Applying Supply Chain Logistics Modeling to Border Security and Efficiency

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Abstract

The tragic events of 9/11 resulted in an accelerated, substantive increase in cross-border regulations, programs and the application of technologies like Intelligent Transportation Systems (ITS) to address security concerns. The entire length of the supply chain has been identified as a key area where security must be enhanced; indeed, security is currently the highest priority concern in cross-border and international transportation. At the same time, service quality for all users - as well as economic cost to both the transportation industry and public infrastructure providers - must be assessed in light of these expanded security requirements.

Both the public and private sectors must make decisions on the implementation of new security initiatives and investment in enabling information technologies, human resources, infrastructure, and organization changes. The necessary Benefit-Cost and Return on Investment calculations depend very much on the accurate estimation of how process changes impact security, productivity, service and cost. Benefit and cost estimation can be improved through the use of process mapping and simulation models, which can efficiently estimate process change impacts under different regulatory and information technology scenarios. The process mapping approach is especially useful in measuring firm specific impacts on private sector stakeholders and the tradeoffs that may occur in the supply and transport chains moving products across borders.

This paper describes the process mapping of cross-border trucking from Canada into the United States and demonstrates how simulation modeling based on the mapping of the cross-border transport chain can be used to identify and quantify strategic and operational choices in both the public and private sector. The process mapping research is part of a larger program mapping the supply chain of all modes involved in border transportation.

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1. Introduction

The tragic events of 9/11 resulted in an accelerated, substantive increase in cross-border regulations, programs and the application of technologies like Intelligent Transportation Systems (ITS) to address security concerns. The entire length of the supply chain has been identified as a key area where security must be enhanced; indeed, security is currently the highest priority concern in cross-border and international transportation. At the same time, service quality for all users - as well as economic cost to both the transportation industry and public infrastructure providers - must be assessed in light of these expanded security requirements. The new security reality requires all stakeholders to take responsibility for the security of their supply chains and trading partners (Chow, Frank, Gados, forthcoming).

Both the public and private sectors must make decisions on the implementation of new security initiatives and investment in enabling information technologies, human resources, infrastructure, and organization changes. The necessary Benefit-Cost and Return on Investment calculations depend very much on the accurate estimation of how process changes impact security, productivity, service and cost. Benefit and cost estimation can be improved through the use of process mapping and simulation models, which can efficiently estimate process change impacts under different regulatory and information technology scenarios. The process mapping approach is especially useful in measuring firm specific impacts on private sector stakeholders and the tradeoffs that may occur in the supply and transport chains moving products across borders.

This paper describes the process mapping of cross-border trucking from Canada into the United States and demonstrates how simulation modeling based on the mapping of the cross-border transport chain can be used to identify and quantify strategic and operational choices in both the public and private sector. The process mapping research is part of a larger program mapping the supply chain of all modes involved in border transportation (Chow and Liu, 2006).

The current security driven cross-border regulatory environment is presented; in particular, the role of the U.S. Automated Commercial Environment (ACE) - the IT “backbone” used by U.S. Customs and Border Protection (CBP). One specific ITS program under ACE - Free and Secure Trade (FAST) - is designed to facilitate commercial vehicle border crossing. The importance of process mapping, and the simulations that can be developed from it, is then presented. To illustrate this, Canada to U.S trucking processes are presented – with a specific detailed focus on how FAST and non-FAST border clearances work. This leads to how one can simulate the adoption of FAST, and from it calculate the benefits to both efficiency and security for the private and public sector. Finally, future applications of this technique are discussed.

2. The Cross-Border Regulatory Environment

Security regulations dominate post-9/11border initiatives. Stakeholders are now required to take an active role in the security of their complete supply chains. Governments have in essence “contracted” out some responsibility in managing supply chain security to the private sector, partly in hope that the private sector can come up with innovative solutions. This security focus is the new reality - stakeholders cannot take security for granted, nor dismiss it as solely the responsibility of governments. The private sector must undertake due diligence to ensure that their supply chains are secure - including their customers'. This is the philosophy behind the U.S. Customs Trade Partnership Against Terrorism (C-TPAT) initiative. Judging by the rapid expansion of security regulations and programs, this new reality is not receding and must be accepted by industry. Security's importance in the current regulatory environment cannot be overstated (Chow, Frank, Gados. 2006).

For truck movements from Canada to the United States, the most important regulatory programs currently driving security forward are:

- C-TPAT - an agreement on security process. Members of this program sign an agreement with CBP to monitor their supply chain, the security of its users, and make improvements in security whenever necessary, whether through enhancing their own security process or requesting that one of their customers do so;
- ACE - the Information Technology (IT) "backbone" driving, among other things, the mandatory movement towards paperless, advance notice reporting of cargo manifests – just one sub-component of this system;
- FAST - which uses many of the latest ITS approaches. Acceptance under FAST allows commercial vehicle operators to utilize separate truck lanes at border crossings.

These three key programs for the movement of cross-border freight - C-TPAT, which defines the new standards and protocols; the various information system components of ACE; and FAST, the main program to facilitate freight movements at the border - result in a significantly different way of doing business from the past. When used in combination, they present a powerful solution to improving the security of cross-border supply chains (Chow, Frank, Gados. 2006).

2.1 The Automated Commercial Environment (ACE)

Enabling FAST is the Automated Commercial Environment, which promotes automation and increased data collection. ACE originated to add refinement and sophistication to its predecessor, the Automated Commercial System, which was used by the CBP to track, control, and process all commercial goods imported into the United States. It facilitates merchandise processing, significantly cuts costs, and reduces paperwork requirements for both CBP and the trade community. Beyond this, ACE is a blanket approach and strategy promoting automation of data flows in the supply chain. In many cases, the information travel with shipments in the supply chain is just as important as the physical shipment itself.

Automated manifest reporting is one result of the ACE program. Another component of ACE is the Automated Targeting Systems (ATS), which utilizes the power of IT to assist with the identification of suspect shipments. With increased information in electronic, rather than paper form, ACE improves CBP's decision making and productivity, especially since electronic data is available before goods arrive at a border. One of ACE's main components is the Secure Data Portal, a customized web page that provides a single online access point to CBP systems to streamline all current cross-border programs such as BRASS, PAPS, FAST, etc. (CBP 2005).

ACE is run by the U.S. CBP, the U.S. Office of Information and Technology and, for security threats, the U.S. Department of Homeland Security (DHS). The program works directly between shippers, organizations in the supply chain, and customs, or between whoever else sends automated information directly to CBP.

ACE can yield reduced processing time at customs entry ports, compliance with advance cargo reporting, and broker functionality to transfer pertinent information to the entry filler ensuring a match between entry and manifest, status of cargo crew and drivers, conveyance, and equipment via EDI or the ACE Secure Data Portal (US Customs and Border Protection 2005). By participating in the program, brokers and importers receive dynamic analytical tools, access to their automated account on transaction, compliance and financial data. E-manifest and advanced cargo reporting is also part of this initiative (Chow, Frank, Gados, forthcoming).

2.2 The Free and Secure Trade Program (FAST)

While C-TPAT sets the security environment, and ACE provides the information technology foundation required to support it, FAST can be thought of as the key operational manifestation of the new security environment to move freight across land borders. The goal of the Free and Secure Trade program is to facilitate trade between Canada and the United States while enhancing security. FAST aids CBP officials as they have fewer "unknown" carriers to scrutinize. It is still a relatively new program that requires increased acceptance and adoption by industry.

