascade Gateway are on their way to market. Some of these goods are operating under schedule constraints (if going to international markets, the goods must reach the airport in time to be loaded onto the flight or risk missing it and having to take a later flight), or they may be highly perishable goods on way to markets on the Pacific Coast or further east or south (seafood and fish, in particular). While many of the food and agricultural products are not moving on a set schedule, they are time sensitive because they are perishable and fragile, and delay has an impact on product quality.

In a previous study, we spoke with a carrier with two guaranteed schedules from Canada every night (leaving Canada at 8:00 PM, arriving in Seattle between 1:00 and 2:00 AM, and returning). The schedule is determined by the customer and by the time that the freight must arrive at the dock for loading onto an international flight. For this carrier, the vehicle is not always full (loads are prioritized according to when their flights are taking off), but the schedule is set, and if a truck is running late it will take the freight that has the earlier flight departure. If a driver experiences delay at the border, this carrier will absorb some of the cost; however, the carrier will bill the customer $70/hr delay time for air freight under some circumstances. For example, this carrier may have a load of Washington State cherries and drive directly to the terminal in Richmond, BC, to catch a flight at the Vancouver, BC, airport to Europe or Asia, from which the fruit will be air freighted to international markets (the Vancouver, BC, airport offers less expensive landing rights than SeaTac) (Goodchild, *et al*, 2008).

For another carrier specializing in delivering frozen seafood and agricultural fish from BC, the goods go through a re-handling facility where they are reloaded onto vehicles bound for markets in California, Phoenix, Chicago, and points in between. This carrier transports products valued from $200,000 to $1 million per truckload (at the high end if transporting caviar). This carrier has a set schedule all year (demand for agricultural fish is fairly constant) and does not have the option of building extra time into the trip, as it is caught in the middle between production and consignee time. Delays at the border may cause “temperature abuse” (spoilage) so that the product must be sold at a lower price or is even no longer fit for consumption. This seafood carrier has ownership of the inventory and suffers the cost of any damage from spoilage. This carrier reported that variability in border delay times would need to be reduced by at least 2 hours before it would respond by reducing shipping volumes and changing scheduling requirements from the consignees (Goodchild, *et al*, 2008).

5.4 *Cascade Gateway Commercial Vehicle Origin and Destination and Commodity Characteristics/Manifest Data (bi-national carrier origin and destination)*

As discussed previously, the regional or greater Vancouver to greater Puget Sound trips (about 35 percent of the total) are served by drivers based in the region, who, given the distances, can reasonably make one round trip from their home, to origin, destination, and return, in one working day and not exceed hours of service regulations. However, they cannot make two trips. This creates the arrival pattern we see in Figure 1. In addition to this arrival pattern, we have consistently observed a lack of tight scheduling in regional trucking. Typically, a vehicle operates on about a 4 hour delivery window. As discussed, the variability in border crossing times, travel times, and the nature of regional business contribute to this flexibility, which also reduces incentive to improve resource utilization.

Using data from the Pacific Highway Port-of-Entry Commercial Vehicle Operations Survey (southbound only), or WCOG data, we compiled a transportation profile of commercial vehicle origin and destination data. Table 3: Pacific Highway Cascade Gateway Vehicle Origins and Destinations shows the regional and bi-national nature of shipments through the Pacific Highway crossing. The manifest data show typical origins and destinations for trips crossing the border.

Table 3: Pacific Highway/Blaine Cascade Gateway Vehicle Origins & Destinations
(Source: HCI 2007)

	ORIGINS							
DESTINATIONS	West Lower Mainland	Rest BC	Alberta	East Lower Mainland	Whatcom	West Canada	East Canada	TOTAL
Alaska	0.1%		0.1%					**0.2%**
East Canada	0.1%							**0.1%**
Whatcom	10.5%	0.6%	0.2%	0.1%	0.1%		0.1%	**11.6%**
Puget Sound	34.9%	0.7%	0.8%	0.2%			0.4%	**37.1%**
West WA	4.4%	0.2%	0.1%					**4.8%**
East WA	3.2%							**3.2%**
West U.S.	28.4%	1.7%	0.7%	0.1%	0.1%	0.1%	0.1%	**31.0%**
Rest U.S.	11.6%	0.4%						**12.1%**
TOTAL	**93.2%**	**3.7%**	**1.9%**	**0.4%**	**0.2%**	**0.1%**	**0.5%**	

Using the same WCOG data we compiled a commodity profile for the Pacific Highway border crossing. Figure 9: Pacific Highway Cascade Gateway Commodity Profile shows that when combined together, agricultural products, prepared foodstuffs, and meat, fish, and seafood make up 9 percent of the total, followed by wood products at 7 percent. Also of note is that a large percentage of commercial containers or vehicles crossing here are empty, showing that the majority of commercial vehicles cross the border, deposit their goods, and return empty.

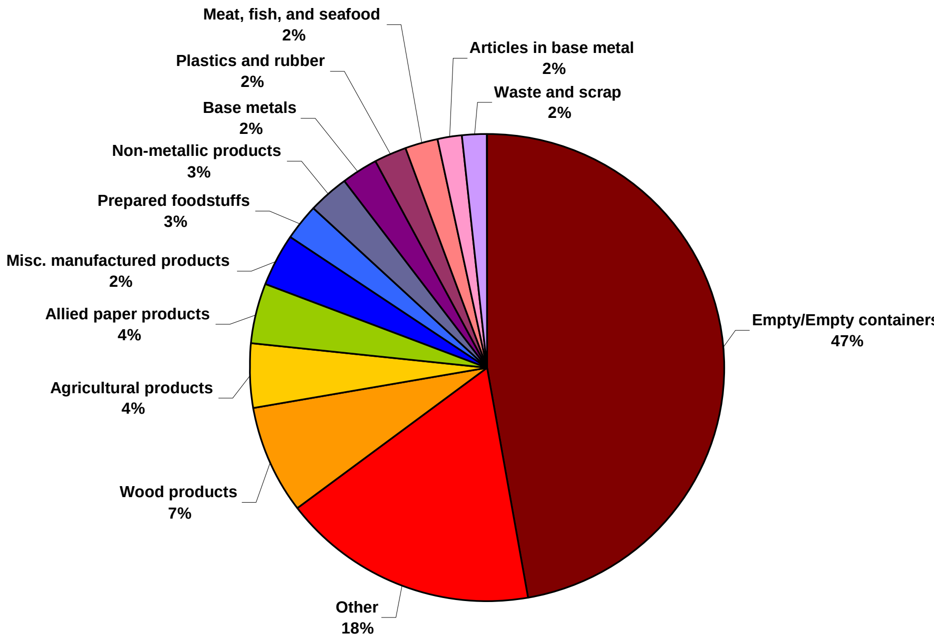


Figure 9: Pacific Highway Cascade Gateway Commodity Profile
(Source: HCI 2007)

5.5 *Comparison Profile—Western (Cascadia) Border Crossings with Northern and Southern Crossings*

Figure 10: Truck Volumes at the Top Five U.S./Canadian Crossings shows truck volumes at the top five crossings with the largest annual truck volumes in 2006. Notice the order of magnitude difference between the Pacific Highway crossing, the largest western crossing, and the largest crossing overall. Notice also the typical end of year depression in volumes.

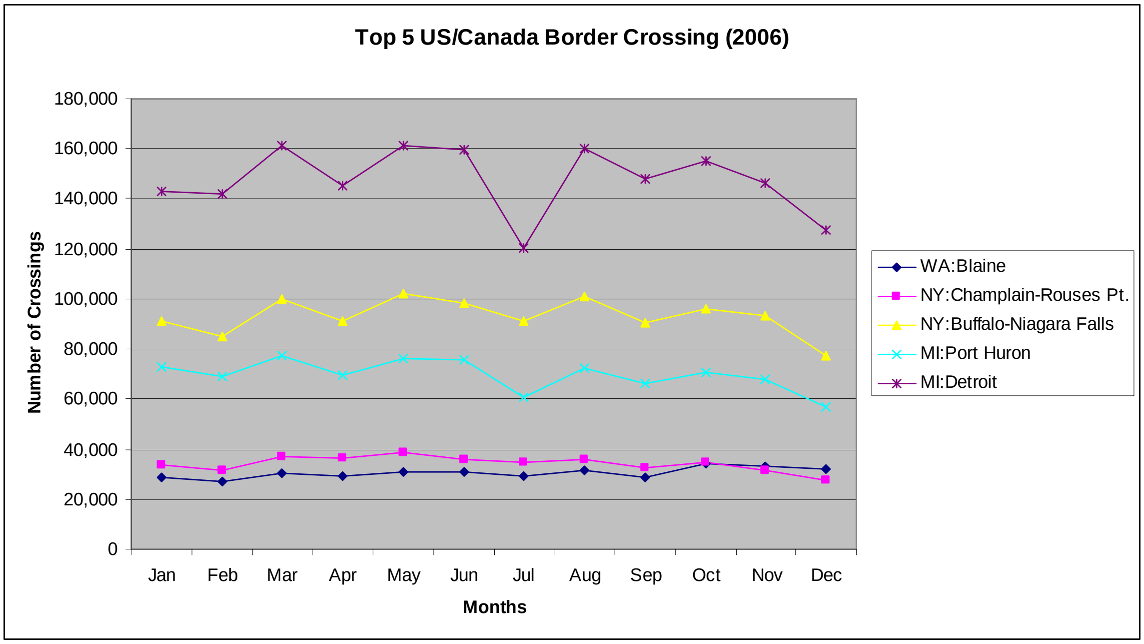


Figure 10: Truck Volumes at the Top Five U.S./Canadian Crossings
(Source: USDOT/BTS 2006)

These volumes are similar to those at the top five U.S./Mexico crossings, shown in Figure 11. The U.S./Mexico crossings show a strong late summer and fall peak from agricultural and maquiladora production, but also reveal a December dip in volume.

