IMTC Simulation Modeling of Commercial Vehicle Processing at the Pacific Highway Land-border Port of Entry

Phase 1 Technical Memo

Prepared by:

Whatcom Council of Governments

For:

Transport Canada

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Introduction and background

WCOG & IMTC

This report has been completed by the Whatcom Council of Governments (WCOG), the U.S. metropolitan planning organization (MPO) for the Whatcom County metropolitan planning area (MPA), based in Bellingham, Washington. The northern border of Whatcom County is also the Canada-United States border and includes five international land-border ports of entry (POEs). Since 1997, WCOG has been the lead agency of the binational, regional, cross-border planning coalition, The International Mobility and Trade Corridor Program (IMTC). The regional set of border crossings connecting Whatcom County and Lower Mainland British Columbia is collectively referred to as the Cascade Gateway.

Discrete Event Simulation Modeling and Cross-border Transportation

Exploring impacts of operation changes

In 2011 it had become increasingly clear in the Cascade Gateway that too much road capacity and inspection-booth capacity (one of three commercial booths at Pacific Highway) was being exclusively allocated to trucks in the U.S. & Canada's Free and Secure Trade (FAST) programs. U.S. Customs and Border Protection (CBP) wanted to explore the operational impact of eliminating the dedicated approach lane (on BC Highway 15) for trusted trader (FAST program) trucks. The IMTC forum had recently been briefed on research undertaken by the Border Policy Research Institute at Western Washington University (BPRI) that used discrete event simulation modeling to evaluate congestion pricing scenarios for cross-border truck traffic. CBP was very interested in using these same tools to assess the feasibility of alternatives for managing FAST program traffic.

Applying simulation modeling

Over the following year, WCOG, BPRI, CBP, and the B.C. Ministry of Transportation and Infrastructure (BC MoTI), along with other IMTC participating entities, conducted data collection, field tests, and simulation modeling to inform a subsequent shift in approach lane routing, arrival-plaza queuing and metered release in BC, and primary inspection resource allocation. The process and outcomes of this multi-agency collaboration delivered a much-improved operation and illustrated the value of discrete event simulation modeling for informing policy and operations.[1]

> Modeling FAST program alternatives in 2011 supported multi-agency consensus to make policy changes and corresponding investments to optimize traffic operations

[1] Two documents (of many) that describe this work include Professor Mark Springer's Regional Freight Capacity Management: Free and Secure Trade (FAST) Program Optimization at the Pacific Highway, Southbound Crossing (BPRI 2011) and BPRI's 2011 Pacific Highway Southbound FAST Lane Study: Final Report.

In 2014, with consensus of IMTC participating agencies and funding from the U.S. Federal Highway Administration (FHWA) and the B.C. Ministry of Transportation and Infrastructure (BC MoTI), WCOG initiated the Dynamic Border Management Project (DBM). This project was centered around the acquisition of a simulation modeling software and application of this software to three border-operations scenarios: Radio frequency identification (RFID) travel-document strategies, simulation of border wait-time system modifications, and optimization of primary inspection booth allocation and scheduling between standard-vehicle and NEXUS trusted-traveler operations. With input from IMTC partner agencies, WCOG purchased the discrete event simulation software ExtendSim.

Since 2014, WCOG staff has received numerous trainings for the simulation software, including recently completed advanced training in simulation model structure and data integration. WCOG has continued to use simulation software for more recent evaluations of proposed booth additions and wait-time changes expected to result from continued growth in the NEXUS traveler population.

Advancements in Commercial Vehicle Inspections

Non-intrusive inspection

As an alternative to physically opening and off-loading vehicles, US CBP and Canada Border Services Agency (CBSA) often use non-invasive inspection (NII) devices to generate digital imaging of vehicle composition and contents. Such inspections are typically done after primary inspection if additional questions or risk factors arise. NII systems such as the Vehicle and Cargo Inspection System (VACIS) have typically used high energy gamma radiation and thus required controlled spaces and procedures to prevent radiation exposure to drivers and inspection staff. More recently, lower energy systems have been developed which remove these risks thus allowing drivers to remain in vehicles during scans. This greatly reduces the time needed to perform NII scans.

Pre-primary inspection screening

On both the U.S.-Mexico border and U.S.-Canada border, CBP has been implementing various operations to gather needed information *before* a truck arrives at the primary inspection booth. This is done both to improve security and reduce overall processing time. On the Mexican border, NII scanners have been placed in the lead up to primary inspection where there is available space within the CBP operational footprint.

Pre-primary inspection activities on the U.S.-Canada border have thus far been limited to the Peace Bridge border crossing between Fort Erie, Ontario and Buffalo, New York. At Peace Bridge, where CBSA and CBP lease their facilities from the Buffalo and Fort Erie Public Bridge Authority, CBP has partnered with the authority to install various elements of pre-inspection on the Canadian side of the bridge in plaza space that the authority owns. The array of vehicle and driver data collection systems that have been placed in this pre-inspection environment includes license plate readers (LPRs), facial recognition cameras, radiation portal monitors

> The PARE project at Peace Bridge, which is testing several technology-based pre-primary strategies, also illustrates how the physical and institutional makeup of a port-of-entry influence the feasibility of specific strategies. Modeling helps forecast feasibility and system performance as well as estimate the impact of policy changes if options exist.

(RPMs), Decal & Transponder Online Procurement System (DTOPS) readers, and RFID scanners (for FAST driver cards). CBP continues to evaluate the Peace Bridge installations under the Pre Arrival Readiness Evaluation (PARE) project. While NII scanning is currently not part of the PARE evaluation, it is planned for a PARE Phase II.

An important aspect of the pre-arrival operations at Peace Bridge is that the bridge authority, *not* the federal inspection agencies, owns the facilities that vehicles use to cross the border (roadway, plazas, bridge). Thus, they can require, as a condition of using the bridge, compliance with traffic operations, carrier documentation, and import documentation that do not necessarily align with current inspection agency authorities. An example is Peace Bridge's requirement that *empty* trucks have an electronic manifest. While expanding the legal requirement for carrier manifests to empty trucks has been advocated for, it has not yet been enacted in U.S law. Without such legislation, border crossing ports-of-entry operating in government-owned facilities and on public roads and rights-of-way would not be able to require this element of the current PARE operation. Related to these location-specific requirements, the bridge authority also provides a building (and staff) where truck drivers can park, complete needed transactions (e-manifests, etc.), and then proceed through the pre-primary system. These important physical, financial, and legal conditions are different at every port-of-entry and combine to determine which strategies are operationally beneficial and feasible.

