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2012 Evaluation of Mobility at the Pacific Highway Truck Crossing, Southbound

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2012 Evaluation of Mobility at the Pacific Highway Truck Crossing, Southbound

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Border Policy Research Institute
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Bellingham, Washington
www.wwu.edu/bpri/

About the Border Policy Research Institute

The BPRI focuses on research that informs policy-makers on matters related to the Canada-U.S. border. Policy areas of importance include transportation and mobility, security, immigration, energy, environment, economics and trade.

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Introduction

A multi-year effort has been underway to improve the mobility of trucks traveling southbound through the Pacific Highway border crossing in Blaine, Washington. The effort grew out of CVO (commercial vehicle operations) studies undertaken by the Whatcom Council of Governments (WCOG) in collaboration with the Border Policy Research Institute (BPRI). The impetus for the studies was the truck congestion and delay evidenced at Pacific Highway in the mid 2000s. The IMTC (International Mobility and Trade Corridor project), a regional stakeholder forum, identified CVO studies as a priority, and the BPRI and WCOG responded to the need. Partial funding of the effort was provided by the Washington State Department of Transportation (WSDOT), making use of federal Coordinated Border Infrastructure funds. Paired north- and southbound CVO studies were undertaken in 2006¹ and 2009.⁴ By 2010 the data gathered in these studies had been used to produce a simulation model of the southbound crossing.⁵ Model results indicated that mobility could be improved by making different use of inspection booths and highway lanes. In particular, the elimination of the dedicated FAST booth and approach lane was predicted to greatly reduce delay. In response to these results, U.S. Customs and Border Protection (USCBP) proposed that a pilot project be undertaken to test such a reconfiguration. The pilot project took place in February – April of 2011, and the results of that effort are documented in a report titled “2011 Pacific Highway Southbound FAST Lane Study: Final Report.”⁸

The pilot configuration was so effective that USCBP began to investigate ways to permanently reconfigure the crossing. The B.C. Ministry of Transportation (BCMOT) became active in this effort, because the plaza upstream of the inspection booths falls within Canadian jurisdiction. More modeling was undertaken,¹⁰ and the BCMOT then constructed a new arrangement of queuing lanes and signals in the plaza. Construction was complete in the spring of 2012. USCBP then requested that a final round of field measurements be gathered to document the performance improvements achieved by the reconfigured plaza and the elimination of a dedicated FAST booth. This document provides the results of a field project undertaken in August 2012, as requested by USCBP.

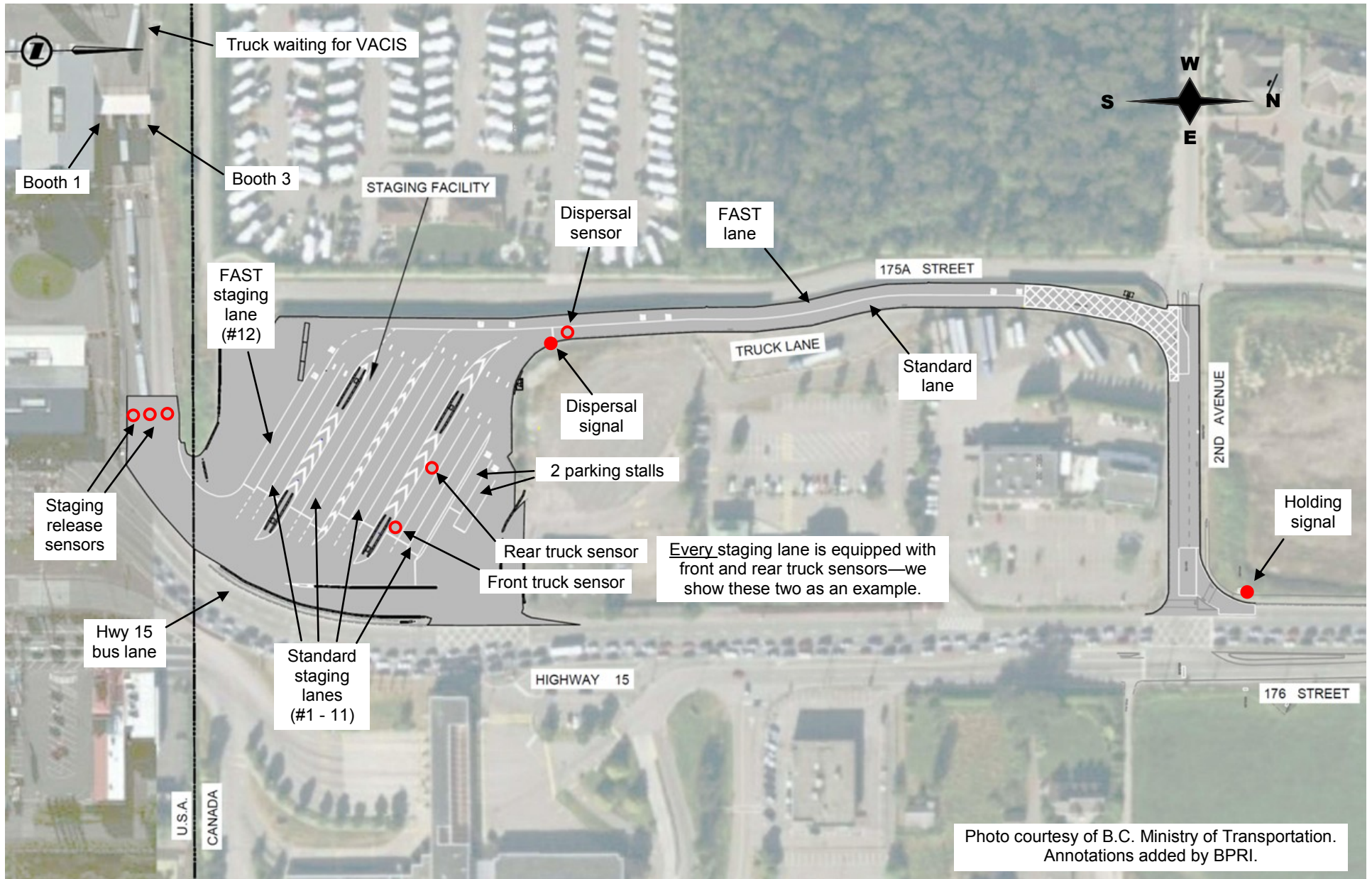
Figure 1 documents the layout of the reconfigured staging facility as it existed in summer 2012. Trucks enter the plaza via a 2-lane truck road leading south from 2nd Avenue. Standard trucks (i.e., non-FAST) use the east lane, reaching a “dispersal signal,” which directs them to one of 11 separate staging lanes. They are later released from the staging lanes, in a first-in first-out manner, and move to a final queuing area immediately upstream of the inspection booths. FAST trucks use the west lane in the truck road to reach lane #12, dedicated to FAST. Trucks in lane #12 receive preference over the ones in lanes #1 – 11, so FAST trucks reach the area just upstream of the booths more rapidly. Both types of trucks are mingled in that final queuing area, and all are free to choose any of the three booths.