At a land border crossing, this program utilizes a passive RFID (Radio Frequency Identification) transponder card that is posted to the inside of a truck's driver-side window to identify the vehicle and link it to its previously declared contents, shippers and consignees through the ACE system. The transponder is read automatically at the border, is easy to install and requires no power source. To confirm the status of the driver, there is a biometric (fingerprint) driver identification card. The driver identification card is manually checked. FAST members are subject to electronically filed advance reporting (through ACE) of their freight traveling to the United States from Canada.

To participate in FAST, both the carrier and driver(s) undergo security background checks. If they pass, the FAST transponder card is issued. The driver submits all ten fingerprints for the customs database, and when the driver arrives at the customs booth, their identity can be verified via scanning one of their fingers and comparing it to this database. The program is voluntary and the application process requirements/steps include: corporate information and a security profile; then an independent risk assessment is performed; once the assessment is complete, an approval for FAST participation is authorized; and, the FAST transponder card is issued.

For the United States, a FAST approved carrier will have met all aspects of C-TPAT through the FAST registration process. Motor carriers must ensure that all of their employed drivers are in possession of a valid FAST Commercial Driver Identification Card. Carriers participating in FAST have responsibilities to ensure that mechanical security seals are used on all loaded containers or trailers destined for the United States when required, and where appropriate, and must follow ISO/PSA standard 17712.[1] The driver, carrier and importer must all participate in C-TPAT to be eligible for FAST processing (US Customs and Border Protection 2005). Most of the initial approval processing is conducted by CBP. FAST is open to all importers and carriers.

If all the above criteria are met, then the secure motor carrier obtains access to dedicated FAST lanes (see Figure 1) at the land crossings (where already implemented) and expedited shipment clearance. In addition, if there is an extended red threat advisory in the United States only FAST approved shipments may be allowed to cross without a complete physical inspection of each individual shipment.

U.S. Customs and Border Protection

Figure 1: FAST Lane (Hochman 2005) – at Port Huron, MI

This program benefits CBP as it separates low risk shippers from the general freight traffic – allowing resources to be focused on higher risk-profile shipments. In addition, FAST aligns the requirements of C-TPAT and the comparable Canadian programs, providing some simplification and "rationalization" of cross-border programs. The program is voluntary; therefore, the adoption rate of the program by industry is a key metric for its success.

2.3 Impact of These New Border Programs

Perhaps the most striking common feature of most of the post-9/11 regulations and programs is the lack of public analysis regarding their economic or policy implications (Chow, Frank, Gados, forthcoming). For the most part, benefit-cost discussions are extremely sparse in the economic literature or studies available on regulatory topics.[2] Analysis or discussions about policy

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[1] ISO 17712 refers to a cargo seal security standard (Downey, L. K. 2006).

[2] This is a non-trivial economic and policy matter. Even before 9/11, delays for the trucking industry were cited as the central source of costs associated with the border. Since approximately 70% of Canada-U.S. trade travels by truck, trucking provides a vital link to businesses and the economy. A one hour delay was found to cost about $40 for the truck and driver alone. With an average delay of 30 minutes multiplied by the 14 million trucks that cross the border each year, this amounts to an annual cost of $280 million to the trucking industry alone. In addition to

implications are even more non-existent. Examination of stakeholder impacts, at least for transportation service providers, lies somewhere between these two extremes. For some regulations, there is fairly significant discussion of stakeholder impacts. For others, there is next to nothing. There is extremely little review of the impacts on shippers in the public literature. Process mapping and simulation of these programs provides answers to some of these questions. This is demonstrated for FAST since it is an ITS application with the duo goals of enhancing both the security and efficiency of cross-border freight movements.

3. Process Mapping and Simulation Modeling for Cross-Border Transportation

Process mapping is a commonly used method for designing and analyzing processes. A process map is essentially a visual aid for picturing work processes, which show how inputs, outputs and tasks are linked. It is a simple yet powerful method of looking beyond functional activities to understanding system relationships between the activities and information flows.

Process mapping involves the mapping of the "As Is" state that defines how the work is currently being performed and a "To Be" state that defines a new level of performance that can be achieved via process redesign. An enabler, such as new information technology, intelligent transportation systems, regulations and policies, or organizational change, is generally needed to make the new process possible.

Once a detailed process map exists for a complete process, the stakeholders can:

- Better understand how processes interact in a complete systems;
- Locate process flaws that are creating systemic problems;
- Evaluate which activities add value for the customer;
- Mobilize and focus resources to streamline and improve processes; and,
- Identify processes that need to be reengineered.

Process mapping is a natural task preceding simulation modeling and analysis, which can be used to help estimate the benefits and costs of changes in border related processes, changes in regulations or policy, changes in the types of technology (in particular, ITS) that are utilized, and the participation rate by users of different technologies or programs. This will help justify the costs incurred in making a decision to improve the system productivity and/or prioritize the order of enhancements. Advanced computer simulation modeling is an important decision-making tool that allows us to understand and visualize the impacts of the change and the costs prior to implementation. Given the complex nature of many supply chains, simulation modeling is one of the few approaches that can capture the dynamic nature of the system in a realistic and useful manner. Simulation modeling provides its users with the opportunity to determine the effects of specific changes under consideration for one part of the supply chain on other individual supply chain "links" and on overall supply chain performance. It can also help avoid costly errors in implementation.

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this, trucking companies must, directly or indirectly, bear the penalties of late deliveries (Ontario Chamber of Commerce Borders and Trade Development Committee 2004)

One survey of post-9/11 impacts states that the cost to the Canadian trucking industry due to the changes in U.S. border security measures ranges from \$179 million to \$406 million per annum (DAMF Consultants Inc. and LP Tardiff & Associates Inc. 2005).

Process mapping and simulation are the tools being utilized in several projects in process or completed. These include, but are certainly not limited to:

- The U.S. Department of Transportation documentation of end-to-end supply chain processes to accurately capture their inter-modal productivity attributes (Onder 2004);
- The mapping of the Mexico to U.S. border transportation processes (Ojah 2002);
- The development of high level process maps which illustrated the typical Canadian Customs and Revenue Agency (now Canada Border Services Agency) and U.S. Customs (now CBP) clearance processes, and provided detailed descriptions of each of these processes (IMTC 2003);
- Process mapping of the CVO Data Clearinghouse/Brokerage Facility and simulation to demonstrate the capability of intelligent transportation systems technology to speed up both commercial vehicles and commuter international border crossings in an operational environment (MacDonald and UBC 2005).

Process maps have also been developed for Canada-U.S. cross-border truck and international freight movements (Chow and Liu 2006). The process mapping project began with a single mode of transport, trucking, and eventually expanded to mapping freight movement by all modes of transport. The individual mode process maps are modular and can be combined to form inter-modal transportation combinations such as ocean-truck or truck-rail-truck with the addition of the mapping of interface processes between the modes. The process maps of the stakeholders in the cross-border supply chain can be linked with both the domestic Canadian ITS architecture and with the Border Information Flow Architecture (BIFA) to identify potential information linkages that support the efficient and secure movement of freight across borders. These process maps can also provide a bridge between public information architectures and the private information architectures of logistics service providers and freight shippers. Finally, the process maps are the basis for simulating the impact of operational changes in the supply chain, proposed legislation, rule or policy changes, or the utilization of new information technology and ITS. The simulation modeling can be used to analyze multiple scenarios including different security regulations, different information technology and ITS applications, and different rates of compliance to regulations or adoption of programs.