The PARE project is demonstrating the benefits of pre-primary operations. It also illustrates how the physical and institutional makeup of a port-of-entry determines which strategies provide a net benefit. Simulation modeling provides important information about which strategies are likely to improve operations and what changes (policy and infrastructure) would be required to enable a compelling business case.

The 2020 question – A pre-primary NII scanner for empty trucks at Pacific Highway?

Current evaluation of pre-primary scanning of empty trucks U.S.-bound through Pacific Highway

In the Cascade Gateway border region, CBP has already started installing newer generation NII scanners (specifically the Z Portal sold by Rapiscan® Systems) in the secondary inspection areas for passenger vehicles. These scanners use multiple X-ray types which allow drivers to remain in the vehicle and provide much faster processing than past NII systems.

CBSA and CBP currently have the older VACIS NII scanners in the secondary inspection areas for commercial vehicles at both the U.S. and Canadian Pacific Highway facilities.

Empty truck focus

CBP's current interest in deploying a Z-portal NII for pre-primary scanning of trucks is specifically focused on empty trucks. At Pacific Highway, it is estimated that nearly a third of U.S.-bound trucks are empty. For empty trucks, inspection agencies are primarily interested in confirming that the vehicle is not carrying any cargo (or contraband) and that the driver is admissible to the country. If these conditions can be established prior to engagement with an inspector at the primary booth using technology that is faster than current inspection methods (i.e. NII instead of visual confirmation, facial recognition/RFID instead of verification at the booth) it is hypothesized that total inspection time for this large portion of arriving trucks would be significantly reduced. Pre-primary imaging from the NII, along with driver and carrier information would be reviewed in real time at a centralized processing facility and needed determinations would be quickly sent back to the primary booth inspector. By the time the truck pulls up to the primary booth the inspector will know whether a truck can be waived through, needs to be asked a clarifying question or two, or needs referral to secondary inspection. It is hoped that the benefit of more expeditiously processing empty trucks would significantly decrease border wait times for all trucks.

Pre-primary inspection *in Canada*

An important challenge at the U.S. Pacific Highway POE however is that the spatial constraints of the existing facility layout (as shown in the figure below) would require that a pre-primary NII system for trucks be placed just across the border in British Columbia in the commercial vehicle staging area owned and operated by the B.C. Ministry of Transportation and Infrastructure (BCMoTI). This fact further increases the value of applying a simulation model.

Aerial photo of U.S.-bound truck arrival layout between truck staging area in BC and US CBP POE.

First, if advanced by CBP, this NII-for-empties strategy would require significant collaboration (and likely investment) by BCMoTI. For example, staging area signal systems would need to be reconfigured, highway signage would need to be changed, and industry outreach and communication would be needed. Collaborative data collection and analysis and the use of transparent modeling software supports trust and mutually beneficial decision making.

Second, the prospect of placing equipment in Canada used by U.S. agencies to generate imaging and verify credentials and identity will at least require a review to ensure such procedures are allowable under applicable Canadian law (including the recent Canada-U.S. Preclearance Agreement). While such legal questions are outside the scope of this project (and would likely be handled in our nations' capitals), using simulation modeling to first evaluate *operational* feasibility could identify fatal flaws before legal review is initiated. Modeling can also identify opportunities for policy changes to support successful implementation (e.g. document requirements, payment options, traffic enforcement, etc.)

Identifying operational scenarios to test

By setting up the model to reflect the current and proposed key process steps from a truck's arrival at the end of the queue to departure from primary inspection, the analysis can illuminate where introduction of new processes may affect (for better or worse) operations at other points in the system flow. This could lead stakeholders involved in this analysis to consider additional alternatives to model such as routing of FAST trucks, other locations for certain equipment (e.g. RFID or transponder readers), lane and booth allocation, etc.

Phase I and Phase II

This technical memo reports findings from a Phase I modeling effort. The objective at this time is to use mostly existing data to model existing operations (baseline) and model four scenarios where the NII-for-empties concept is applied. In the near term, this work aims to establish whether or not the proposed changes will improve overall border throughput and which variables are most important for achieving desired outcomes. Findings from Phase I will be discussed with stakeholder agencies and are intended to assist them (especially CBP) in deciding whether to keep developing this concept towards deployment.

If operating agencies see merit in advancing deployment, a Phase II modeling effort (a separately funded, new effort) would seek to refine outputs and model additional scenarios for consideration. These would likely include:

- Gathering and applying more current data on empty-loaded ratios (including by FAST-program truck status, and time of day)
- Gathering and applying more refined data on vehicle arrival rates and truck-plaza transition times.
- Working with stakeholders to define additional routing and equipment placement scenarios.
- Adding scenarios that include other elements being reviewed at the national level under the PARE evaluation (e.g. e-manifests for empties).

Model Development

Stakeholder Consultation

As an essential part of setting up the simulation model and documenting operational assumptions, such as currently envisioned layout of pre-primary scanner and traffic flow, WCOG staff convened two consultation meetings that involved Transport Canada, U.S. CBP, and CBSA. More detail about attendees, discussion topics, and findings is included in Appendix 1.

Process Flow and Phase I Assumptions

This section describes each process step in the southbound Pacific Highway truck simulation. More detail is available in Appendix 2.

The annotated photograph on the following page illustrates the key processes from a truck's arrival at the end of the current queue to the conclusion of primary inspection by U.S. CBP. The description of each node also includes the data used to simulate the various rates, probabilities, system capacities, etc.