Project Logistics

The project took place in coordination with local officials of USCBP and the Canada Border Services Agency (CBSA). Planning began in June 2012 and proceeded in a rapid manner, due to the existing framework of relationships and processes developed to support the earlier series of field studies. Logistical details follow:

- Staffing and Funding. A field team of six students from Western Washington University was recruited, and team members were vetted by CBSA and USCBP. David Davidson (BPRI Associate Director) and Hugh Conroy (Project Manager at WCOG) served as supervisors. The BPRI hired the students and paid the cost of the project from internal funds.

Figure 1. Annotated Diagram of Staging Facility, Summer 2012



- Schedule. Field work took place on two days:
 - Tuesday, August 21, 8:00 a.m. to 5:00 p.m.
 - Wednesday, August 22, 8:00 a.m. to 5:00 p.m.

The schedule was developed in consultation with USCBP. The heaviest traffic exists in the Monday – Thursday period, and traffic is significant from early morning through early evening. This set of days and hours allowed us to collect large continuous sequences of CVO data that are representative of high-traffic conditions at the port.

- Methodology. We used Palm Tungsten E2 personal digital assistants (PDAs) running a set of custom data-collection windows created with Pendragon Forms 5.1 software. The internal clocks of the PDAs were synchronized to within one second, such that a timestamp collected at one station could be accurately compared to a timestamp collected elsewhere with a different PDA. There were four stations, as follows:
 - *FAST queue-end*. At this station, a student recorded the time that a given truck joined the queue forming within the plaza’s lane dedicated to FAST. Because queue length can change, this was a roving station. The time of arrival of every truck was collected, as well as the license plates of most trucks.
 - *Standard queue-end*. At this station, a student recorded the time that a given truck joined the queue forming within the lanes dedicated to non-FAST trucks. Because queue length can change, this was a roving station. The time of arrival of every truck was recorded, as well as the license plates of most trucks.
 - *Booths*. At this station, a student recorded activities occurring at the three commercial inspection booths. For a given truck, the license plate was recorded, a timestamp was captured when the truck came to a stop adjacent to a booth, and a second timestamp was captured when the truck began to move away from the booth. The difference between the two timestamps pertaining to a single truck represents the amount of time spent in the inspection process. Subtracting the queue-end timestamp of a given truck from its booth-arrival timestamp allows computation of the time the truck spent waiting in the queue. Data was collected for most trucks transiting the booths.
 - *Exit booth*. At this station, a student recorded the time at which a truck passed by the USCBP exit booth, together with the truck’s license plate. Comparing this timestamp to upstream timestamps allows computation of the total time spent transiting the port-of-entry, or alternatively, the total amount of time consumed by the USCBP inspection process (including both primary and secondary inspection). Data was collected for most trucks.

License plates were used as the means to tie together the timestamps associated with a given truck. At the end of each field day, the data from all PDAs was uploaded automatically by the Pendragon application, with all data placed into an MS Access database. Data was then exported to an MS Excel spreadsheet to perform post-processing, which included the steps necessary to bundle the information relative to a specific truck into a single record, and to compute the various statistics presented later in this report.

Changes in wait-times achieved by the reconfiguration are meaningful only when considered in relation to the overall traffic volume, because changes in volume obviously cause changes in wait-time. We therefore collected the queue-end arrival times of every truck in order to be

able to generate a complete profile of the rate of arrivals, which could then be compared to the traffic volume encountered in earlier studies. On the other hand, the wait-times of trucks can be meaningfully characterized based upon a sample of the trucks moving through the crossing, which is why it was sufficient to collect booth-data and license plate values for most (but not all) of the trucks.

Results

Excel Spreadsheet. The main product of the project is an MS Excel spreadsheet containing 1,364 rows, with each row containing the data describing “sightings” of a single truck as it progressed through the port. Not all rows contain a complete record of a truck’s progress, due to aspects of the methodology described above (i.e., a *sample* of trucks was measured at the booths and exit, but *all* trucks were captured as they joined the queue). Errors in recording license-plate values likewise resulted in a number of incomplete records, as no matching queue-end record could be found for a truck observed at the booths. Finally, some vehicles had no license plates, making it difficult to accurately log their progress. Despite all such issues, the Excel spreadsheet contains a very robust set of data from which to derive statistics pertaining to wait-times and duration of inspections. A copy of the data may be requested from the BPRI. The spreadsheet contains:

- 1,221 records of arrival of trucks at the queue-end.
- 1,063 records of inspection duration (272 FAST, 791 non-FAST).
- 966 records of wait-times within the queue.