4. Canada to U.S. Trucking Processes

Trucks moving from Canada across the border into the United States undergo an intricate process involving many departments and regulatory steps. This section outlines how the process maps describing this were produced, what the “top level” and “sublevels” are, as well as explains some detailed steps involved in the process so as to give a thorough understanding of this approach. For these detailed process maps, effective simulations can be developed to determine the benefit-cost of various possible process changes.

4.1 Overview

The process of transporting freight from the Canada to United States was mapped based on an extensive literature review of processes to be modeled and field visits to collect process information for micro level mapping. Feedback and review from industry was used to validate the accuracy of the process mapping (Chow and Liu 2006).

All truck freight movement processes were classified at the top level detail into three sub-processes, Outbound Transportation (from Canada), Border Clearance, and Inbound Transportation (into the United States) as illustrated in Figure 2.

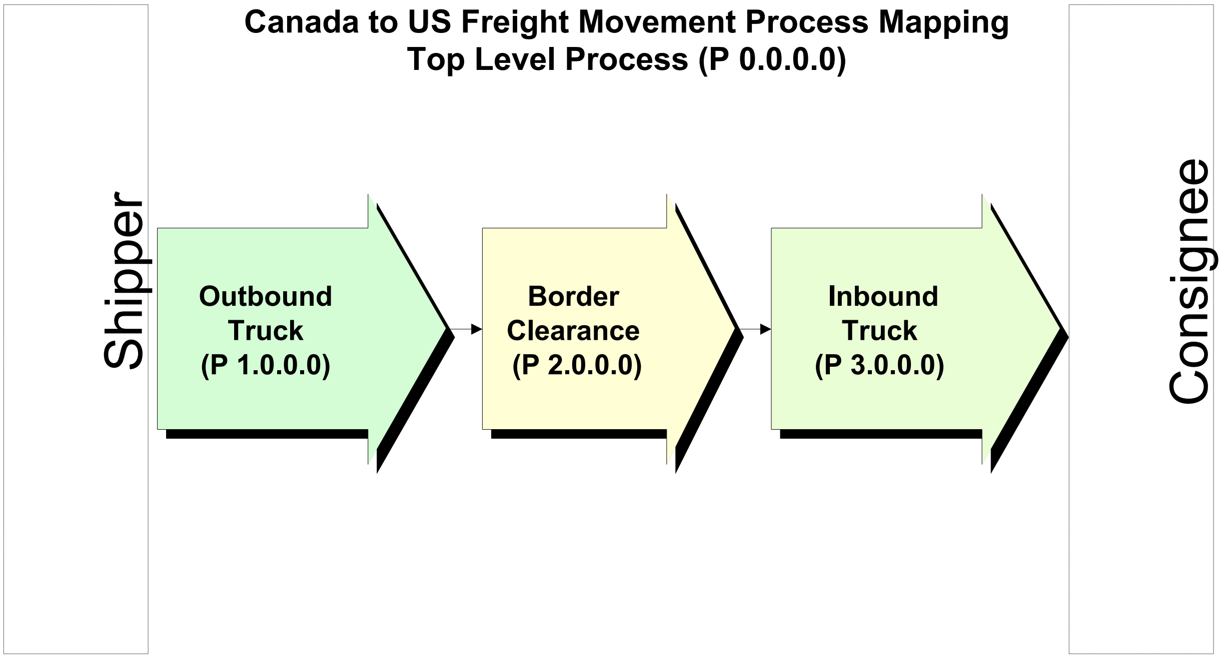


Figure 2. Canada-US Freight Movement Process Mapping (Top Level)

The process charts are displayed in increasing detail for each sub-process before proceeding to the next equal level process. The next level of detail for each of these sub-processes is shown in Figures 3, 4 and 5.

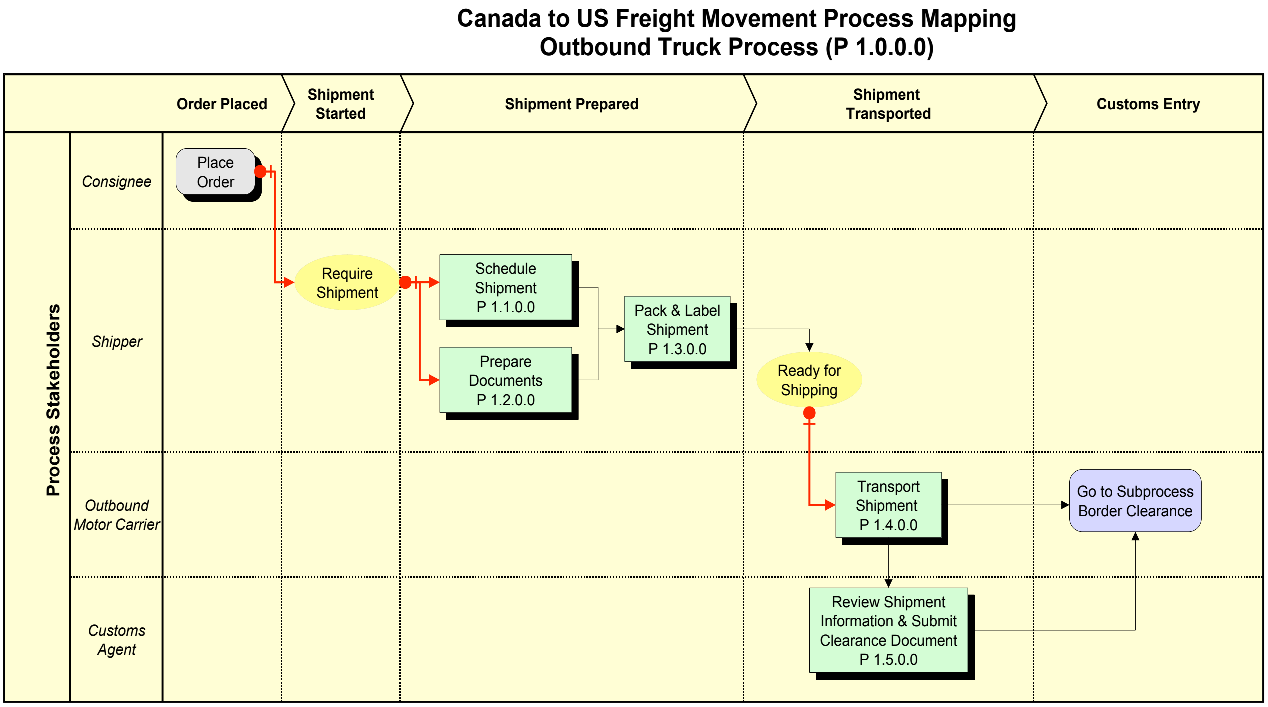


Figure 3. Outbound Truck Process (Sublevel)