Model layout

Sequence of process nodes and key data & parameters applied at each node

1. Arrival rate of trucks into the system.
- Based on historical data from loop detectors.
- This is where the model assigns truck type based on 2016 IMTC survey data: General Purpose (GP) loaded, GP empty, FAST loaded, FAST empty)

2. Staging area approach
- Splits to two lanes.
- Lanes are dedicated to truck categories depending on scenario.
- Existing signal & VMS here release trucks to allotted holding lanes based on downstream capacity available.
- Each approach lane capacity set to 10 trucks.
- Drive time from signal to next node is included here.

3. Staging area holding-lanes
- Currently (baseline) there are 12 holding lanes: the southernmost lane dedicated to FAST trucks. FAST-first green-light policies are coded into this model node.
- In NII scenarios, scanning equipment occupies lanes 12 & 11, thus shifting FAST to lane 10 with 9 lanes remaining for GP loaded trucks.
- Each lane capacity set to 3 trucks.
- Drive time from signal to next node is included here.

3a. NII node

For NII scenarios this node includes the time it takes a truck to go through pre-inspection and roll through the NII scanner

5. Primary inspection queue
- This node assigns trucks to 3 primary inspection lanes (PILs) based on available capacity.
- In certain NII scenarios, one PIL is dedicated to empty trucks only.
- PIL queue capacity is set to 6 trucks.

6. Primary inspection
- Based on 2016 data, times are set as a function of average inspection time for each truck type.
- Empties arriving from NII are set to clear primary quicker than loaded trucks.

Staging Area

Because the staging area (holding lanes and signals) is where most of the new equipment and procedures under consideration would be implemented, additional discussion of these features is helpful.

NII Pre-Inspection Processing Time: Based on consultation with CBP, it is estimated that, just prior to rolling through the scanner, each empty truck will require between 60 and 70 seconds to interact with a remote CBP operator (via a speaker/mic interface) to ensure, among other things, that the driver is aware they can opt-out of the scan. Because this operational sequence is not yet in place anywhere, estimating the duration of pre-inspection in the model is achieved by applying variable percentage factors to trucks' historical *primary* inspection processing time, thus keeping the input somewhat grounded in reality.

NII Scanner: Based on consultation with CBP, the NII scanner would likely occupy the two southern-most staging area lanes (one of these lanes being decommissioned due to the machine's size). In the modeled NII scenarios, <u>all</u> empty trucks would transit this lane (including empty FAST-program trucks). Loaded FAST trucks would still use an adjacent dedicated lane, and the remaining nine lanes would be available to all other general purpose (GP) trucks (essentially all loaded, non-FAST commercial vehicles).

Primary Inspection Queue Area

PIL Allocation: There are three primary inspection lanes (PILs) at the southbound Pacific Highway POE. Currently, all PILs are general purpose, meaning each may be utilized by any commercial vehicle (regardless of FAST or empty/loaded status). Modeled NII scenarios would test having one PIL dedicated for empty trucks having transited the NII scanner.

PIL Capacity: Based on aerial photography, the estimated capacity of each PIL queue is 6 vehicles (18 total between three PIL queues). This data is constant for all scenarios tested.

Primary Inspection Processing Time: The duration of time it takes a truck to be processed through primary inspection is based on its truck type (GP Loaded, GP Empty, FAST Loaded, FAST Empty) and whether that truck transited the NII scanner. Processing times are based on data collected from the 2016 IMTC Border Freight Operations study.

NII-scanned Trucks: Based on consultation guidance, it is assumed that trucks that have gone through pre-inspection and transited the NII scanner would roll through a primary inspection booth, either not stopping or stopping briefly. Additional checks for these trucks would occur in secondary inspection, outside the scope of this modeling effort. Because of the uncertainty in the duration of time this primary inspection "roll-thru" would take, the duration estimate in the model is achieved by applying variable percentage factors to trucks' otherwise estimated primary inspection processing time to keep the input grounded in real-world data, similar to the pre-inspection processing time.

Scenarios

The variability of the input data was chosen in order to run scenarios with a full factorial design – that is, every possible combination of specified inputs is simulated. With the input data specified in Appendix 2, 48 combinations were tested, not including the baseline scenario. Each combination is also run five times to generate a better statistical average of outputs. By using a full factorial design, specific combinations can be defined and compared in a database analysis tool. For this project, Tableau has been used to parse and visualize each combination.

Baseline

The baseline scenario is a simulation of current operations as accurate as the input data allows. Because certain data points have been retrieved from different time periods, and some data are largely inferred, baseline outputs like wait-times cannot necessarily be compared to, and validated with, real-world archived analytics. Instead, the baseline is used as a best-estimate reference point for assessing the NII scanner scenarios against current operations.

NII Scenarios

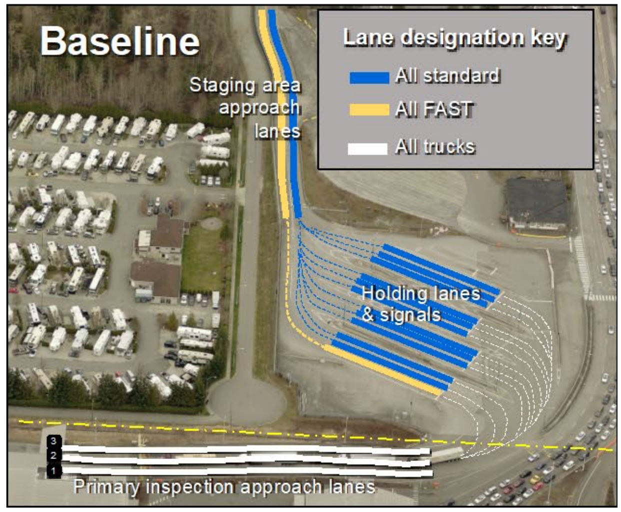
The 48 combinations of input data are organized into four scenarios, not including the baseline.