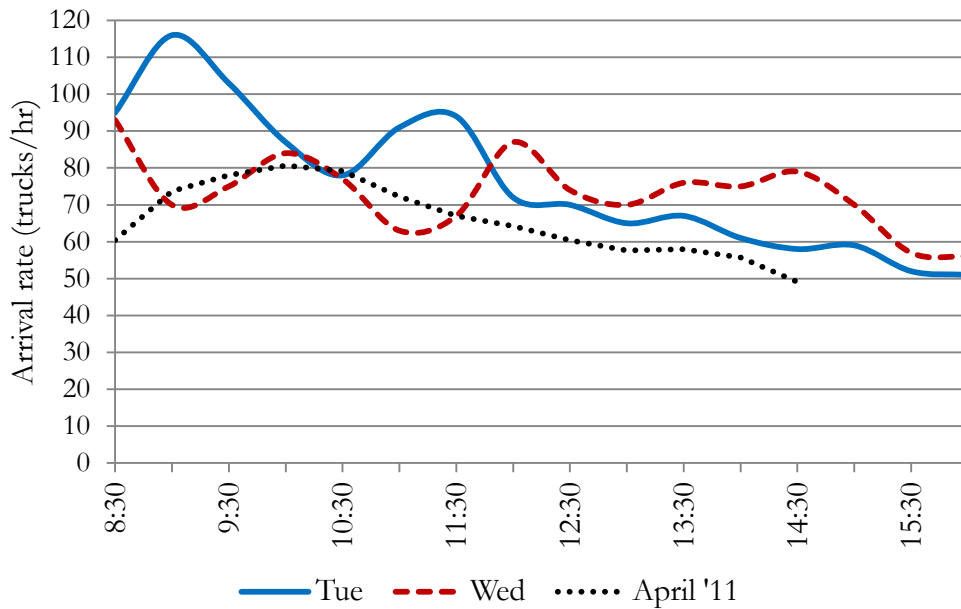
Comparability of Traffic Volume. To ensure a fair comparison of the wait-times experienced before and after the reconfiguration of the crossing, it is necessary to examine the traffic volume encountered during the various phases of surveying. Table 1 shows counts of the total number of southbound trucks arriving at the crossing during the six peak hours between 09:00 and 15:00. The bottom row of the table contains the volumes observed on the two days of this 2012 field effort, and the top five rows of the table contain values collected during the baseline phase and pilot phase of the spring 2011 pilot test (see pages 26 – 33 of our 2011 final study⁸). The traffic volumes observed this summer are the two highest values found in the table.

Figure 2 provides a different perspective of traffic volumes, focusing upon peak arrival rates that are encountered during the course of a day. Surges in traffic can cause rapid queue building, so it is again necessary to determine whether the conditions in 2012 are comparable to those in 2011. The black dotted line represents the average profile of arrivals during the 12 weekdays of the 2011 pilot phase—i.e., the red-highlighted days shown in Table 1. (This black line is identical to the one

Table 1: Total Arrivals from 09:00 to 15:00 on Survey Days
Blue italic = Baseline Phase 2011, Red = Pilot Phase 2011, Black = 2012

Mon		Tue		Wed		Thur	
<i>28 Feb '11</i>	<i>335</i>	<i>1 Mar '11</i>	<i>292</i>	<i>2 Mar '11</i>	<i>349</i>	<i>3 Mar '11</i>	<i>350</i>
<i>7 Mar '11</i>	<i>n/a</i>	<i>8 Mar '11</i>	<i>322</i>	<i>9 Mar '11</i>	<i>343</i>	<i>10 Mar '11</i>	<i>356</i>
21 Mar '11	395	22 Mar '11	395	23 Mar '11	331	24 Mar '11	375
28 Mar '11	432	29 Mar '11	412	30 Mar '11	416	31 Mar '11	392
4 Apr '11	398	4 Apr '11	430	6 Apr '11	389	7 Apr '11	359
		21 Aug '12	470	22 Aug '12	448		

Figure 2: Rate of Arrival vs. Time of Day



published in Figure 2 of our spring 2011 *Border Policy Brief*.⁶⁾ The other two lines show the arrival-rate profiles of the two days we surveyed in summer 2012. Each 2012 field day exhibited arrival rates that were greater than those observed in the 2011 pilot phase. Both the time-of-day data (Figure 2) and the 6-hour-cumulative data (Table 1) demonstrate that traffic volumes in summer 2012 were greater than in spring 2011. This means that, other things being equal, the wait-times observed in 2012 would be expected to be *higher*.

Figure 2 also reveals a substantial difference between the two 2012 field days with respect to the profile of arrivals throughout the day. The Tuesday data (Aug. 21) exhibits large peaks earlier in the day, while the Wednesday data (Aug. 22) shows a more even pattern throughout the day. These different arrival patterns result in corresponding fluctuations in wait-time, as seen below. It is fortunate that the days have such distinctive patterns of arrivals, as it provides a better sense of how the crossing operates under differing volumes of traffic.

Inspection Duration. Evaluation of any changes in the duration of the inspection process is also necessary in order to compare changes in mobility over time. Table 2 shows various measurements of inspection duration that have been made at this crossing over the years. There has been a gradual decrease in duration over time, as USCBP has worked to refine the inspection process (e.g., introduction of e-manifest). A significant reduction is evident when comparing the data collected this summer to that collected during the 2011 pilot project. This means that, other things being equal, the wait-times observed in 2012 would be expected to be *lower* than those of 2011. This factor

Table 2: Inspection Duration at Southbound Pacific Highway (sec.)