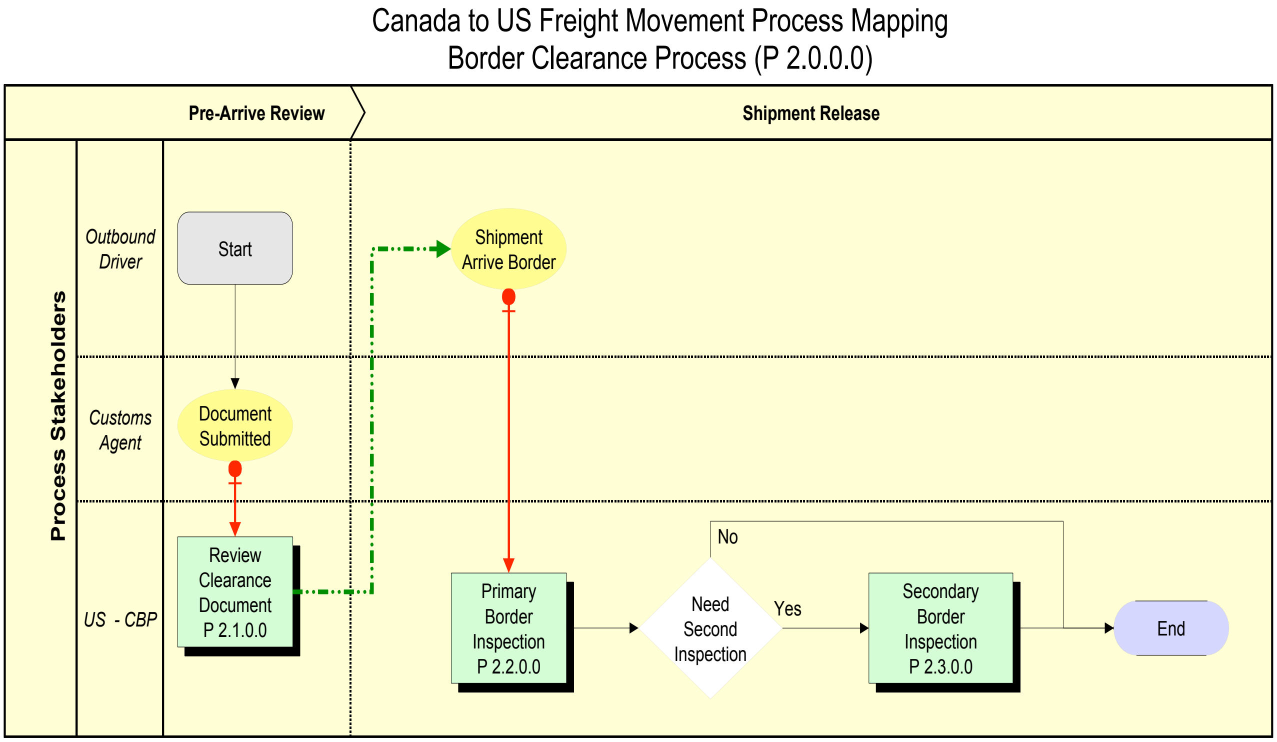


Figure 4. Border Clearance Process (Sublevel)

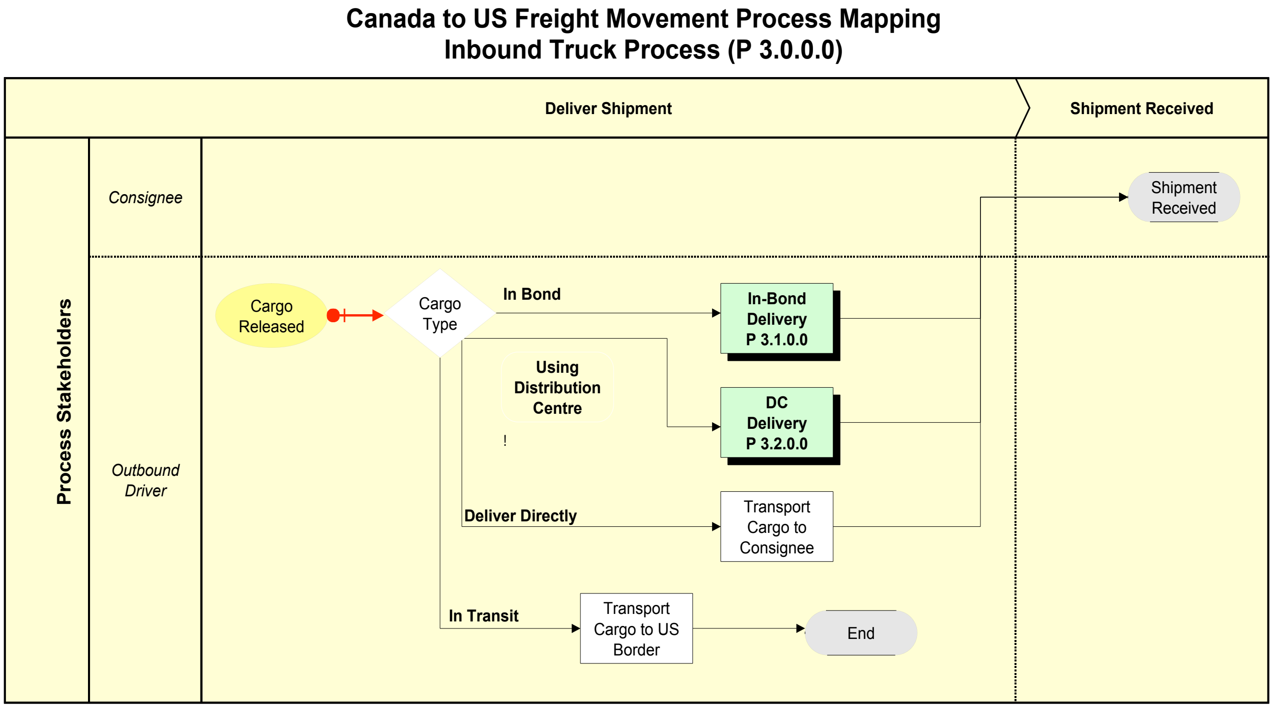


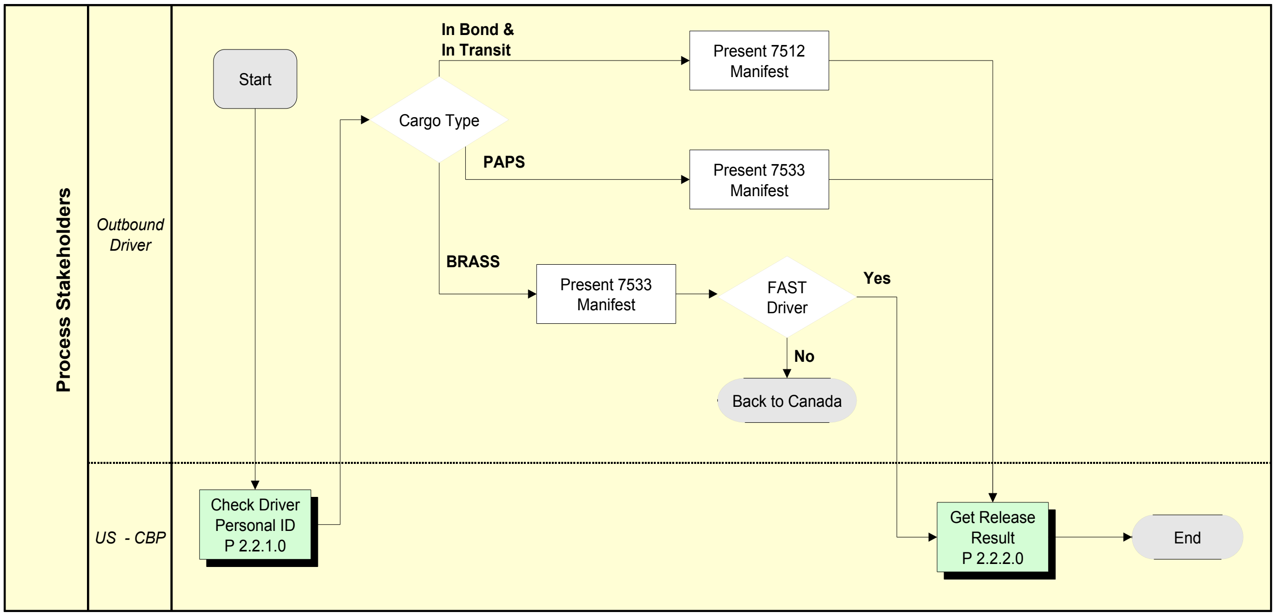
Figure 5. Inbound Truck Process (Sublevel)

4.2 FAST versus Non-FAST Border Processes

Within the Outbound Truck Transportation Process (P 1.0.0.0) a shipper can choose to be FAST certified and can choose a FAST certified carrier. The focus is now on border processes where these decisions impact the speed and economy of trans-border truck movements.