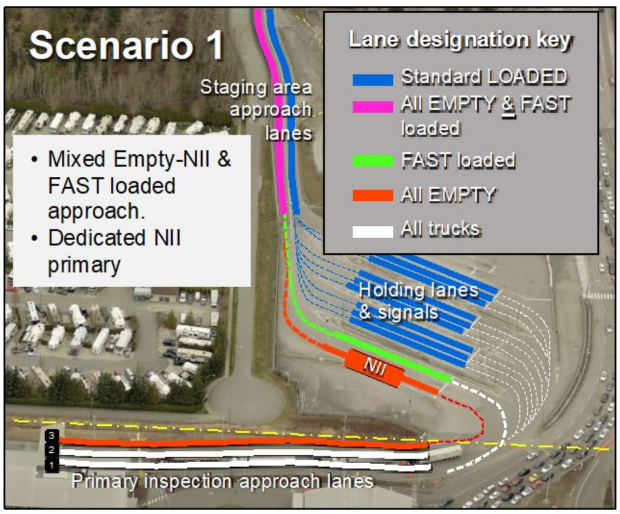
The four scenarios are combinations of two approach lane allocation setups and two PIL allocation setups. Each of these four scenarios assumes an NII scanner is located in the staging area and that all empty trucks pass through it.

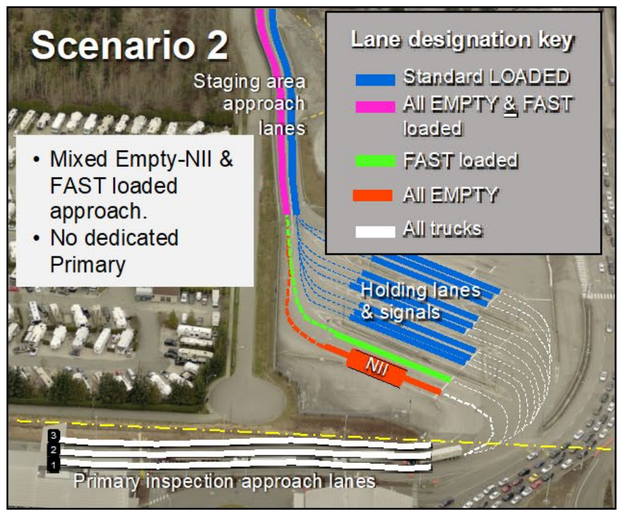
Each NII scenario is comprised of 12 sub-scenarios, which are combinations of the two processing time inputs for NII-scanned empty trucks:

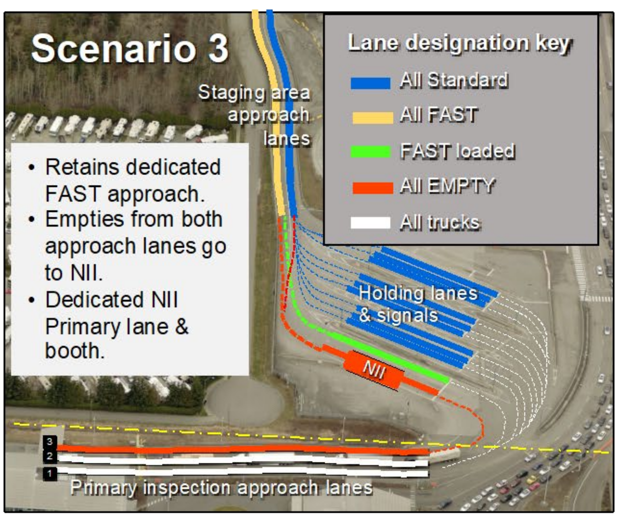
- processing at and through the NII scanner
- processing at the primary inspection booth

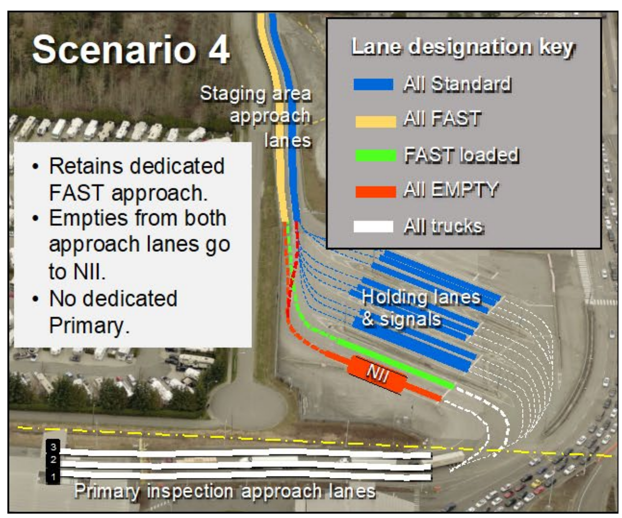
Additional details on these variable inputs and their values can be found in Appendix 2.











Outputs

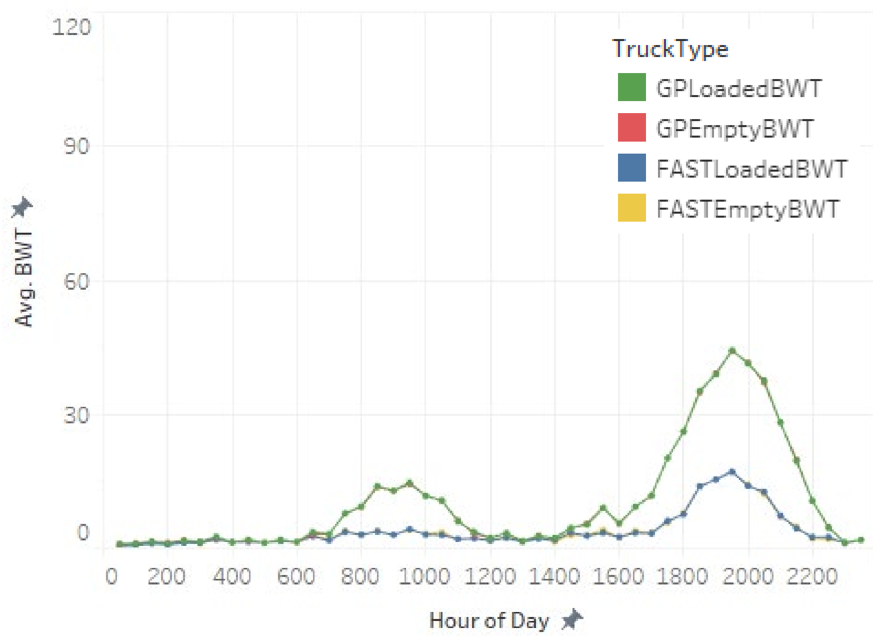
Overall system benefit

In addition to the security improvements of improved scanning technology, a basic question operating agency are interested in answering when evaluating configurations of this strategy is, will the investment and/or policy changes improve system efficiency? Thus, a key output of the model for each simulated commercial crossing is Actual Border Wait-time (ABWT) – the elapsed time from when a truck arrives at the end of the queue to when it arrives at the primary inspection booth. Average ABWTs are generated for the model's simulated 24 hour run period.