	2006 ¹	2011 ⁷	2012
FAST truck	87	79	62
Standard truck	120	102	94

Table 3: Wait-Time and Arrival Statistics by Day and Hour

Tue 21-Aug		8 to 9		9 to 10		10 to 11		11 to 12		12 to 13		13 to 14		14 to 15		15 to 16		16 to 17	
		<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>
431	# in Sample	11	27	31	32	20	42	15	41	13	34	12	43	9	39	11	29	6	16
	Min. Wait	0:01:29	0:01:24	0:03:06	0:10:20	0:06:50	0:28:30	0:04:10	0:23:05	0:04:43	0:21:52	0:06:00	0:12:09	0:04:19	0:03:39	0:01:14	0:01:25	0:03:36	0:06:19
0:21:59	Avg. Wait	0:02:59	0:05:39	0:09:47	0:21:57	0:21:17	0:43:25	0:19:34	0:41:29	0:11:51	0:39:39	0:09:31	0:29:22	0:11:12	0:17:05	0:02:48	0:04:48	0:07:48	0:11:12
	Std. Dev.	0:01:08	0:02:54	0:03:44	0:10:05	0:07:06	0:06:09	0:09:44	0:08:12	0:07:17	0:08:03	0:02:32	0:10:25	0:05:22	0:09:56	0:01:23	0:03:46	0:02:48	0:02:58
1:04:54	Max. Wait	0:04:56	0:12:20	0:15:51	0:53:36	0:29:49	0:54:46	0:33:15	0:59:45	0:27:41	0:54:49	0:13:10	1:04:54	0:21:06	0:52:29	0:05:17	0:17:24	0:10:45	0:15:31
615	# Arrivals	20	49	39	64	16	62	23	71	20	50	16	51	13	45	17	35	2	22

Wed 22-Aug		8 to 9		9 to 10		10 to 11		11 to 12		12 to 13		13 to 14		14 to 15		15 to 16		16 to 17	
		<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>	<i>FAST</i>	<i>STD</i>
535	# in Sample	15	32	22	41	26	32	15	66	18	49	13	48	23	52	7	39	7	30
	Min. Wait	0:01:56	0:01:26	0:01:56	0:03:36	0:04:03	0:04:14	0:01:11	0:01:20	0:01:04	0:01:16	0:01:04	0:01:24	0:02:21	0:03:11	0:01:15	0:01:36	0:02:38	0:02:09
0:07:28	Avg. Wait	0:03:50	0:04:57	0:06:15	0:10:14	0:08:03	0:13:47	0:07:47	0:09:33	0:04:55	0:06:23	0:04:10	0:05:10	0:06:06	0:07:25	0:04:27	0:07:24	0:04:34	0:08:02
	Std. Dev.	0:01:53	0:02:06	0:04:41	0:06:08	0:04:24	0:06:56	0:07:11	0:08:06	0:03:26	0:03:32	0:03:48	0:02:43	0:03:01	0:03:04	0:04:03	0:06:01	0:01:22	0:03:27
0:33:45	Max. Wait	0:08:36	0:10:13	0:17:22	0:27:30	0:23:39	0:33:45	0:26:29	0:31:13	0:10:55	0:14:20	0:15:46	0:15:27	0:12:55	0:18:58	0:13:18	0:27:18	0:06:46	0:13:28
606	# Arrivals	23	49	23	52	30	47	10	57	21	53	17	59	21	58	11	46	7	22

therefore counteracts the effect of higher traffic volumes as discussed above. Use of the southbound simulation model would be required in order to conduct the most precise “apples to apples” comparison of wait-times, which is beyond the scope of this validation effort.

Throughput of the crossing is basically controlled by the duration of the inspection process, with quicker inspections generating greater throughput. For both our 2011 and 2012 projects, USCBP provided hourly counts of the trucks cleared in aggregate through all booths as recorded within their Automated Commercial Environment (ACE) system. As single overall averages descriptive of the three configurations, those values are: 64 for 2011 Baseline, 73 for 2011 Pilot, 80 for Summer 2012. Note the relationship between an at-booth throughput value of 80 trucks per hour and the arrival rates documented in Figure 2. On Tuesday there were long periods in which the arrival rate exceeded 80, and substantial queues therefore developed. Arrivals were generally less than 80 per hour on Wednesday, and queues did not develop that day. It is evident that problematic delays and queues may yet return to Pacific Highway if traffic levels continue to grow such that the arrival rates routinely exceed 80 per hour. Continued efforts to reduce the inspection duration are seemingly the best future course of action, together with attempts to process a greater proportion of traffic through FAST, as inspection durations are shorter for FAST trucks.