For non-FAST freight, the clearance documents must be submitted to the U.S. CBP one hour before the freight arrives at the border. For FAST freight, the clearance documents must be submitted electronically 30 minutes before the freight arrives at the border. CBP reviews the documents. When the freight arrives at the border, it will be inspected at the primary border inspection booth. Depending on the primary inspection results, some of the freight will require secondary inspection. This is illustrated in Figure 4.

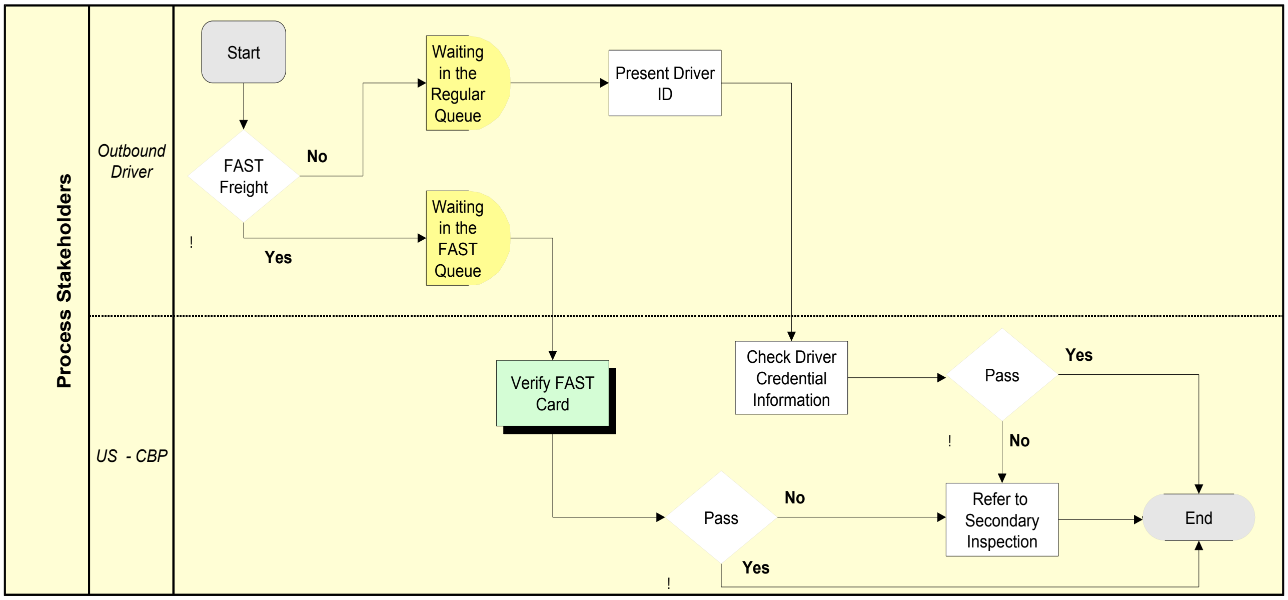
When the driver arrives at the primary inspection booth, the inspector first checks the driver's identification. The driver also needs to present the customs clearance documents – usually prepared by a customs broker. If the shipments are In-Bond or In-Transit, the driver presents a 7512 manifest. If the shipments are under the Pre-Arrival Processing System (PAPS), the driver presents a 7533 manifest. If the shipments are under Border Release Advanced Screening and Selectivity (BRASS), the driver must be a FAST accredited driver and present a 7533 manifest. The CBP Inspector obtains the release results as illustrated in Figure 6. For clarity, it is assumed in the simulation demonstration below that the freight is not traveling in-bond or in-transit but is clearing at the border for delivery to final destination in the United States.



Canada to US Freight Movement Process Mapping
Primary Border Inspection (P 2.2.0.0)

Figure 6. Primary Border Inspection (Sublevel)

If the freight is FAST qualified, the driver waits in the FAST lane. If not, the driver waits in the regular lane. The U.S. CBP inspector verifies the driver's FAST card, and checks the driver's credential status. If the driver does not pass the verification, the truck proceeds to secondary inspection as illustrated in Figure 7.



Canada to US Freight Movement Process Mapping
Check Driver ID (P 2.2.1.0)

Figure 7. FAST Verification

If the drivers in the FAST lane do not have the FAST card, the inspector has the discretion to send the vehicle to the back of the regular truck lane. The driver presents the FAST card; the inspector swipes the FAST card, and pulls out the credential information from the Commercial Vehicle Information System Network (CVSN). The inspector checks the driver photo on the screen (See Figure 8). If there is no problem, the truck proceeds to the next step. Otherwise, the driver goes to secondary inspection as shown in Figure 7.

Canada to US Freight Movement Process Mapping
Verify FAST Card (P 2.2.1.1)

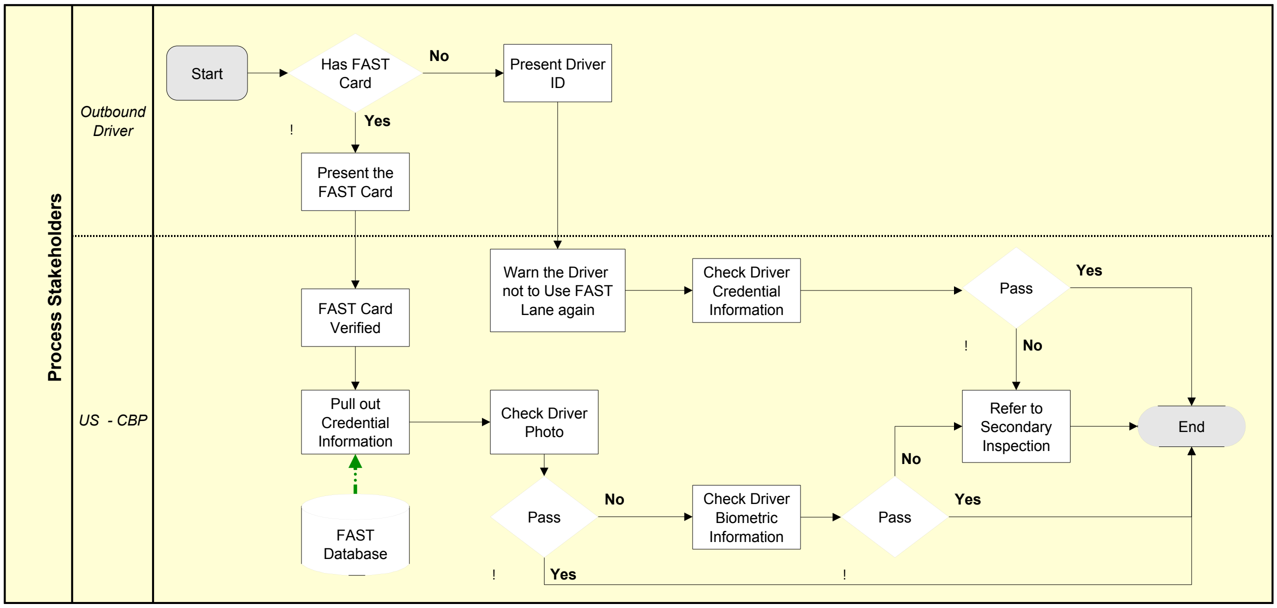


Figure 8. Verify FAST Card

The detailed process map of FAST can now be converted into a simulation model to help quantify under various scenarios the impact of this ITS application to the security and efficiency of cross-border freight movement versus the traditional non-FAST process.