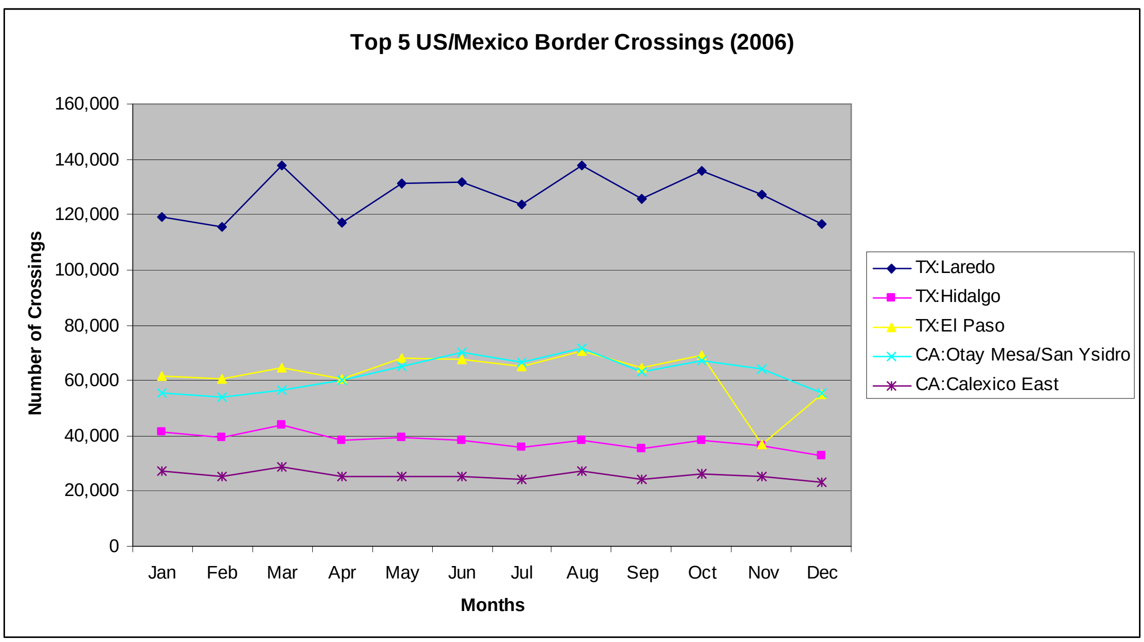


Figure 11: Truck Volumes at the Top Five U.S./Mexico Crossings
(Source: USDOT/BTS 2006)

6. Data Sets—Correlating Delay and Arrival Times

To develop solutions that might reduce border crossing times, it is necessary to understand whether crossing times are long because of excessive demand (more vehicles arriving per time period than can be processed in that period) or because of some reduction in supply (reduction in the ability of the border to process vehicles). To do so, we compare vehicle arrival volumes obtained from the BC MOT loop detectors with crossing times for the same period from the GPS data. If the arrival rate proved to be a good predictor of crossing times, we could assume that crossing times were primarily determined by arrival rate. However, if crossing times are not well predicted by arrival rate, then we could assume that factors other than arrival volume contribute significantly to crossing time.

Figure 12: Arrival Volume versus Crossing Time shows arrival volumes versus crossing times for May 7, 2007. Arrival volumes for each 5 minute period were obtained from the BC MOT data set at loop 15-905U. Loop 15-905U captures only FAST vehicles. In each 5 minute period, if a truck arrives at the back of the queue, its crossing time is compared with this arrival volume. If two vehicles arrive in this period, their crossing times are averaged; however, this is not typical due to the density of crossing times in our data set. We can observe that the border is almost always in a congested state, with most crossing time observations greater than 0. The regression equation is estimated as $\hat{Y} = 6.6613 + .1056X$ with an R^2 value of 0.0002061. This indicates that arrival volumes are a poor predictor of crossing time and describe significantly less than 1 percent of the variability on this date. If demand were the primary cause of delay, arrival volume should affect crossing time and we should see a stronger correlation.

As mentioned, however, our data set contains crossing time observations approximately once every 30 minutes. In addition to comparing individual days, we considered the correlation between arrival volume and crossing time for larger data sets to generate a higher density of observations.

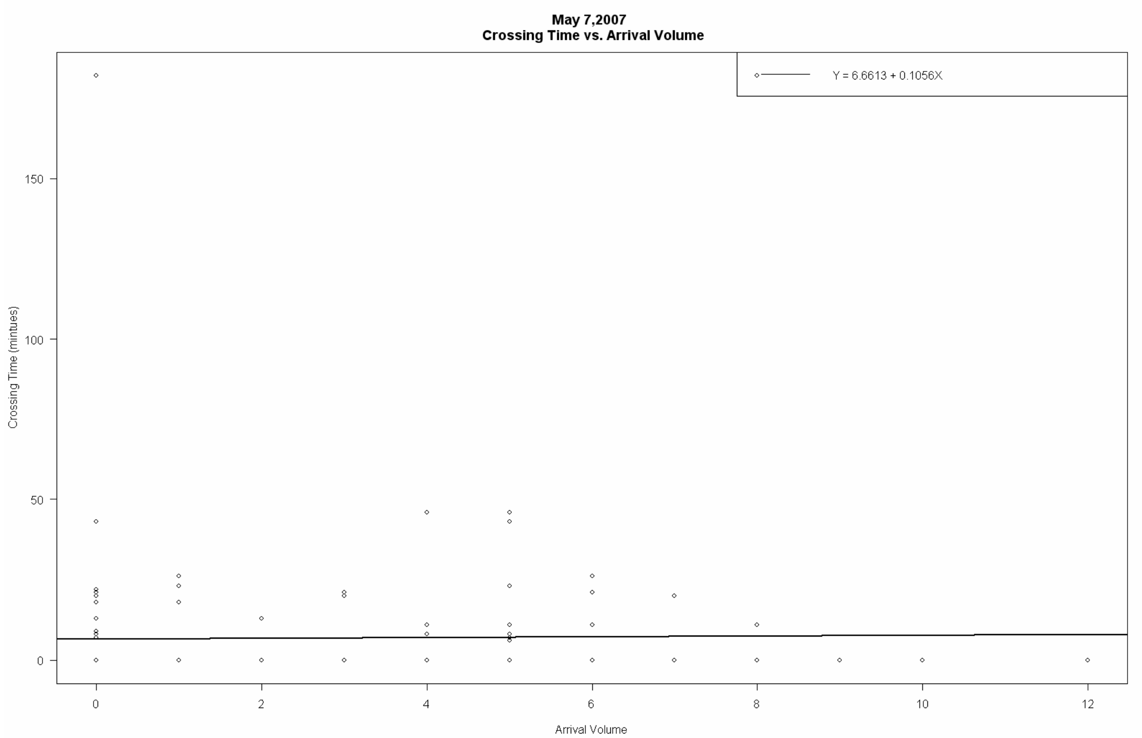


Figure 12: Arrival Volume (number of vehicles) versus Crossing Time (minutes) between 8:00 AM and 8:00 PM for May 7, 2007

6.1 *General Seasonal and Temporal Patterns*

Figures 13 through 16, one for each season in 2007, show the average crossing time in each 5-minute interval and the total arrival volume in that same 5-minute interval. Volumes were collected from loop 15-905U, which is in the FAST lane and captures only FAST volumes but is typically outside of the congested region.