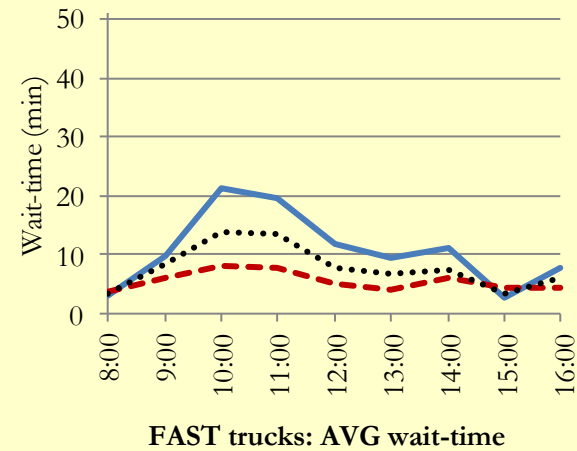
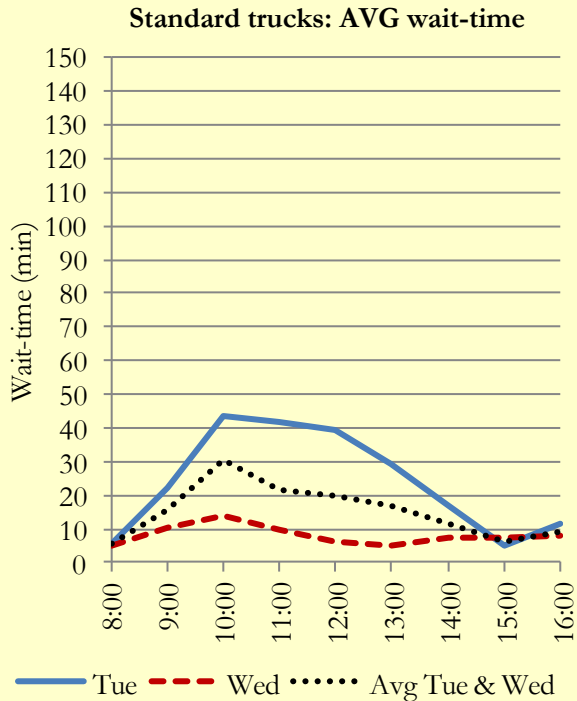
Discussion of Wait-Times. The wait-time data collected in summer 2012 is summarized in Table 3, which for ease of comparison is organized in a format similar to that used in our 2011 final study.⁸ The leftmost column contains overall values pertaining to each of the two days—e.g., for the sample of 431 trucks observed on Tuesday, August 21, the overall average wait-time was 21 min. 59 sec. The remaining nine columns of the table present an hourly breakdown, for FAST and standard trucks separately, of operations over the course of the day.

Figures 3 through 5 provide a visualization of the data in order to assist discussion. The organization of the figures on the page is meant to facilitate easy comparison between sets of data. Graphs that neighbor each other to the left or right have identical vertical axes so that wait-times are easily comparable. Note, however, that the bottom three graphs related to FAST trucks have vertical axes at a different scale than the top three, which relate to standard trucks.

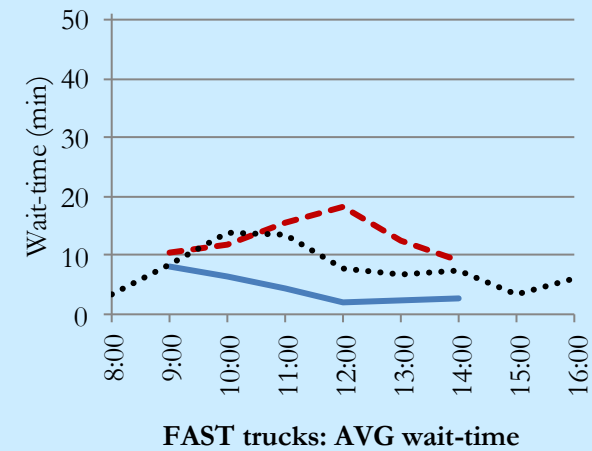
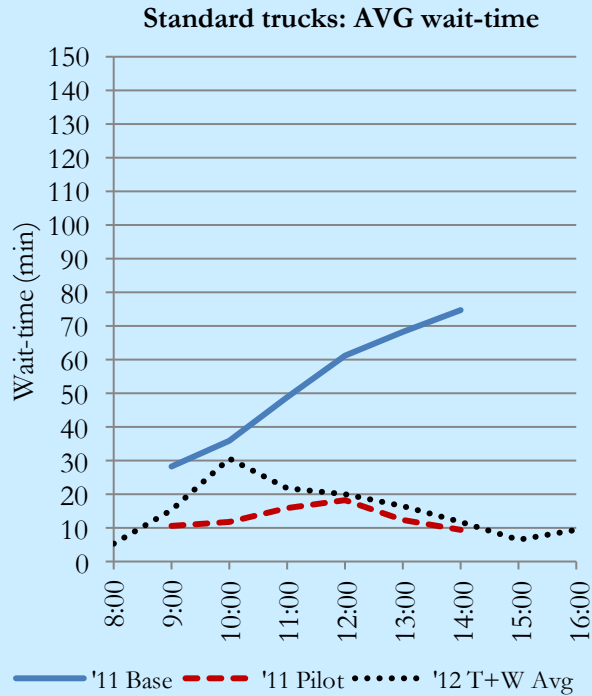
Figure 3 reveals the differences observed between the two summer 2012 survey days. The gray-shaded rows labeled “Avg. Wait” in Table 3 are used directly to generate Figure 3. As mentioned earlier, there were *surges* of traffic on Tuesday, and a *steady* series of arrivals on Wednesday. The steady traffic yielded similarly smooth graphs of wait-times (shown by the red dashed lines), which reached 10:00 a.m. peaks of about 14 min. and 8 min. for standard and FAST trucks, respectively. The overall average wait-time was 7 min. 28 sec. on Wednesday. On Tuesday, the rate of arrivals peaked at 115 per hour at about 9:00 a.m. (see Figure 2), and surged again to 95 per hour by 11:30 a.m. These surges resulted in subsequent rises in wait-times (the solid blue lines in Figure 3). There was a driver error in the staging plaza (to be described below) simultaneous with the surge in traffic, with the net result that the queue of trucks extended onto Highway 15 to a point just south of 8th Avenue. Both FAST and standard trucks are mingled in any queue that forms on Highway 15, so FAST trucks also experienced higher wait-times. But, after reaching 2nd Avenue in the mingled queue, a FAST truck is then able to bypass the cohort of standard trucks collected in the staging plaza, so FAST trucks continued to enjoy significantly shorter wait-times than standard trucks (seen by comparing the solid blue lines in the top and bottom halves of Figure 3).