5.0 Simulation of FAST Adoption

Once a process has been described in detail using process mapping, software such as iGraphx or Arena can be used to develop a simulation model based on the physical flow of goods through the process. This simulation is populated with expected or actual data observations. From this, several outputs are calculated for the various scenarios examined. These outputs are then used to calculate savings/costs to the various stakeholders in the process. Essentially, simulation modeling converts a “static” description of a process into a tool that can answer “what if” questions (Anupindi, Chopra et al. 2006).

5.1 Simulation Methodology

Applying this specifically to the FAST versus non-FAST land border clearance situation, there are two key independent input variables – the arrival of trucks at the border and what percent of them are eligible to use the FAST lane. The arrival of trucks can be actual individual observed events, however, rate of truck arrival for various times of the day can be used as a good approximation. The percent of FAST approved trucks is best determined through field interviews – the current level and expected realistic future adoption rates for this voluntary program. Referring to the process map in Figure 7, this represents the traffic between the "Start" and the "FAST Freight" decision point, and the percent "yes" versus "no" at the "FAST Freight" decision point, respectively.

The two key "cost" pieces of information required are the amount of time spent at primary inspection for FAST and non-FAST vehicles. The difference between these two is the amount of security labour resources per inspection that can be freed up for other security related activities – a measurement of one component of the ability of FAST to enhance security. Multiplying the primary inspection time savings by the total FAST inspections provides a labour unit measure of enhanced security. The amount of wait time spent in the FAST versus non-FAST queue is calculated by the simulation software. The difference between these is a key measure of improved efficiency that is captured by the trucking industry. This time can then be multiplied by the FAST traffic volumes and by the cost to the industry for wait time.

The above presents the mechanics of the simulation. The other critical aspect to this approach is ensuring that a complete range of scenarios is examined. The two key independent variables can differ greatly depending on time of day and which particular land border crossing is being simulated. Table 1 presents a range of alternative scenarios that all need to be examined to completely answer benefit-cost questions related to the FAST process (Clark 2006).

Table 1. Possible FAST Scenarios

Adoption Rate (%)	Frequency of Arrival (Trucks/Hr)				
			Low	Med	High
	Zero	Scenario 1			
	Low		Scenario 2	Scenario 3	Scenario 4
	Med		Scenario 5	Scenario 6	Scenario 7
	High		Scenario 8	Scenario 9	Scenario 10

Some of the questions answered by the various scenarios include:

- Scenario 1: This is the base case – no FAST lane. This simulation provides the estimate of security labour used and wait time cost for industry – both of which the goal of FAST is to improve. This can be compared with actual staffing levels and studies identifying wait times at border crossing to ensure the base simulation is accurate;
- Scenario 2: Low traffic volume and low FAST adoption rate. Running simulations with data reflecting these conditions provides insights into the benefits-costs and feasibility of running FAST lanes at low volume border crossing or low truck volume times of day.

These measurements would assist policy development about trade efficiency issues – is it worth a large expansion of FAST to facilitate trade even under low traffic conditions?;

- Scenario 6: Medium traffic volume and medium FAST adoption rate. These simulations answer questions such as "what adoption rate and at what truck traffic volume is required to ensure a positive benefit-cost from the FAST program" and "what level of promotion and education is required to obtain an adoption rate that ensures positive results from the FAST program"?;
- Scenario 10: High traffic volume and high FAST adoption rate. With simulations focused in this area, optimization of items such as the number of truck crossing lanes and staffing levels can be addressed to further refine the FAST process.

This is just a sampling of the operational and policy issues that can be better addressed by apply process mapping and the resulting simulation modeling to border programs designed to enhance both the efficiency and security of international supply chains.

5.2 FAST Simulation Model Demonstration with Artificial Data

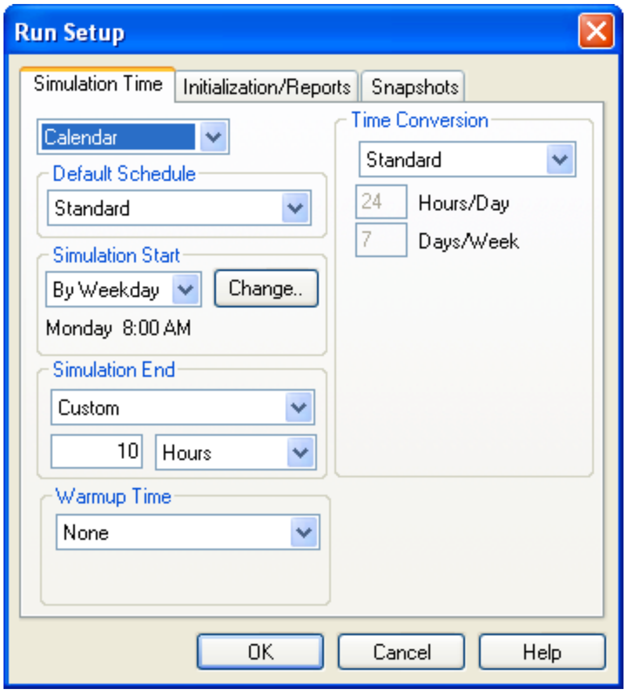
To demonstrate how a simulation is run, the process map is populated with artificial data that was determined to be realistic. This is the first step in producing results which will eventually aid in future decision making of the program. Table 2 shows the results for running an initial simulation on Scenarios 1, 3, 6, and 9. In order to run this sample model, the following assumptions were made:

- Inter-arrival Time: 0.5 – 1.5 minutes (Normal Distribution/ Medium Traffic)
- Regular Inspection Time: 1 minute
- FAST Inspection Time: 30 seconds

- Scenario 1: Without FAST Lane
- Scenario 3: 10% Trucks using FAST Lane
- Scenario 6: 30% Trucks using FAST Lane
- Scenario 9: 50% Trucks using FAST Lane

Next, the simulation environment was described. To describe the simulation environment, information is specified in multiple dialog boxes, the collection of which is called a Scenario. The first four elements in the scenario include:

1. Run Setup: Run Setup allows set simulation timing and defines how the results of simulation are placed in a report. The simulation time is set to be from 8am to 6pm on Monday. The time duration is 10 hours.



Calendar

Default Schedule: Standard

Simulation Start: By Weekday Change..