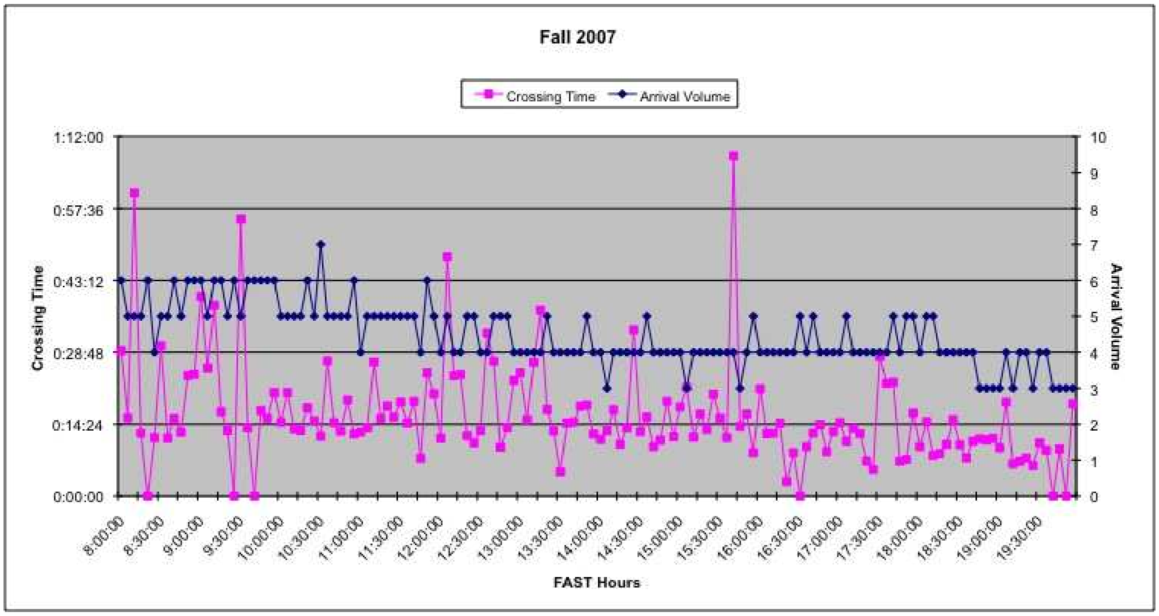


Figure 13: Fall 2007 Delay versus Crossing Time (FAST Hours)

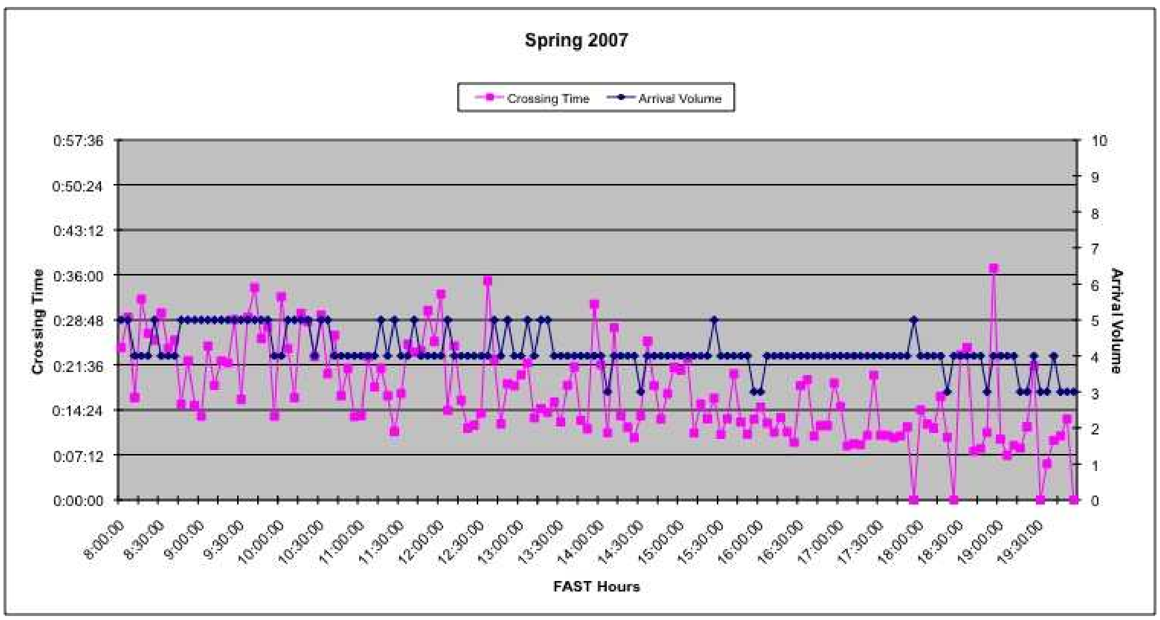


Figure 14: Spring 2007 Delay versus Crossing Time (FAST Hours)

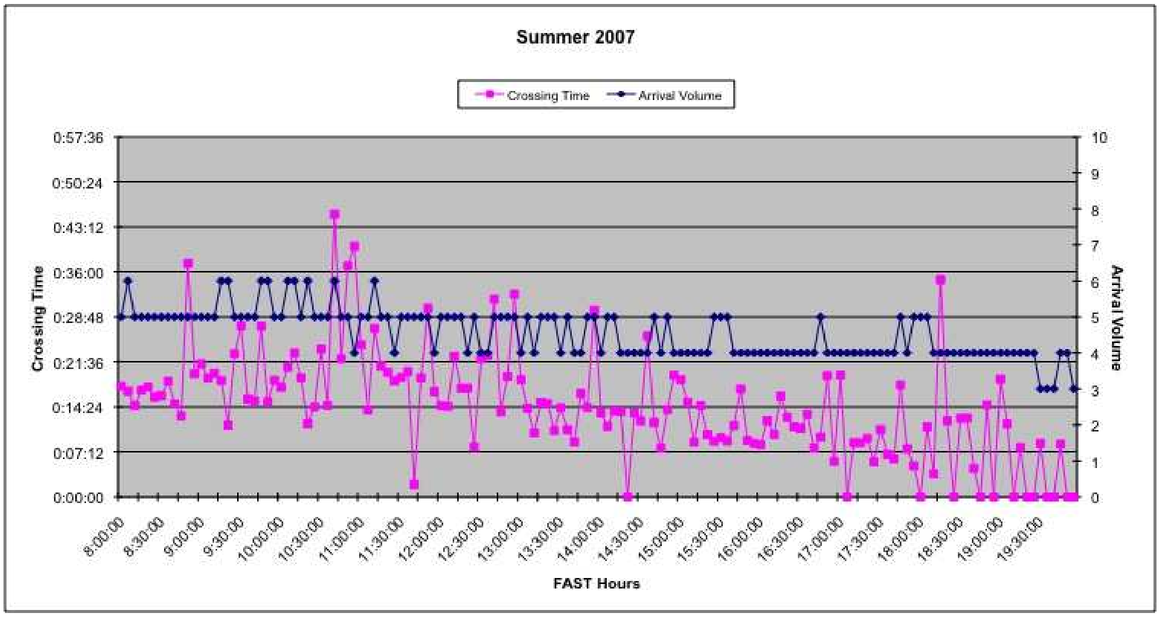


Figure 15: Summer 2007 Delay versus Crossing Time (FAST Hours)

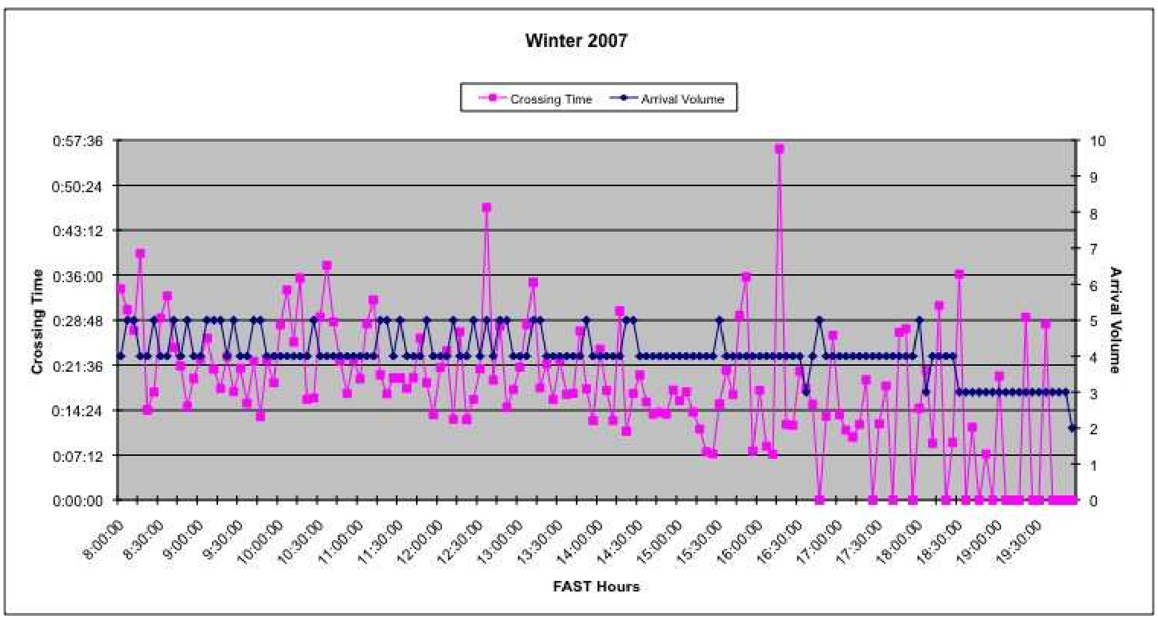


Figure 16: Winter 2007 Delay versus Crossing Time (FAST Hours)