Anecdotally, USCBP personnel say that the conditions observed on Wednesday—steady traffic that rarely backs up onto Highway 15—is the more common situation. We are thus lucky to have been present on Tuesday, a day that placed greater stress on the system. To represent a blend of the two

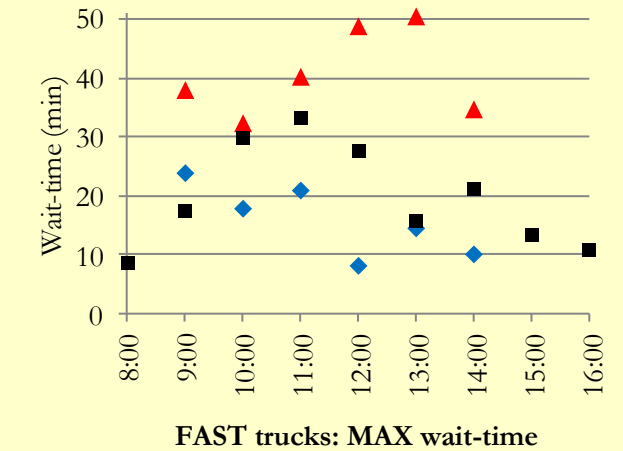
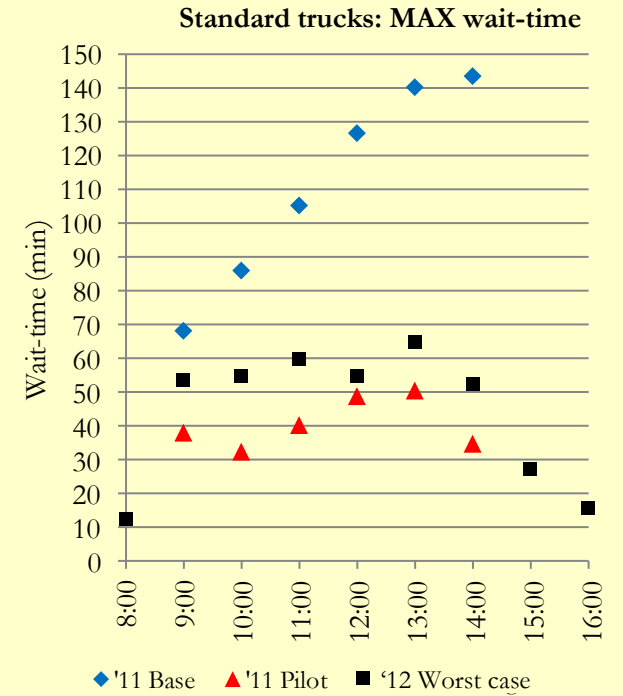
**Figure 3. Average Wait-Times:
Comparing Tue & Wed,
2012 Data Alone**



**Figure 4. Average Wait-Times:
Comparing 2012 Data to
2011 Baseline & Pilot Data**



**Figure 5. Maximum Wait-Times:
Comparing 2012 Data to
2011 Baseline & Pilot Data**



days, the dotted black line in Figure 3 shows an average based upon the combined two-day sample of 966 trucks. This average plot likely errs toward an overstatement of actual “average” conditions, given the insights shared by USCBP staff.

Figures 4 and 5 each provide comparisons between three configurations: (1) the 2011 baseline highway configuration; (2) the 2011 pilot configuration, in which FAST trucks received no preferential treatment prior to arrival at a booth; (3) the 2012 configuration, in which the upstream staging plaza constructed by BCMOT restored some preference to FAST trucks. Figure 4 examines average wait-times. The dotted black line is the same “2-days-averaged” 2012 data as is shown in Figure 3. The 2011 plot lines are as previously published on page 11 of our 2011 final study.⁸ The 2011 plot lines span fewer hours of the day because we worked longer days in the 2012 field effort.

As to be expected, the 2012 configuration results in *average* waits for *standard* trucks that are akin to those observed during the 2011 pilot phase—i.e., the dotted black line in the top half of Figure 4 is most similar to the dashed red line. The two lines differ essentially at 10:00 a.m., the time just subsequent to the previously discussed surge of arrivals on Tuesday, August 21, 2012. That surge results in a spike of the dotted black line. Aside from that spike, the dotted black line hovers slightly above the red line at the other five data points plotted from 09:00 through 14:00. Given that the dotted black line is likely an overstatement of actual “average” conditions today, we conclude that the 2012 configuration is yielding wait-times equal to or better than those observed during the 2011 pilot. If USCBP is correct that the conditions observed on Wednesday, August 22, 2012, are more representative of today’s “average,” then standard truck mobility is actually slightly better today than it was in the 2011 pilot. (Mentally slide Figure 3’s dashed red line right and note that it would generally exist beneath Figure 4’s dashed red line.) We noted earlier that counterbalancing changes in conditions are evident when comparing 2012 to the 2011 pilot—traffic volumes were higher in 2012, but inspection durations were shorter. The effect of the inspection durations is evidently the stronger of the two. Irrespective of such speculation, the 2012 configuration clearly is yielding average wait-times for standard trucks that are far shorter than those observed in the baseline 2011 configuration (solid blue line), when one booth was dedicated to FAST.

With respect to FAST trucks, Figure 4 shows an expected result—i.e., the 2012 configuration yields shorter average wait-times as compared to the 2011 pilot. This result is expected because the 2012 configuration restored a degree of preferential access to the booths for FAST trucks. Also expected, however, is that the baseline configuration (solid blue line) offered the lowest wait-times. In that configuration, FAST trucks proceeded in a dedicated lane to a dedicated booth, experiencing a wait only if there happened to be another FAST truck directly ahead. In the 2012 configuration, a FAST truck bypasses the cohort of standard trucks waiting in the staging plaza, but then mixes with standard trucks in the short queuing area that exists downstream of the plaza and upstream of the booths. That queue typically is two or three trucks, resulting in average waits that are about five minutes longer than they were in baseline conditions.