Baseline wait-time profile

The graph below shows the 24-hour average wait-time profile in the baseline (current) condition. Because there is no current operational difference in how empty and loaded trucks are routed through the inspection process, their ABWTs within their respective general purpose (GP) and FAST (trusted trader) categories are essentially the same (overlapped). In the baseline condition, the longest average wait times in the evening peak are about 45 minutes for GP trucks and just under 20 minutes for FAST trucks.

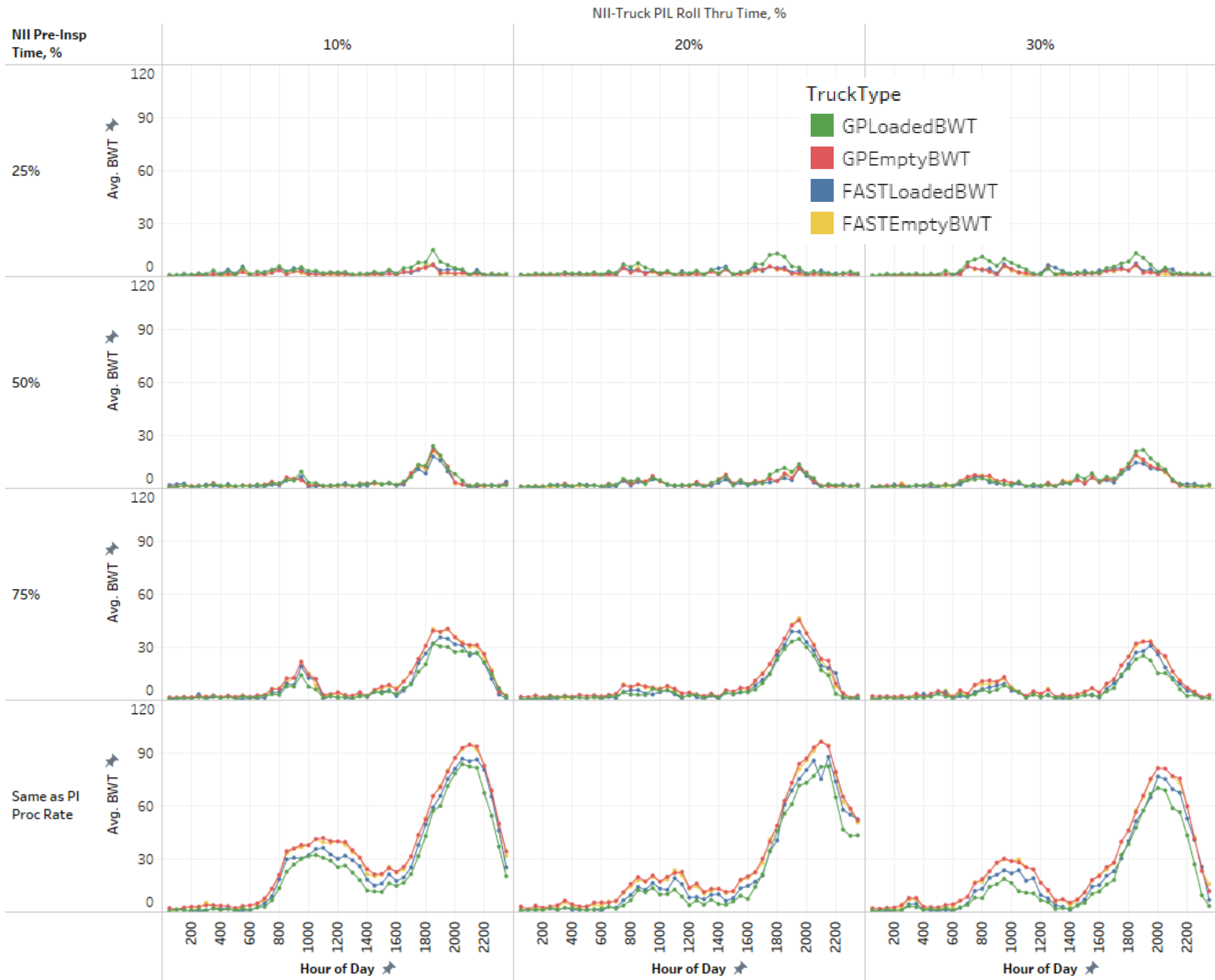
Baseline scenario 24-hour ABWT profile (in minutes):



NII scenario wait-time profiles

As discussed previously, the four main NII scenarios are reach run with 12 different combinations of processing times producing 48 total 24-hour ABWT profile outputs. The results of Scenario 1 (and its sub-scenarios) are shown below. All scenarios are viewable in an online Tableau Dashboard set up for this project.

Scenario 1 (split into the 12 sub-scenarios) 24-hour ABWT profile (in minutes):



NII scenario wait-time observations

Scenario 1 wait-time outputs illustrate outcomes that seem to hold across the other scenarios as well:

- Model outputs show that average ABWT for *all trucks* is most sensitive to the amount of time it takes empty trucks to go through pre-inspection and the NII scanner.
- The amount of time it takes empty trucks to roll through primary inspection does not affect system wait times nearly as much as pre-inspection times.

Focusing on NII-processing time as the strongest determiner of ABWT, we see from the above output graphs that:

- Peak average ABWT is *slightly lower* when NII inspection time is 75 percent of typical primary inspection time (about 70 seconds).
- Peak average ABWT is *significantly lower* if NII inspection time is 50 percent of typical primary inspection time (about 45 seconds).