While there appears to be some relationship between the average crossing time and the arrival volume, it is not particularly consistent. To evaluate this further, a series of correlations were conducted, with an independent variable of arrival volume and a dependent variable of crossing time.

Figure 17: Correlation between Volume and Crossing Time by Season and Figure 18: Correlation between Volume and Crossing Time by Day of Week show aggregate data for the 2007 GPS data set again from loop 15-905U. The figures show the regression

equations for the total 5 minute arrival volume estimated from the average 5 minute crossing times in the same period. There are four lines in Figure 17, one for each season, and five lines in Figure 18, one for each day of the week.

The regression equations and correlation coefficients are summarized in tables 4 and 5. X is the arrival volume in number of vehicles, and Y is the average border crossing time in the 5 minute interval.

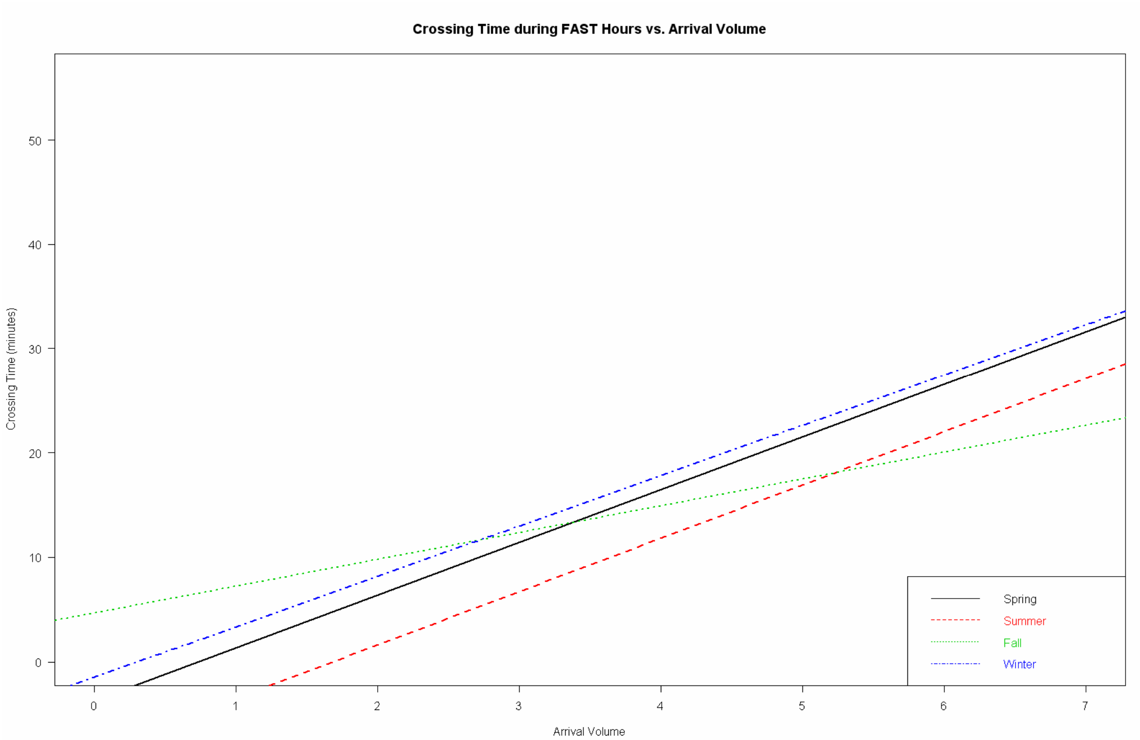


Figure 17: Correlation between Volume and Crossing Time by Season

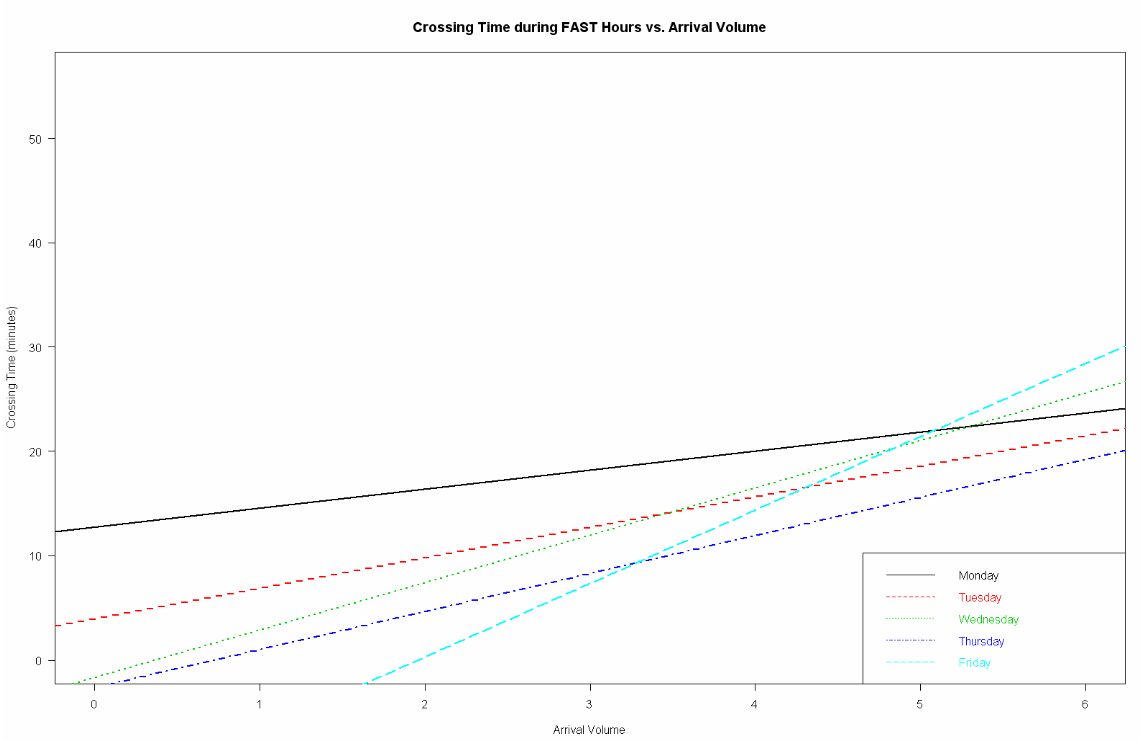


Figure 18: Correlation between Volume and Crossing Time by Day of Week

Table 4: Regression Results by Season for 2007

Seasons	*Spring*	*Summer*	*Fall*	*Winter*
Regression equation	Ŷ = -3.6909+5.0439X	Ŷ = -8.5163+5.0868X	Ŷ = 4.6846+2.5608X	Ŷ = -1.434+4.818X
Correlation coefficient	17.94%	20.81%	5.19%	10.31%
Average crossing time	19 minutes, 25 seconds	17 minutes, 38 seconds	16 minutes, 30 seconds	21 minutes, 38 seconds

Dependent variable is 5 minute arrival volume,
Independent variable is 5 minute average crossing time**.**

Table 5: Regression Results for Day of Week for 2007

Weekdays	*Monday*	*Tuesday*	*Wednesday*	*Thursday*	*Friday*
Regression equation	Ŷ = 12.756+1.818 X	Ŷ =-3.9680+2.9139X	Ŷ = -1.672+4.535X	Ŷ = -2.6108+3.6345X	Ŷ = -14.252+7.057 X
Correlation coefficient	13.43%	8.43%	15.54%	19.64%	20.68%
Average crossing time	20 minutes 35 seconds	18 minutes, 25 seconds	19 minutes, 38 seconds	15 minutes, 9 seconds	22 minutes, 24 seconds

Dependent variable is 5 minute arrival volume,
Independent variable is 5 minute average crossing time.