Table 4: Aggregate Average Wait-Times for Three Configurations

	2011 Baseline ^s	2011 Pilot ^s	Summer 2012
FAST trucks	4.0 min.	12.1 min.	8.7 min.
Standard trucks	52.1 min.	12.1 min.	16.1 min.
Sample size	2,547	3,557	966

Table 4 presents a single aggregate average wait-time value for each kind of truck in each of the three configurations discussed above. These aggregate values also illustrate the way in which the 2012 configuration has restored preferential access to FAST trucks, while still yielding a large reduction in wait-times for standard trucks, as compared to the baseline configuration.

Figure 5 shows the maximum wait-times experienced under the various configurations, and the same trends are evident as were just discussed with respect to Figure 4. Maximum wait-times for standard trucks in 2012 were substantially lower than those observed in the baseline configuration, but also higher than they had been in the pilot. Wait-times for FAST trucks are longer than they had been in the baseline, but shorter than observed in the pilot. FAST trucks wait less than standard trucks.

Operational Problems with the 2012 Configuration. In two days of continuous observation of operations, we noticed various problems that related to the 2012 configuration. Some problems are associated with deliberate misbehavior on the part of truck drivers, some are due to minor flaws in the operation and/or design of the plaza and its signal system, and some are long-standing ones that continue to interfere with mobility. The following discussion uses terms that are linked to Figure 1. When in doubt about what is being described, common terms found in the text and in the figure will prove useful—terms capitalized in the text refer to matching terms on the figure.

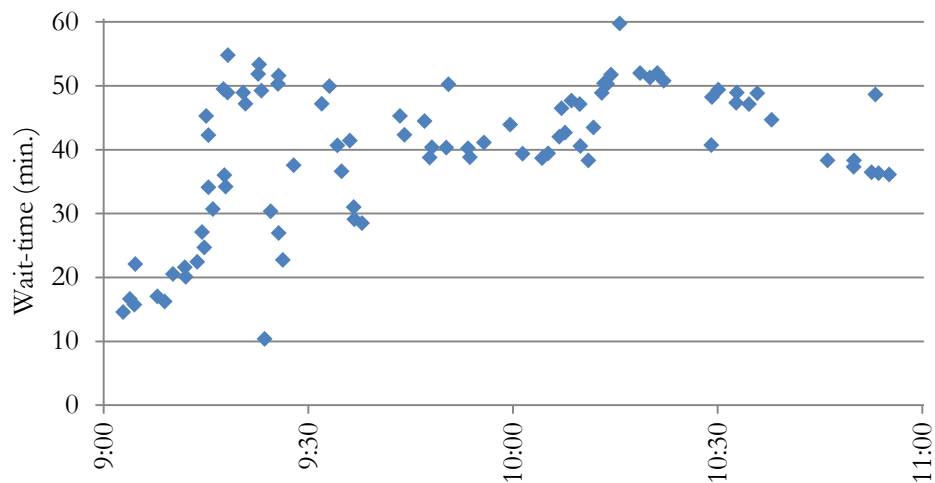
Deliberate Misbehavior.

1. When queues extend north up Highway 15, some commercial vehicles turn west on 4th Avenue (off the area pictured in Figure 1), south on 175A Street, east on 2nd Avenue, and then into the plaza's Truck Lane approach. These vehicles thereby bypass the queue between 4th and 2nd Avenues on Highway 15. Small numbers of vans, panel trucks, and automobiles were witnessed jumping the queue in this manner.
2. Similar to the above, small commercial vehicles (autos, vans) were observed bypassing the queue present on Highway 15, making the turn west onto 2nd Avenue (in the manner that would be used by residents using 2nd Avenue to access their homes), and then turning into the plaza's Truck Lane approach.
3. When queues extend north up Highway 15, small numbers of commercial vehicles bypass the mandatory turn west on 2nd Avenue and continue south using the Hwy. 15 Bus Lane. These vehicles then turn west into the area just upstream of the Staging Release Sensors. Such vehicles bypass the queue on the highway, as well as the entire staging plaza. Barriers could be used to make it impossible to turn from the Hwy. 15 Bus Lane into the truck plaza.
4. Vehicles were observed using the FAST Lane within the plaza's Truck Lane approach and then turning into Standard Staging Lanes once past the Dispersal Signal. Barriers could be used to separate the Fast Lane and the Fast Staging Lane from the remainder of the Staging Facility, making it impossible to bypass the queue in this manner.

5. Vehicles were observed traveling to a Standard Staging Lane other than the one to which they were directed by the Dispersal Signal. Typically the control system works sequentially upward through Standard Staging Lanes, while maintaining an empty staging lane between the lane that is being filled by the Dispersal Signal and the one being released to approach the booths. For example, the system might be directing trucks to enter lane 5, maintaining lane 6 as an empty buffer, and signaling vehicles within lane 7 to proceed to the booths. In this example, a truck would be directed to go to lane 5, but would instead drive to the back of lane 7, thereby tagging onto the back of the group of vehicles being released toward the booths. Such vehicles bypass the entire wait within the Staging Facility.
6. Vehicles that were not FAST-compliant used the Fast Lane and Fast Staging Lane to bypass the entire wait within the Staging Facility. Unless USCBP closely monitors which vehicles traverse the Fast Staging Lane and are then found to be non-Fast when processed at the booth, such behavior is undetected.
7. Vehicles waiting within the Staging Facility run red lights and move toward the Staging Release Sensors when not yet authorized to do so. This typically occurs at times of high congestion, and may be due to drivers believing that the system has erroneously held them in the Staging Facility for an unfair length of time.