All NII scenarios remove most of the wait-time advantage currently experienced by trucks that use the FAST lane and shown in the baseline ABWT output.

In all NII scenarios, and as shown in the Scenario 1 output, empty trucks (regardless of FAST-program status) experience similar or *longer* ABWT than loaded trucks.

Operational indicator outputs

Truck backups at the NII scanner

In addition to wait-time measures, the model also tracks how many total trucks are waiting in the border queue generally and in each specific queuing process (PIL queues, staging area lanes including the NII scanner, staging area approach lanes, and Hwy 15). In NII scenarios, where all empty trucks[2] are routed to the single NII scanner in the staging area, some operational impacts can be deduced:

- As NII pre-inspection processing rates increase, queues extend back from the NII scanner with increasing frequency and length.
- When those extensive backups of empty trucks from the NII scanner occur, they block access to the two staging area approach lanes.
- Extensive empty truck backups from the NII scanner also block the efficient use of the staging area FAST lane by FAST-program loaded trucks, largely eliminating the wait-time benefits currently experienced by those trucks.
    - In all NII scenarios, in the staging area one queue lane of trucks is dedicated to the NII scanner and one is dedicated to the FAST lane – however in the model input data there are seven times more empty trucks transiting the border than loaded FAST trucks.

Initial Conclusions and Next Steps

Based on the available input data and assumptions, the outputs of this modeling exercise simulating the addition of an NII scanner to the staging area indicate:

a) Either minimal effects or reductions in wait-times for all trucks in the system *if* pre-inspection processing rates at the NII scanner are on average around 70 seconds or less and empty trucks are minimally impeded as they transit primary inspection
b) Increase in wait-times for all trucks, empty and FAST alike, if pre-inspection processing rates at the NII scanner are on average longer than 70 seconds, which causes extensive backups of empty trucks.

Additional operational issues that the model illuminates, are that 1) most NII scenarios show longer wait times for empty trucks than for loaded trucks and 2) the installation of the NII effectively removes the current wait-time reduction benefits for FAST trucks.

[2] Data from the 2016 IMTC Border Freight Operations study indicate about 42 percent of commercial vehicles through the southbound Pacific Highway POE are empty and about 6 percent are loaded and FAST-compliant.

As implementation of the NII-for-empties concept is further evaluated by CBP and other U.S. and Canadian stakeholders, the current model outputs have quantified the impact of NII inspection time on overall system efficiency and also illuminated how re-ordering the sequence and physical location of process steps might create bottlenecks that would add to overall wait-time.

Near term discussions

With delivery of this simulation model and initial analysis to Transport Canada and other stakeholders, WCOG will, through the International Mobility and Trade Corridor Program (IMTC), review Phase 1 findings and facilitate interagency discussion of next steps for gauging operational feasibility and benefits of the pre-primary NII concept. Topics to be raised for discussion include:

- What policies and technologies would likely result in reliably shorter pre-processing at the NII scanner? (e.g. mandatory e-manifests for empties, integration of DTOPS and/or RFID readers, facial recognition, etc.)
- Are there other locations and lane-configurations that could be considered for the NII, for the FAST lane, etc.? For example, could the NII be placed in the northeast of the staging area, *after the holding area signals*, with empty trucks approaching via the eastern of the two plaza approach lanes? This might allow multiple holding area lanes for empty trucks and minimize empty-truck queues that, as seen in current model scenarios, prevent full use of approach-lane splits up stream.

For questions and additional information, contact:

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Stakeholder consultations & additional data collection

First consultation:

The first project consultation with agency stakeholders occurred February 14, 2020 at U.S. CBP's Pacific Highway port of entry (PoE). Participants included:

- **Transport Canada**: Chris Hoff, Heather Carrier, Matthew
- **U.S. Customs and Border Protection (CBP)**: Lisa Brown, Kenneth Williams, Craig Hope
- **Canada Border Services Agency (CBSA)**: Morgan McJanet
- **B.C. Ministry of Transportation & Infrastructure (BCMoTI)**: Karamjeet Deogan
- **Whatcom Council of Governments (WCOG)**: Jaymes McClain, Hugh Conroy

At this meeting, WCOG staff reviewed current assumptions about how the proposed NII system would operate, how the simulation model could be set up to reflect both the current and proposed future operation, and got feedback from CBP and other stakeholder agencies on additional factors to consider. Sources of data used to reflect baseline operations were also reviewed.

Important clarifications were made regarding truck-traffic control expected to exist just prior to the proposed NII scanner as well as a remotely operated two-way communication interface which will allow drivers an opportunity to opt out of the NII scan.

Discussion that informed Phase 1 model scenario development included:

- the likelihood that regulations will change in the near future to require all empty trucks to have an electronic manifest. This would reduce or remove the need for inspector-driver dialog (reducing pre-inspection processing times).
- the possible reallocation of the two approach lanes into the greater truck staging area.
- interest in dedicating a primary inspection booth to NII-scanned empty trucks.

Discussion at the meeting also supported the value of collecting several hours of fresh inspection-time and other process-time data in the following week or two.

Supplemental data collection

On Wednesday, March 4, staff from Transport Canada's Pacific District Office in Vancouver, BC worked with WCOG to collect a current batch of commercial vehicle primary inspection times at the US POE at Pacific Highway.

Several hours of data were collected (over 200 records) which were used to confirm that inspection time data collected in 2016 (over 1,600 records) were still representative. The 2016 records are also related to several other recorded attributes that are used in this Phase 1 model (e.g. empty/loaded status, trusted trader status, vehicle classification).

WCOG and Transport Canada intended to collect other data on March 4, specifically arrival rates and transition times between signaled zones of the truck staging plaza, however an atypical traffic control strategy that day (deployed by staff of the adjacent duty-free store) blocked off truck access to most of the holding lanes, rendering such data collection infeasible.

Jasmine Luk and Elaina Liang of Transport Canada help WCOG collect primary inspection times for commercial vehicles. March 4, 2020.