With these larger data sets we see a much stronger correlation between arrival volume and crossing time, with correlation coefficients in the range of .05 to .21. However, we argue the correlation is still surprisingly weak, with at most 21 percent of the variability described by the independent variable. We can conclude that while there is some correlation between arrival volume and crossing time, many other significant factors also contribute to border crossing time. We believe these results show a much weaker correlation than frequent border crossers would expect. However, these results are consistent with the expectations of the border crossing agents and CBP border manager, who understand that the solution to border crossing delay will not come solely from additional primary booth capacity. This analysis provides quantitative support for these experts' intuitive expectation. Looking across days of the week and seasons, there does not seem to be a relationship between average crossing time and the strength of the correlation between arrival rate and crossing time.

A final observation that can be made is that while arrival patterns at the border are reasonably consistent, delay patters are much more variable. Due to the weak correlation between arrival rate and observed crossing times, a more detailed simulation was not pursued.

7. Primary and Secondary Delay

To analyze processing time delay it is necessary to determine the type of delay that is occurring. We differentiate between two types of delay, *Primary Delay* and *Secondary Delay*. Primary delay occurs when a vehicle waits in the queue and is processed through the primary inspection booth only. Occasionally a secondary inspection is required, which consists of the vehicle being run through the VACIS machine and further questioning by the CBP and an agricultural specialist. [15]

The GPS Freight Carrier Data Set contains information about truck arrival times at and truck departure times from the border. An algorithm was developed to quantify primary versus secondary delay by analyzing the departure times of commercial vehicles. Vehicles are in a single line and exit the border one at a time unless they are held longer for additional inspection. Secondary crossing times are observed if a driver has arrived at the border earlier than the previous driver and is released from the border later than the previous driver. The crossing time defined as secondary is the difference in the two vehicle departure times. Given that just one lane of traffic was under consideration and the primary booth operated in a first come-first served manner, if a vehicle departed after a vehicle that arrived after it, there must have been a secondary cause of delay, secondary in that it was not caused by the initial queue or primary inspection process.

We define primary delay as delay not identified as secondary, and it therefore includes all queuing at the primary booths and primary inspection time, but may include additional delay, for example, in the case two vehicles do not arrive at the border in temporal proximity. Our calculation of secondary delay, therefore, is a lower bound, and we do not know to what extent we underestimate secondary delay. Although we used a lower bound, it shows that secondary delay is still a significant contributor to total crossing time and is reasonably consistent throughout the year.

Figure 19 shows secondary crossing times make up almost 25 percent of the crossing time observations. Almost a quarter of the observed crossing times is not due to delay caused by waiting for a primary inspection or being served at the primary inspection booth. Our method of identifying primary and secondary crossing times is clearly an estimate, but even with this method, we see that the value of secondary delay is significant.

[15] It is not necessary for the truck to be carrying only food and agricultural supplies for a driver to be questioned by the CBP Agricultural Specialist, as packing materials may harbor pest infestations or insects banned from entering the U.S.

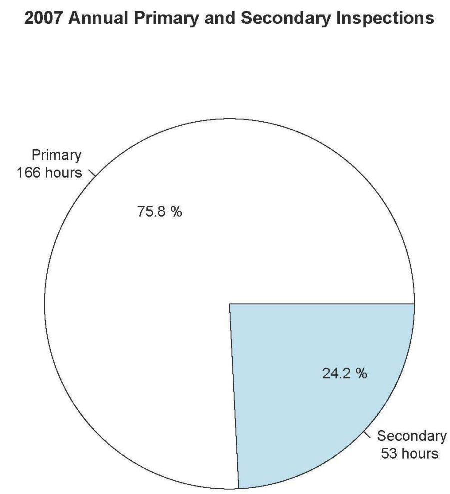


Figure 19 Secondary Crossing Time Compared to Total Crossing Time, 2007

Figure 20 shows how the secondary crossing times vary with season, and Figure 21 shows the variation by month. The highest value is observed in June 2007, at 32 percent of total crossing time.

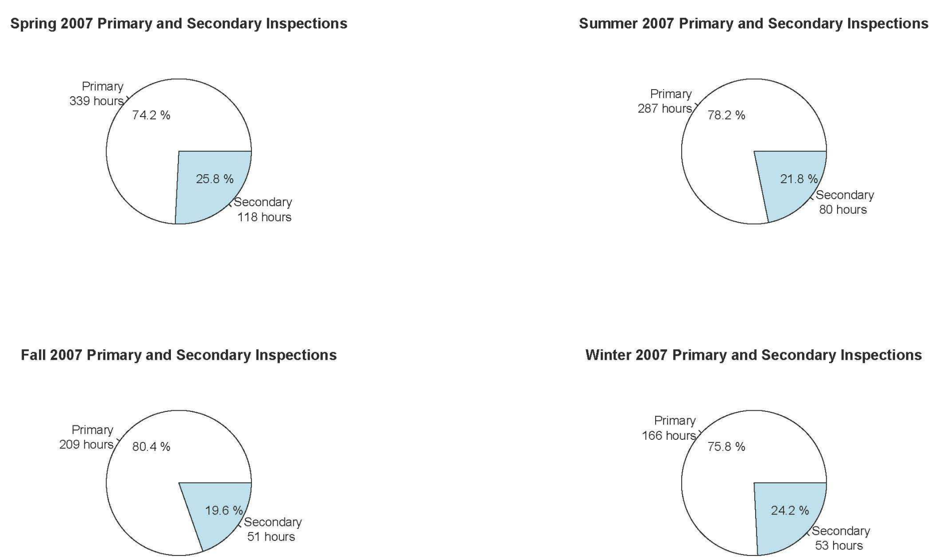


Figure 20: Secondary Crossing Time Compared to Total Crossing Time, 2007 (By Season)

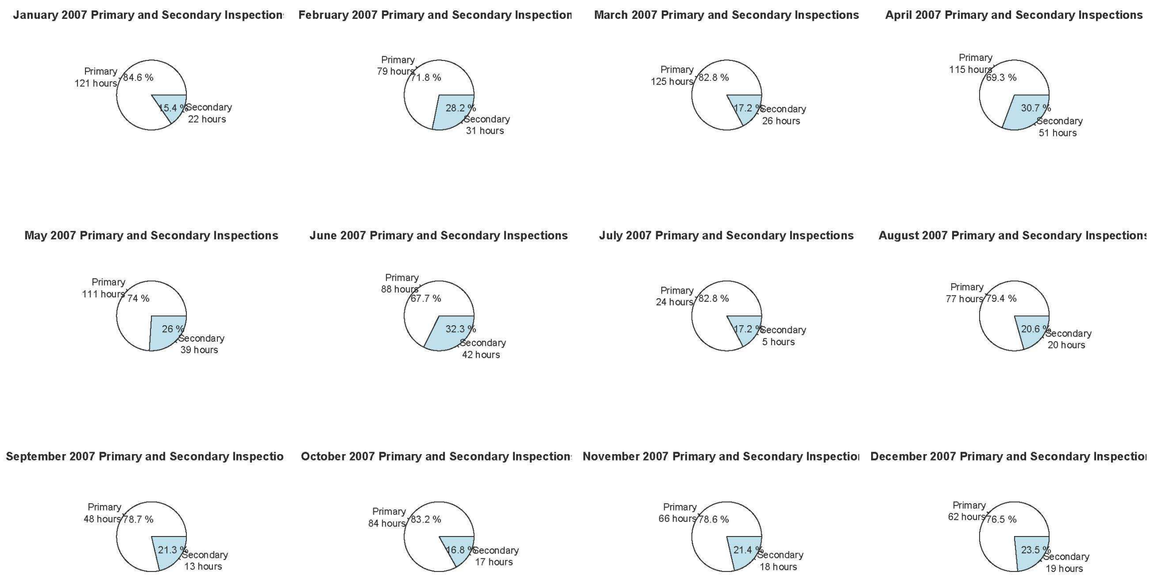


Figure 21: Secondary Crossing Time in Compared to Total Crossing Time, 2007 (By Month)

8. Policy Discussion and Conclusion

Our analysis of the causes of delay and the estimated separation of primary and secondary delay indicates that border crossing time is weakly correlated with arrival volume and that delay reduction strategies that are not focused on development of primary booth capacity have potential. We see that 'border readiness' or 'border preparedness' is an important factor in terms of quick and efficient transit of the Cascade Border—that the FAST program does offer shorter transit times for those carriers who decide to enroll. For these carriers, the FAST program with its objective to offer expedited clearance to carriers that have demonstrated supply chain security and enrollment in C-TPAT has had a promising beginning.