Such behaviors are intended to jump ahead in the queue in a manner unfair to fellow drivers. We note that overall system throughput is unaffected by such behavior—some drivers simply experience longer waits because their peers have jumped ahead of them in the queue. The frequency of such behavior is not great. Figure 6 is a scatter plot of the wait-times experienced by standard trucks during two hours of peak congestion on Tuesday, August 21, when there was a queue extending north on Highway 15 to almost 8th Avenue. The data points that fall well beneath the obvious general clustering are likely instances of queue-jumping of one type or another. For instance, just prior to 9:30 there are several trucks that enjoyed waits of 30 minutes or less at a time when the typical wait-time was about 50 minutes.

Figure 6: Scatter Plot of Wait-Times, Standard Trucks, August 21



Accidental and/or Unavoidable Behavior.

8. A vehicle can stop at the Dispersal Signal at a point so far north that it fails to trigger the Dispersal Sensor. Such a vehicle never receives a green light to enter the Staging Facility. On Tuesday morning during the period of peak arrivals such an incident occurred, and a queue rapidly extended north onto Highway 15. When trucks arrive at a rate of 115 per hour, a 10 minute error can result in a 1,700 foot (one-third mile) queue on the highway. A possible solution is to install signage directing drivers to pull up to the painted stop bar at the Dispersal Signal. Another solution is for the control system to simply turn green and direct a truck forward at a slow baseline frequency (e.g., once every two minutes) even when it senses no truck at the Dispersal Sensor.
9. There are two Parking Stalls available within the Staging Facility, enabling a driver to complete paperwork that may be necessary prior to exiting Canada. At times the number of trucks needing to park exceeds the available space. Such trucks then park within one of the Standard Staging Lanes, which leads to erratic behavior of the control system (described in the following section). A possible solution is to convert Standard Staging Lane #1 into a third parking stall. In conjunction, better signage near the Dispersal Signal would help drivers understand the location of the available Parking Stalls.
10. A vehicle stationed over a Staging Release Sensor might loiter there while quite a bit of empty space develops between it and the booths. Such a vehicle prevents the control system from releasing other vehicles from the Staging Facility. Signage might be deployed to ensure that drivers continue to creep forward over the Staging Release Sensors.

System Programming Issues.

11. When a truck remains stationary within a Standard Staging Lane due to breakdown or to driver behavior (i.e., inappropriately parked there), the control system seems not to gracefully degrade to new a lane-release sequence that correctly skips that lane. We observed an instance in which a truck was parked over the Rear Truck Sensor in lane 7 for a half hour. The control system continued to try to fill that lane for awhile. Eventually, the control system entered a mode in which it never issued green lights for the adjacent lane 6 (and possibly lane 8), but continued to release other lanes.
12. The control system never directs more than one standard length tractor-trailer rig into lanes 2, 3, 4, or 5. It appears that a single truck positioned correctly over the Front Truck Sensor also extends so far back as to trigger the Rear Truck Sensor within its lane.
13. The control system includes a parameter dictating how many Fast trucks in a row are released from the Fast Staging Lane before a green signal is issued to a Standard Staging Lane. At times of great congestion (e.g., Tuesday morning), it is our belief that the system provides too much benefit to Fast trucks. We witnessed intervals several minutes in length in which no Standard Staging Lane received a green light, while Fast trucks continued to move. Drivers of standard trucks must perceive that some motion is occurring within their queue.
14. A Front Truck Sensor consists of a set of three detector loops. We believe that in one instance a pickup truck at the front of a Standard Staging Lane was triggering the front-most loop, and a semi-rig was so close behind as to trigger the rear-most loop of the same sensor array. The control system issued a green, allowing the pickup truck to advance. But the control system did not then issue another green to release the semi-rig. The semi-rig had to wait through another entire series of sequential lane releases before receiving a green light.

An oft-noted source of delay was again evident—the delay caused downstream of the inspection booths by trucks attempting to reach the VACIS machine. A truck clearing through booth 1 or 2 that has been sent to VACIS examination but that can't proceed directly to the VACIS can find itself blocking the route that other trucks must take as they clear through booths 2 or 3 and attempt to turn south to the exit booth. We assume that USCBP has previously investigated solutions such as holding a truck at the booth until the way is clear to advance all the way to the VACIS (which has the effect of blocking only one booth, rather than two or three), or routing trucks through the VACIS in the opposite direction, which might accommodate a larger number of queued trucks waiting for VACIS availability.

Conclusion

Several items are worth mentioning in conclusion:

- The plaza reconfiguration constructed by BCMOT has succeeded in its goal of retaining the overall benefit of reduced wait-times for standard trucks, while restoring a degree of preferential access to FAST trucks.
- There continue to be ways in which the plaza can be fine-tuned to produce maximum use of its capacity, and/or optimal fairness to users.
- There are various ways in which drivers intentionally misbehave in order to jump the queue. Such behavior is to the detriment of fellow drivers, but does not affect the throughput of the crossing. These behaviors are most likely to occur when high traffic volumes have resulted in a queue of trucks extending north on Highway 15, but we believe that instances of such congestion are fairly infrequent at this time. Some such behaviors can be prevented with fairly simple modifications to the plaza.
- USCBP has achieved a significant reduction in the average length of the inspection process, as evidenced by comparison to datasets collected in prior years. USCBP now processes 80 trucks per hour at the booths, as compared to 73 in spring 2011.
- Traffic at the crossing has grown. On one field day, the rate of arrivals exceeded 80 per hour for a significant portion of the day, resulting in lengthy queues. Future growth in traffic will result in a recurrence of long queues unless USCBP finds ways to shorten the duration of all inspections, or unless the proportion of FAST trucks increases (because such trucks are processed more rapidly at the booth).
- We are grateful, as always, for the outstanding cooperation we received from USCBP and CBSA in the conduct of this field project.

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