First model build & second consultation

A second stakeholder consultation meeting, held virtually due to current social distancing recommendations, occurred March 16. Participants included:

- **Transport Canada**: Chris Hoff, Elaina Liang, Jasmine Luk
- **US CBP**: Lisa Brown, Craig Hope
- **BCMoTI**: Lina Halwani, Karamjeet Deogan
- **WCOG**: Jaymes McClain, Hugh Conroy

During this meeting, WCOG staff:

- Reviewed the baseline and four NII scenarios that were established in the model
- Reviewed the data and assumptions used to model each process step in the simulation
- Consulted with CBP and BC MoTI about assumptions that had been built into the model since the last consultation
- Reviewed initial findings

Detailed Model Framework and Data Inputs

The simulation model requires several critical data inputs in order to simulate the desired scenarios. For the Pacific Highway commercial POE queue and inspection process, inputs are those data and parameters that affect how trucks move through the border and what causes trucks to accumulate wait time. Because the southbound Pacific Highway commercial POE is unique in its design, there are several sub-processes that each require their own data.

Highway Approach

Arrival Rate: Trucks are created in the model based on an interarrival rate calculated from the Cascade Gateway Border Data Warehouse. The Warehouse's *Volume* data point measures the total number of trucks entering each specific crossing, with query options by vehicle type and date. The data is calculated based on loop-detectors in the border approach roadways and queue lanes. Due to the availability of data, rates of arrival are for this simulation are based off average volume counts from Wednesdays in October 2019. This data is constant for all scenarios tested.

Staging Area Approach: The southbound Pacific Highway staging area is fed by two approach lanes. As it currently operates, the western lane is dedicated to FAST-program compliant trucks and the east lane is available for general purpose commercial traffic (GP trucks). Approach lane allowance are changed in the model based on the scenario.

Approach Lane Capacity: Based on aerial photography, the estimated capacity of each approach lane is 10 trucks (20 total). This data is constant for all scenarios tested.

Roll Time, Approach Lane to Staging Area: Approach lanes are signalized, with trucks released when capacity within the staging area is available. Based on consultation guidance and observations from the March 4, 2020 data collection effort, the estimated amount of time it takes a truck to "roll" from an approach lane to a staging area lane is: 15 seconds to GP lanes; 10 seconds to FAST/NII lanes. This data is constant for all scenarios tested.

Types of Trucks Arriving: In the model, trucks are categorized with two attributes: empty/loaded status and trusted trader status. These combine to create four unique truck types:

- GP Loaded
- GP Empty
- FAST Loaded
- FAST Empty

The proportion of trucks assigned to each truck type is based on data collected in June 2016 as part of the IMTC Border Freight Operations (BFO) study.

Data extracted from the 2016 IMTC BFO. This data is used to compute the proportion (%) of, and the average primary inspection processing rate (Avg (sec)) for, each truck type.

Truck Type	n	Avg (sec)	%
All	836	98	100.00%
Loaded	482	100	57.66%
Empty	354	95	42.34%
GP	674	106	80.62%
FAST	162	63	19.38%
GP Loaded	430	104	51.44%
GP Empty	244	110	29.19%
FAST Loaded	52	64	6.22%
FAST Empty	110	63	13.16%

Staging Area

Staging Area Lanes: The staging area is designed to queue trucks in an organized manner and release them when primary inspection lane (PIL) capacity is available. The current design dedicates the southern-most staging area lane for FAST trucks and the remaining 11 lanes for GP trucks.

NII Scanner: Based on consultation guidance, the NII scanner would occupy the southern-most staging area lane (with an additional lane decommissioned due to the machine's size). In model scenarios where NII is present, all empty trucks would transit this lane. FAST trucks would still occupy one dedicated lane, and the remaining 9 lanes would be occupied by GP trucks.

NII Pre-Inspection Processing Time: Due to insufficient data on the duration of time it takes a truck to go through pre-inspection and roll through the NII scanner, scenarios are tested with this duration being a percentage of a truck's otherwise estimated primary inspection processing time.

Staging Area Lane Capacity: Based on aerial photography, the estimated capacity of each staging area lane is 3 trucks. This data is constant for all scenarios tested.

Roll Time, Staging Area to Primary Inspection Queue Area: Staging area lanes are signalized, with trucks released when capacity within the primary inspection queue area is available. Based on consultation guidance and observations from the March 4, 2020 data collection effort, the estimated amount of time it takes a truck to "roll" from a staging area lane to a PIL is 20 seconds from GP lanes and 15 seconds from the FAST lane. The roll time from the NII scanner to a PIL is assumed to be included in the NII pre-inspection processing time. This data is constant for all scenarios tested.

Input data for each sub-process of the southbound Pacific Highway commercial POE

<table>
<tr><th colspan="2">Highway Approach</th></tr>
<tr><td>Data: Interarrival Rate
does not change</td><td>Based on half hour increments in 24 hours from Wednesdays in October, 2019 <based on a probability distribution></td></tr>
<tr><td>Data: Approach lane allocation
Approach scenarios: < E | W >
variable</td><td>1. FAST Empty/Loaded | GP Empty/Loaded <base>
2. FAST Empty/Loaded + GP Empty | GP Loaded</td></tr>
<tr><td>Data: Approach lane capacity
does not change</td><td>10 vehicles per approach lane (20 total) <constant value></td></tr>
<tr><th colspan="2">Staging Area</th></tr>
<tr><td>Data: Staging area lane allocation
Staging area scenarios:
< GP | FAST| NII >
variable: base and non-base</td><td>1. 11 GP | 1 FAST <base only>
2. 9 GP | 1 FAST | 1 NII <all non-base scenarios></td></tr>
<tr><td>Data: Staging area lane capacity
does not change</td><td>3 vehicles per staging area lane <constant value></td></tr>
<tr><td>Data: NII pre-inspection + portal roll thru time
Pre-Insp percent of processing rate scenarios: < # >
variable</td><td>Pre-inspection and portal roll thru times based on % of PI processing rate:
1. 0.25
2. 0.5
3. 0.75
4. 1</td></tr>
<tr><th colspan="2">Primary Inspection Queue Area</th></tr>
<tr><td>Data: 3 PIL allocation
PIL scenarios: < 1 | 2 | 3 >
variable</td><td>1. GP | GP | GP <base>
2. GP | GP | NII Empties only</td></tr>
<tr><td>Data: PIL capacity
does not change</td><td>6 vehicles per PIL queue <constant value></td></tr>
<tr><td>Data: PIL processing times
NII prim insp percent of processing rate scenarios: < # >
variable</td><td>Baseline proc rates <based on a probability distribution>
NII-Empties roll thru time based on % of PI processing rate:
1. 0.1
2. 0.2
3. 0.3</td></tr>
</table>

Primary Inspection Queue Area

PIL Allocation: There are 3 PILs. Currently, all PILs are general purpose, meaning each may be utilized by all trucks. In model scenarios where NII is present, two scenarios test having one PIL dedicated for trucks having transited NII.