However, we also see that some types of carriers have less incentive to utilize security border crossing measures and procedures (ACE, FAST, C-TPAT) depending on the kinds of goods they carry. This is the case at the Mexican border where producers (or shippers) do not become C-TPAT certified as it is more difficult to secure the supply chains for fruits and vegetables. For those who can be certified, the seasonality of the exports makes it difficult to have a certified pool of C-TPAT/FAST drivers who can transport the product from origin to destination. To make the process more complicated, military inspections at this border break the secure supply chain, thereby making most of the trips non-compliant with FAST requirements (Villa and Vázquez 2008).

We see that the FAST program is very effective and does improve travel times for most carriers who become approved. In order to create more incentive for higher enrollments in the FAST program, we strongly suggest the FAST lane not be opened to all traffic during times of high congestion. Opening up the FAST lane during these times reduces the incentive for other types of carriers to enroll in the program, as well as reducing its efficiency and purpose. Anecdotal data support our conclusion that FAST is especially troublesome for food and agriculture carriers, which has consequences for supply chain logistics in agriculture and other industries.

To better serve the profile of Cascadia freight, we suggest a modified version of the FAST program for those food and agricultural carriers who need additional flexibility for pick-up times, especially those carrying perishable goods. This is especially needed for carriers who have less control over the supply chain, LTL carriers, and food/agricultural carriers. This version, or perhaps a different level of FAST approval and C-TPAT certification, would be more appropriate. However, this level would not approach the same trust and security relationship that these measures currently ensure between CBP and the transporter of goods.

Efficient transportation flows across the U.S.–Canada border are necessary for continued economic stability and growth in both countries. As these two countries move forward in trade, continuing adaptation to changing transportation needs will be critical in maintaining efficiency and reducing costs to ensure stability and growth. The Cascade Gateway has a distinct and unique commodity and trade profile that affects usage, operations, efficiency, and infrastructure locations. The Seattle-Vancouver trade corridor is an important route through this Gateway, with Seattle and Vancouver each serving as international hubs for the flow of goods in this region as well as internationally. Therefore, there is a specific need to evaluate and forecast the composition of agriculture and other commodities at the primary gateway in this corridor, the Cascade Gateway. By knowing the potential growth and increases in commodity flows across border crossing locations, policy makers can better adapt gateways to allow for continuing and increased efficiency in commercial vehicle crossings.

We anticipate increased pressure on trucking companies to reduce cost as fuel prices increase and Transportation Worker Identification Credential cards are required. This price pressure will drive regional carriers to improve efficiency in their supply chains, and therefore the costs of delay and variability in delay will increase. As this pressure grows, the regional industry will be looking to government for solutions that are relevant to Cascadia. This report provides both the contextual knowledge to interpret policy, and an analysis of delay that points to solutions other than solely primary gate capacity, such as trusted traveler programs effective for the food products and agricultural industries, as well as border preparedness.

Acronyms and Initials

ABI/ACS	Automated Broker Interface of the Automated Commercial System
ACE	Advance Electronic Presentation of Cargo Information
BC MoT	British Columbia Ministry of Transportation
CBP	U.S. Customs and Border Protection
CBSA	Canada Border Services Agency
C-TPAT	Customs Trade Partnership Against Terrorism
FAST	Free and Secure Trade
FDA	Food and Drug Administration
IMTC	International Mobility and Trade Corridor
PN	Prior Notice
PSRC	Puget Sound Regional Council
PNWER	Pacific Northwest Economic Region
RPM	Radiation Portal Monitor
USDOT	United States Department of Transportation
VACIS	Vehicle and Cargo Inspection System
WCOG	Whatcom Council of Governments
WSDOT	Washington State Department of Transportation

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http://www.cbsa-asfc.gc.ca/prog/fast-expres/menu-eng.html

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http://www.fina-nafi.org/eng/integ/corridors.asp

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Whatcom Council of Governments (WCOG), Cascade Gateway, Border Data Warehouse:
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Appendix 1

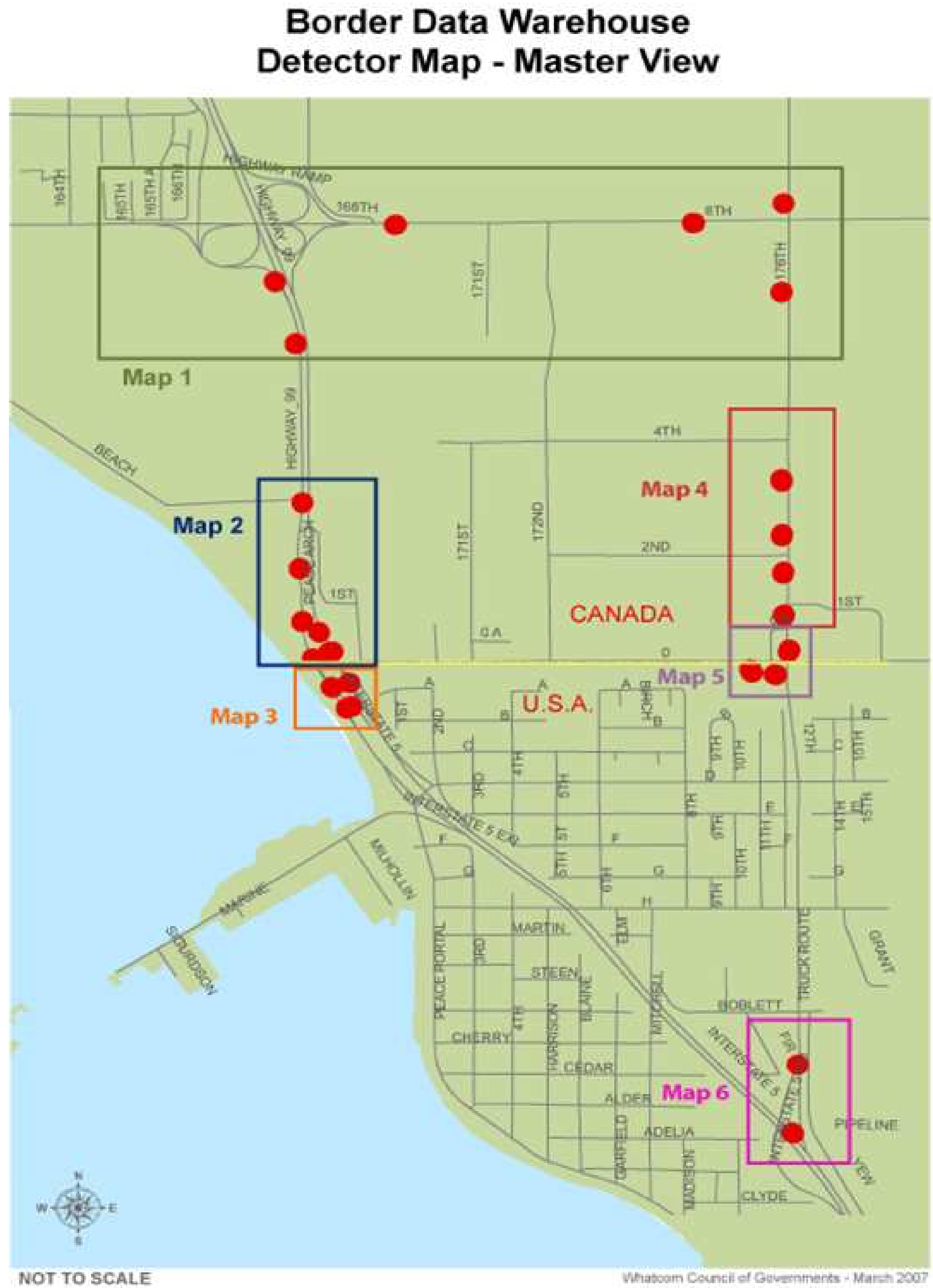

Figure A1: Location of BC MoT and WSDOT loop detectors surrounding the Peach Arch Border Crossing and the Pacific Highway Border Crossing.

Loop detectors are sectioned into six different maps for the ability to zoom into each section of loops. Map 1, Map 4, and Map 5 can be found in figures A2, A3, and A4, respectively.