Monday 8:00 AM

Simulation End: Custom

10 Hours

Warmup Time: None

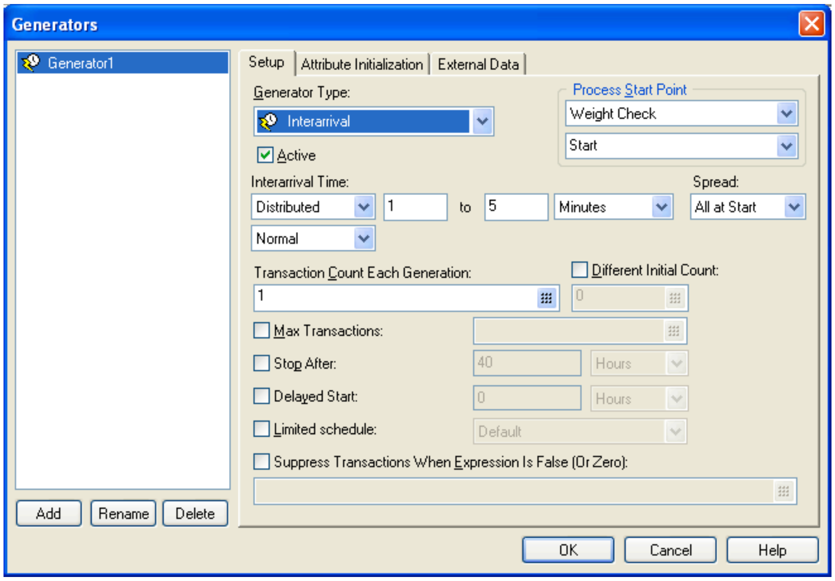
Time Conversion: Standard

24 Hours/Day

7 Days/Week

Figure 9. Run Setup

2. Generators: During simulation, generators create (generate) transactions and introduce them into the process. It is assumed that the trucks' inter-arrival time is normally distributed. Since this is only an example, the Normal Distribution is selected for convenience. The user could select other distributions such as the Exponential Distribution. Only one non-FAST and one FAST lane is assumed. If the data is available, the actual distribution of vehicles can be used by the model.



Generator1

Generator Type: Interarrival

☑ Active

Process Start Point: Weight Check

Start

Interarrival Time: Distributed 1 to 5 Minutes

Normal

Spread: All at Start

Transaction Count Each Generation: 1

☐ Different Initial Count: 0

☐ Max Transactions:

☐ Stop After: 40 Hours

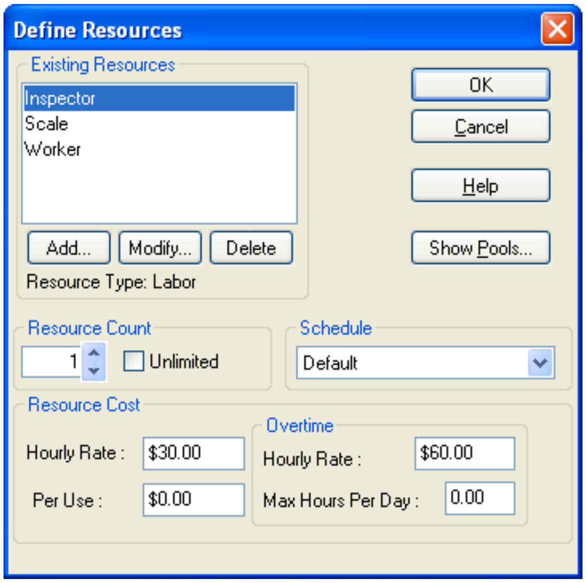
☐ Delayed Start: 0 Hours

☐ Limited schedule: Default

☐ Suppress Transactions When Expression Is False (Or Zero):

Figure 10. Generators

3. Resources: Resources are used at activities to execute transactions. In this example, there is one inspector for each lane at a cost is $30 per hour each.



Existing Resources
Inspector
Scale
Worker
Resource Type: Labor
Resource Count: 1 ☐ Unlimited
Schedule: Default
Resource Cost
Hourly Rate : $30.00
Per Use : $0.00
Overtime
Hourly Rate : $60.00
Max Hours Per Day : 0.00

Figure 11. Define Resources

4. Calendars (Schedules): Schedules are spans of time. Times are either active or inactive. There are several built-in schedules. It is assumed inspectors work from 8am to 6pm. For simplicity, is is assumed there is no break time.

After defining the scenario data, the simulation is ready to run. Simulations run in one of two modes:

- **Run:** The simulation runs in the background. This is the faster of the two modes, but it is not interactive;
- **Trace:** This mode is a simple form of animation. The movement of transactions can be visually tracked. This is the slower of the two modes, but one can interact with the model.

The Report Window automatically opens each time a simulation completes. The window contains the statistical results of the last simulation run.

The simulation report consists of the following categories of statistics:

- **Time:** Contains statistics that measure time during the simulation. Statistics show overall transaction times, and times categorized by department, process, and activity;
- **Cost:** Contains statistics about costs related to transactions, activities and resources;
- **Resources:** Contains statistics related to resource utilization, resource time categorizations, and activity and resource costs;
- **Queue:** Contains statistics collected when transactions waited for processing at activities. Transactions may queue due to resource, inputs collection, or other constraints;
- **Custom:** This page can be used to create a custom page of statistics. It is possible to define new statistics that appear on this page, or copy and paste statistics from any of the other pages to this page.

Once the base values are inputted into the process map, the follow results are produced:

Activity Statistics (Minutes) without FAST Program

	Count	Average Waiting Time	Max Number of Waiting	Max Waiting Time	Stdev Waiting Time
Regular Waiting Time	479	25.35	55	85.5	21.56
FAST Waiting Time	0	N/A		0	N/A

Activity Statistics (Minutes) 10% Trucks using FAST

	Count	Average Waiting Time	Max Number of Waiting	Max Waiting Time	Stdev Waiting Time
Regular Waiting Time	465	9.19	15	42.17	7.45
FAST Waiting Time	54	0.17	1	0.17	0

Activity Statistics (Minutes) 30% Trucks using FAST

	Count	Average Waiting Time	Max Number of Waiting	Max Waiting Time	Stdev Waiting Time
Regular Waiting Time	374	0.13	1	1.08	0.19
FAST Waiting Time	160	0.17	1	0.17	0

Activity Statistics (Minutes) 50% Trucks using FAST

	Count	Average Waiting Time	Max Number of Waiting	Max Waiting Time	Stdev Waiting Time
Regular Waiting Time	121	0.04	1	0.75	0.14
FAST Waiting Time	122	0.17	1	0.17	0

Table 2. Simulation results for Scenarios 1, 3, 6, and 9

For Scenario 1, the average waiting time was 25.35 minutes. This is when no FAST trucks are going through the border. For the subsequent scenarios, it is interesting to note that not only is the waiting time for Non-FAST minimal, the waiting time for Non-FAST trucks is also significantly reduced. As the number of FAST trucks increase, it helps to decrease the traffic in the Non-FAST lane achieving additional benefit for industry.

Finally, if a cost of $40/hour is assumed, a savings of $10.77 per truck per hour can be calculated from Scenario 2: (25.35min – 9.19min) / 60min/hr * $40 = $10.77/truck/hr for Non-FAST companies. For FAST compliant trucks, a savings of $16.79 is achieved: (25.35min – 0.17min) / 60min/hr * $40 = $16.79/truck/hr. As this initial rough simulation demonstrates, the addition of a FAST lane with even a small adoption rate of 10% provides significant cost savings to both FAST and Non-FAST companies.

6. Future Applications of Process Mapping and Simulation Models

The process mapping and simulation modeling technique outlined above can be applied to a number of international supply chain processes with an aim to explore ways of achieving the goals of enhancing freight security and efficiency.

6.1 Populate FAST Simulation Model with Real Data

The framework outlined in this paper makes this an obvious follow-up research project. Preliminary results of this will be presented at the Transportation Association of Canada's 2006 annual meeting.

6.2 Expansion of Modeling to Cover Wider Range of Processes

The cross-border trucking process maps that have been developed clearly identify the interaction between the wide variety of processes and programs that impact freight movements at the Canada-U.S. border. Obviously, there are interactions between these various processes that have not been explored. The FAST simulation should be expanded to cover more of ACE, various types of freight, and the different types of inspections that can occur at the border.