PIL Capacity: Based on aerial photography, the estimated capacity of each PIL queue is 6 vehicles (18 total). This data is constant for all scenarios tested.

Primary Inspection Processing Time: The duration of time it takes a truck to be processed through primary inspection is based on its truck type (GP Loaded, GP Empty, FAST Loaded, FAST Empty) and whether that truck transited the NII scanner. Processing times are based on data collected from the 2016 IMTC BFO.

NII Trucks: Based on consultation guidance, it is assumed that trucks that have gone through pre-inspection and transited the NII scanner would roll through a primary inspection booth, either not stopping or stopping briefly. Additional checks for these trucks would occur in secondary inspection, outside the scope of this modeling effort. Because of the uncertainty in the duration of time this primary inspection "roll-thru" would take, this duration is based on a low percentage of a truck's otherwise estimated primary inspection processing time.

Modeled Scenarios

The variability of the input data was chosen in order to run scenarios with a full factorial design – that is, every possible combination of specified inputs is simulated. With the input data specified previously, 48 combinations were tested, not including the baseline scenario. Each combination is also run five times to generate a better statistical average of outputs. By using a full factorial design, specific combinations can be defined and compared in a database analysis tool. For this project, Tableau has been used to parse and visualize each combination.

The baseline scenario is a simulation of current operations as accurate as the input data allows. Because certain data points have been retrieved from different time periods, and some data are largely inferred, baseline outputs like wait-times cannot necessarily be compared to, and validated with, real-world archived analytics. Instead, the baseline is used as a best-estimate reference point for assessing the NII scanner scenarios against current operations.

The 48 combinations of input data are organized into four scenarios, not including the baseline. The four scenarios are combinations of two unique approach lane allocation parameters and two unique PIL allocation parameters. Each of these four scenarios assumes an NII scanner is located in the staging area and that <u>all</u> empty trucks pass through it.

In the following scenario blurbs, input parameters shared between scenarios are colored-coded the same.

Baseline scenario (no NII scanner)

Approach Lane Allocation (West Lane | East Lane): FAST Empty/Loaded | GP Empty/Loaded

PIL Allocation (PIL 1 | PIL 2 | PIL 3): GP | GP | GP

Scenario 1

Approach Lane Allocation (West Lane | East Lane): FAST Empty/Loaded + GP Empty | GP Loaded

PIL Allocation (PIL 1 | PIL 2 | PIL 3): GP | GP | NII Empties only

Scenario 2

Approach Lane Allocation (West Lane | East Lane): FAST Empty/Loaded + GP Empty | GP Loaded

PIL Allocation (PIL 1 | PIL 2 | PIL 3): GP | GP | GP

Scenario 3

Approach Lane Allocation (West Lane | East Lane): FAST Empty/Loaded | GP Empty/Loaded

PIL Allocation (PIL 1 | PIL 2 | PIL 3): GP | GP | NII Empties only

Scenario 4

Approach Lane Allocation (West Lane | East Lane): FAST Empty/Loaded | GP Empty/Loaded

PIL Allocation (PIL 1 | PIL 2 | PIL 3): GP | GP | GP

Sub-scenarios

Each of the four scenarios have 12 sub-scenarios. These sub-scenarios are combinations of variable NII-related processing time inputs. There are four possible time-inputs for how long an empty truck takes to go through pre-inspection and roll through the NII scanner and there are three possible time-inputs for how long a NII-scanned empty truck takes to roll through a primary inspection booth. These processing times are percentages of the primary inspection times that each empty truck would otherwise experience in the baseline scenario.

NII pre-inspection + scanner roll thru time as a percentage of primary inspection processing time:

> 25%, 50%, 75%, Same as current primary inspection time (100%)

NII trucks primary inspection booth roll thru time as a percentage of primary inspection processing time:

> 10%, 20%, 30%

Supplemental Output Analysis

When all truck types experience similar actual border wait-time (ABWT) profiles over a long stretch of time, it indicates that all trucks are affected by a common factor. In this case, all trucks queue in a single border approach lane on Hwy 15.

In the NII scenarios, all empty trucks must transit one lane in the staging area containing the NII scanner. Because of this, backups occur from the NII scanner to the staging area approach lanes in scenarios where the pre-inspection processing time for empty trucks is close to the time they would otherwise experience in primary inspection. From there, backups would extend upstream to the single shared lane on BC Hwy 15.

High wait-times that are similar across all trucks indicate extensive backups on BC Hwy 15.

The following cross-tabular graphic disregards FAST-program status and shows the average ABWT of empty trucks and loaded trucks for the entire 24-hour modeled period, broken out by the 4 NII scenarios (columns) and 12 subsequent sub-scenarios (rows).

Average BWTs (minutes) in 24-hour period by Empty/Loaded status, by Scenario

When looking at summarized statistics for the whole 24-hour period, it can be seen how determinate the NII pre-inspection processing time is on wait-times, especially in scenarios where pre-inspection offers no processing time reduction benefits as compared to a primary inspection.

Empty trucks also appear to regularly experience higher wait-times than loaded trucks in most scenarios tested regardless of there being a dedicated PIL for empty trucks (as is the case in Scenarios 1 and 3). This is likely attributed to all empty trucks being routed single-file through one NII scanner lane in the staging area, creating a bottleneck. Loaded trucks are dispersed into nine general purpose lanes and one FAST lane and are inspected through 2 to 3 PIL booths, reducing the chances of bottlenecking.