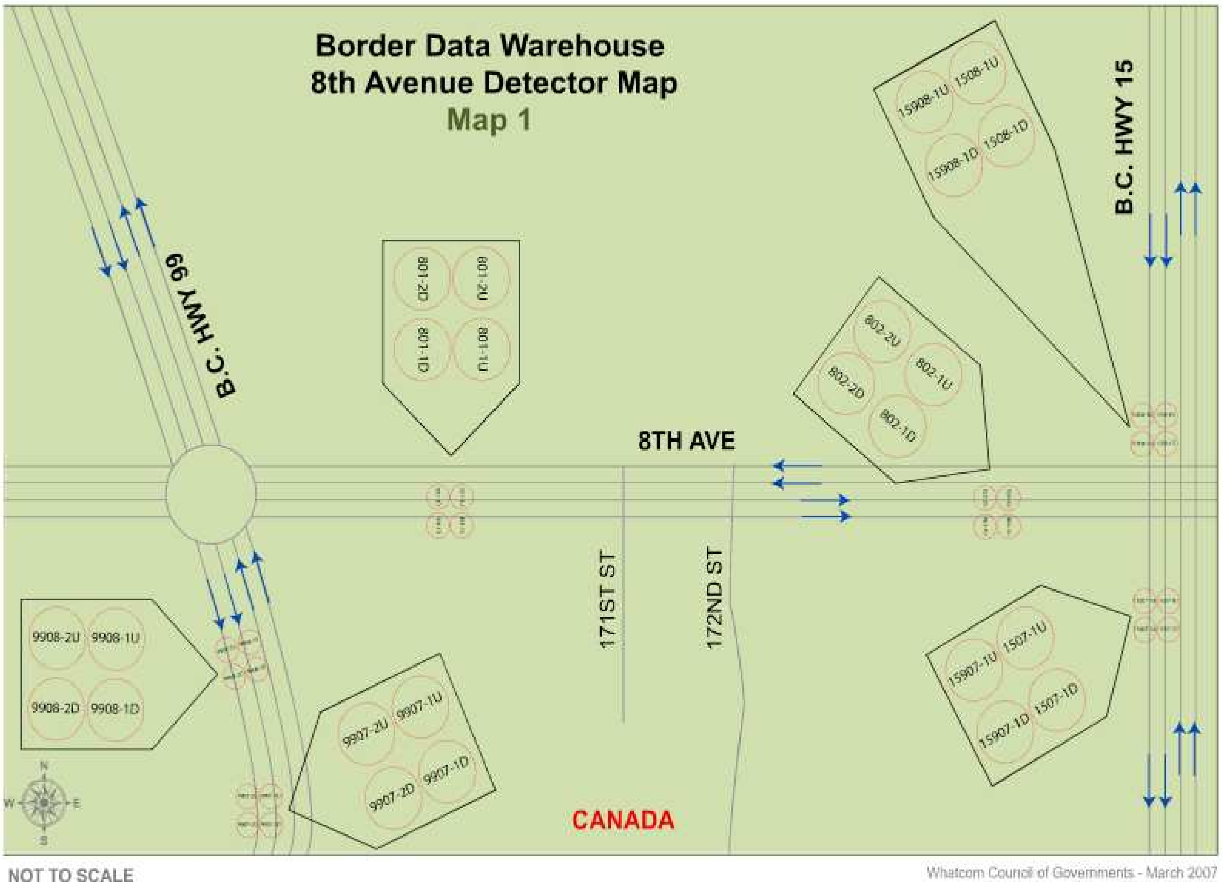

Figure A2: Location of BC MoT loop detectors that detect the most vehicles arriving at the Pacific Highway Border Crossing.

The loop of interest is namely 15-907U, located on the farthest right lane heading southbound on the BC HWY. This figure shows loops over 6000 ft away from the border.

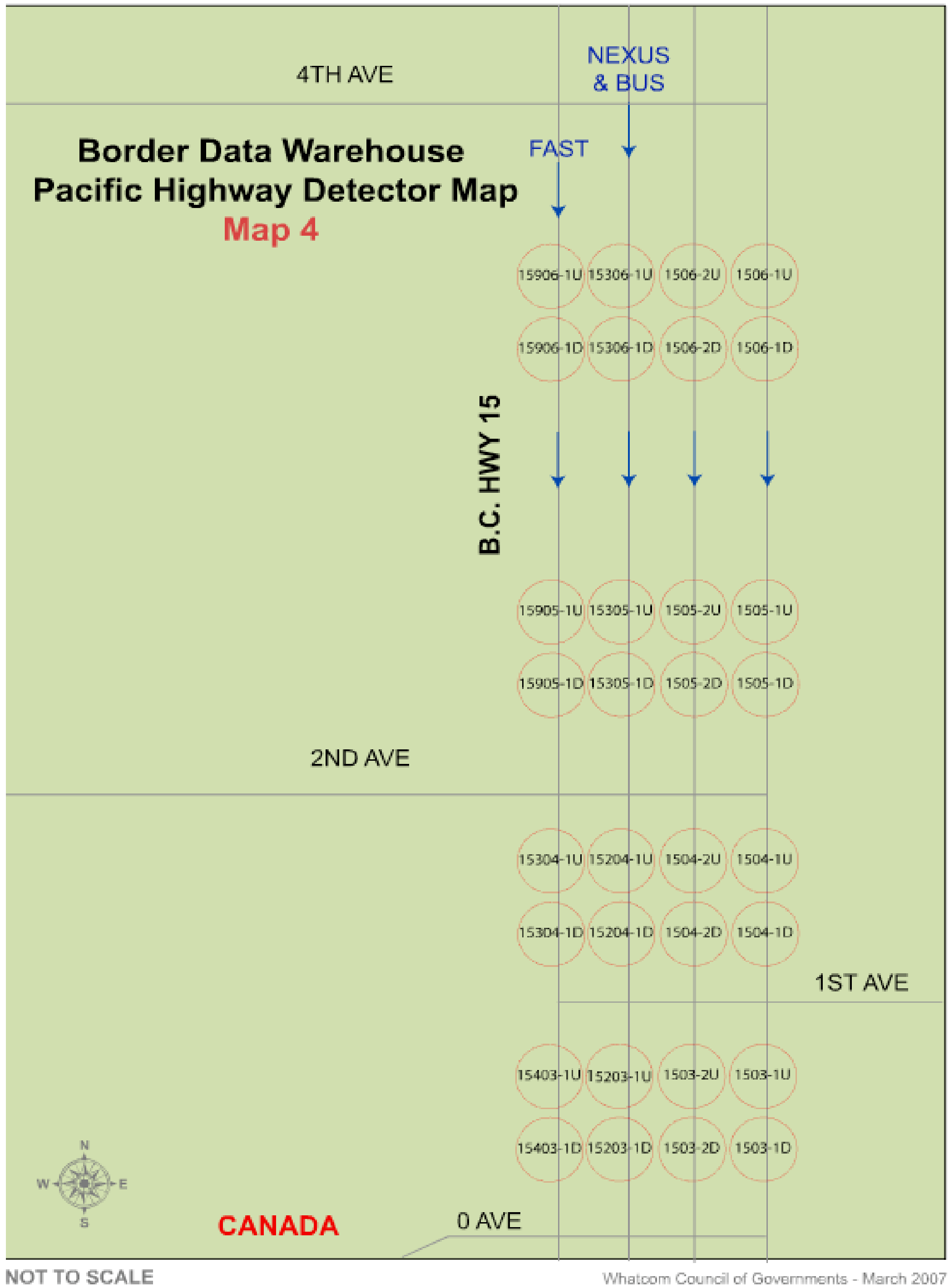

Figure A3: BC MoT loop detectors 15-905 and 15-304 (neither 15-906 nor 15-403 are operating) detect FAST-approved vehicles traveling in the rightmost lane.

This figure shows loops approximately 1500 ft to 2000 ft away from the border.