6.3 Include Other Possible ITS Applications Near or Away from the Border

A key factor behind the security and efficiency of international freight movements is the collection, transmission and analysis of accurate data. Data is also the backbone of today's emerging intelligent transportation systems. The application of a wider range of ITS to facilitate border operations should be explored.

For example, weigh-in-motion plays a role in data collection and confirmation. When a U.S. CBP Inspector verifies the driver's ID, the U.S. Border Inspection Administration System requests the driver verification information and safety screening information from Washington State Department of Transportation's CVIEW system. U.S. or Canada weight check process could provide the driver safety screening result to the CVIEW system. This could be linked to reduce the need for weight inspection on both the U.S. and Canadian side of the border – enhancing the efficiency of the cross-border supply chain. In addition, if this information was linked to ACE, real time truck arrival data could be supplied to border facilities to provide advance notice of peaking problems. This opportunity to expand ITS applications in border processes should be explored through simulation modeling.

6.4 Inter-Modal Transport Chains

The transborder truck process mapping is part of a larger research project to develop process maps of each mode of transport involved in international and cross-border transportation. For example, a companion project is to map the movement of freight by air cargo from Asia to Canada (Vancouver). The scope of the process mapping for cross-border trucking (completed) is illustrated in Figure 12 and the scope of the process maps for international air freight between Asia and Canada is illustrated in Figure 13.

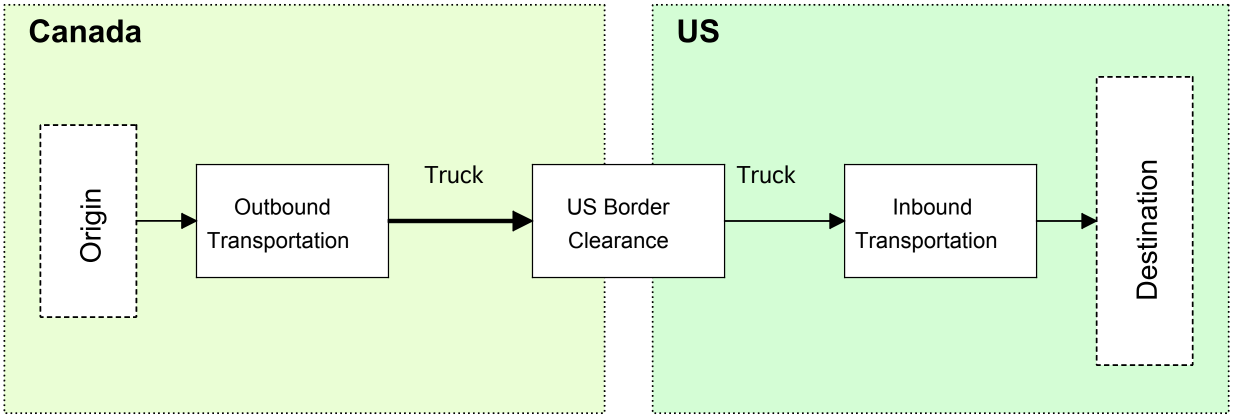


Figure 12. Truck Process Mapping-Scope.

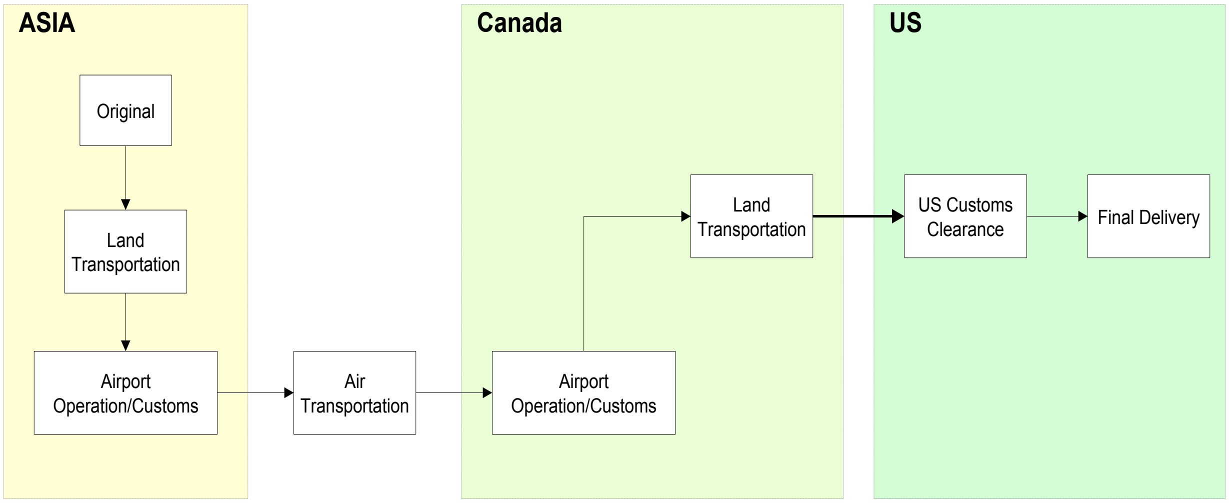


Figure 13. Combining Air and Truck Process Mapping-Scope.

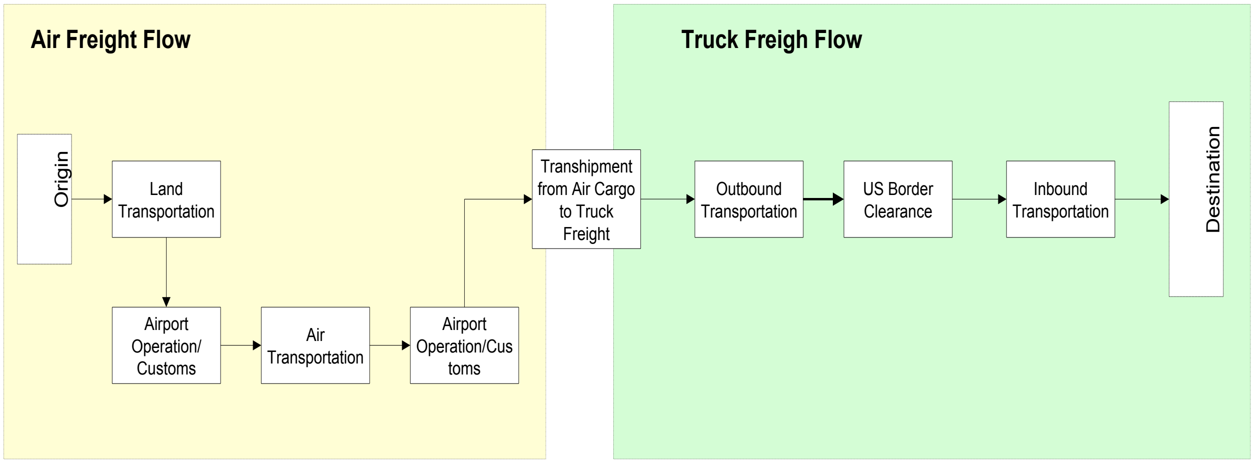


Figure 14. Need to Model the Air-Truck Interface.

The air freight and truck process maps can be combined to model the international and inter-modal movement of freight through the Vancouver gateway to North America. The development of inter-modal process maps requires the modeling of the interface between air freight movement and truck freight movement as illustrated in Figure 14. A similar process can be performed for combining truck and rail, truck and marine and rail and marine to model the complete inter modal transportation environment.

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