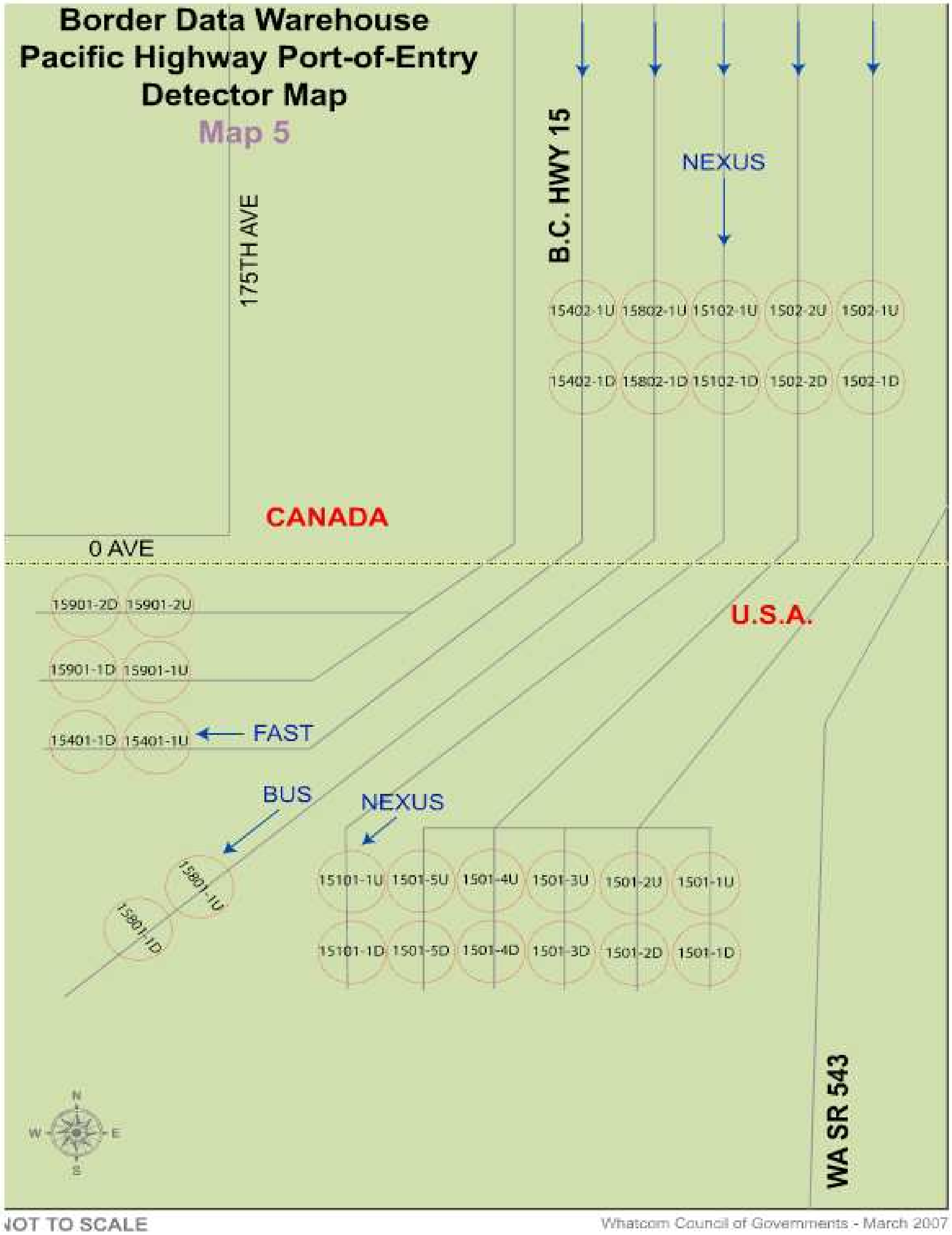

Figure A4: BC MoT loop detectors 15-402 and 15-401 detect FAST approved vehicles traveling along the specified FAST lane.

This figure shows loops approximately 100 ft to 600 ft away from the border. Loop 15-401 is 100 ft from the primary inspection booth.

Appendix 2

- The GPS Freight Carrier Border Delay Data set contains 50,786 usable observations collected between 7/10/05 and 05/12/08
- Within **FAST HOURS** (Monday—Friday 8:00 AM to 8:00 PM) there are **25,037 observations**
- **SOUTHBOUND** there are **19,729 observations** total and **11,281 within FAST hours**

- Tools used for maintenance and analysis:
  - Statistical Software R
  - Microsoft EXCEL

- No observations on the following dates:
  - 08/11/06 – 08/14/06
  - 10/20/06
  - 11/23/06
  - 11/27/06
  - 11/28/06
  - 11/30/06
  - 12/25/06
  - 11/27/06
  - 07/10/07-08/05/07
  - 09/08/07-09/11/07
  - 03/31/08
  - 4/25/08

- Raw text file initially contains columns for [total columns 12]:
  - Resource ID Code
  - Truck Number
  - Manifest Number
  - Consignee Number
  - Consignee Name
  - Arrive Border Date
  - Arrive Border Time
  - Arrive Place
  - Depart Border Date
  - Depart Border Time
  - Depart Place
  - Time at Border

  From these raw data the following fields are added:
  - traveling.direction
    - Traveling direction determined by whether trucks travel between two destinations (places are determined by the GPS):

- North:[S,SW, SSW, SE, SSE] GOODS YARD to [N, NW, NNW, NE, NNE][PACIFIC HWY BORDER, GLOBE GROUND, WHITE ROCK, VANCOUVER, ELGIN] to [S,SW, SSW, SE, SSE] PACIFIC HWY BORDER to [N, NW, NNW, NE, NNE][GLOBE GROUND, WHITE ROCK, VANCOUVER, ELGIN]
- South [N, NW, NNW, NE, NNE][GOODS YARD, GLOBE GROUND, WHITE ROCK, VANCOUVER, ELGIN] to [S,SW, SSW, SE, SSE] PACIFIC HWY BORDER to [N, NW, NNW, NE, NNE][GLOBE GROUND, WHITE ROCK, VANCOUVER, ELGIN] to [S,SW, SSW, SE, SSE] PACIFIC HWY BORDER to

- day.of.arrival
  - day.of.arrival: is the name of a particular weekday
- month
  - month: is the month itself
- date.of.arrival
  - date.of.arrival: is the number of the day of a date
- year
  - year: is the year itself
- season
  - season is defined by: Spring: 3/21 – 6/20, Summer: 6/21 – 9/20, Fall: 9/21 – 12/20, Winter: 12/21 – 3/20
- holiday
  - holidays are:New Year's Day 1/1, Independence Day 7/4, Labor Day 9/7, Thanksgiving 11/26, Christmas 12/25
- quarter
  - quarter:and number to represent a year split into 4 quarters
- num.week.of.year
  - num.week.of.year: there are 0-52 weeks in a year
- miles.from.arrival.place
  - miles.from.arrival.place: is extracted from the intial column of Arrival Place which is the truck's distance from a known GPS location
- direction.arrive.place
  - direction.arrive.place: is extracted from the intial column of Arrival Place which is the truck's distance from a known GPS location that is either [N, NW, NWW, NE,NNE, S, SW, SWW, SE, SEE, E,EN, ENN, ES,ESS, W, WN, WNN, WS, WSS, etc.]
- day.of.depart
  - day.of.depart: is the name of a particular weekday
- depart.total.seconds
  - depart.total.seconds: its depart.border.time converted from hours:minutes:seconds to time in total seconds [seconds are whole numbers making it easier to manipulate when doing analysis]
- miles.from.depart.place
  - miles.from.depart.place: is extracted from the initial column of Arrival Place which is the truck's distance from a known GPS location
- direction.depart.place
  - direction.depart.place: is extracted from the initial column of Arrival Place which is the truck's distance from a known GPS location that is either [N, NW, NWW, NE,NNE, S, SW, SWW, SE, SEE, E,EN, ENN, ES,ESS, W, WN, WNN, WS, WSS, etc.]

- time.at.border
    - time.at.border: its time.at.border converted from the fraction of an hour to time in hours:minutes:seconds
- time.at.border.total.seconds
    - time.at.border.total.seconds: its time.at.border converted from hours:minutes:seconds to time in total seconds [seconds are whole numbers making it easier to manipulate when doing analysis]
- flagged
    - flagged: flagged observations that are peculiar and are named according to the reason why it was flagged
        - Arrival time>departure time
        - Flagging double SB trips or NB trips
        - Delay time>2hrs and 3hrs
        - Duplicates
        - Zero crossing time
    - Duplicates were removed, times less than 10 seconds and more than 6 hours were removed, arrive time greater than depart time were removed.
- inspection.delay
    - inspection delay: type of inspection driver may experience either primary or secondary
        - Definition:primary inspection is a driver only visits the primary booth for an interview or waits in queue. Secondary inspection is all other sources of delay such as VACIS, interface with the FDA, immigration
- ps.time.delay.seconds
    - ps.time.delay.seconds: time in seconds of the difference in time in between two drivers who depart the border
- ps.time.delay
    - ps.time.delay: its ps.time.delay converted from total seconds to hours:minutes

Other Data Set Changes

Adjusting for daylight savings for raw data set

- 2005: 4/3-10/30
- 2006: 4/2 – 10/29
- 2007: 3/11 – 11/4
- 2008: 3/9 – 11/2
- 2009: 3/8 – 11/1
- 2010: 3/14 – 11/7

Hours adjusted for daylight savings

- Spring Forward: so eliminate: 3 hours (10800 seconds)
- Fall Backwards: so eliminate: 2 hours (7200 seconds)