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Eliminating the FAST Lane at the Pacific Highway Crossing: A Simulation Analysis

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ELIMINATING THE FAST LANE

AT THE PACIFIC HIGHWAY CROSSING:

A SIMULATION ANALYSIS

by

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INTRODUCTION

A recent study by Springer (2011) analyzed the results of a 2011 pilot project at the Southbound Pacific Highway Crossing (PHC) for commercial freight traffic. The goal of the study was to gauge the impact of opening the FAST booth, which was restricted to enrollees in the FAST, or Free and Secure Trade program (USCBP, 2005), to general purpose (GP) commercial freight traffic. To qualify for FAST, carriers, drivers, and shippers are required to follow certain security procedures which enhance the safety and security of the border. Trucks enrolled in FAST were then allowed to use the dedicated lane and inspection booth at the Southbound PHC, which enabled them to bypass the frequently much longer queues in the GP lane. In a prior study based on PHC data gathered in 2009, Springer (2010) had used a simulation experiment to examine the estimate the impact of opening the FAST lane to all general purpose traffic. The analysis found that opening the southbound FAST lane and booth to all freight would dramatically cut overall average waiting time, although waiting times for the FAST trucks mixed in with the GP traffic would of course increase.

Based on this simulation experiment, a decision was made to conduct a “live” experiment via a pilot project at the PHC: data were to be collected over a period of several days while two different lane configurations were in operation at the Southbound PHC. The *baseline* configuration was to be the then-current configuration involving one FAST lane and booth, and one GP lane and two GP booths; the *pilot* configuration would consist of a single GP lane and three GP booths (Davidson, 2011). The empirical results of this study were reported in Springer (2011) and in a report published jointly by the Border Policy Research Institute and the Whatcom Council of Governments (2011).

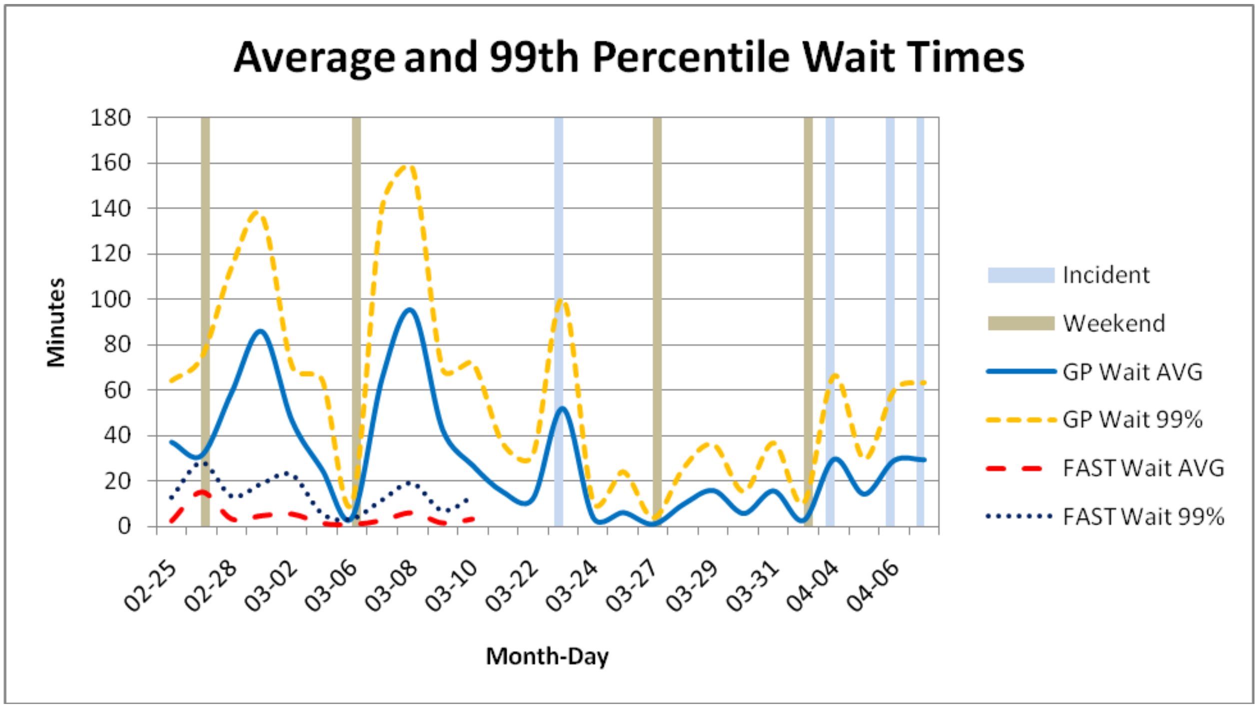

Figure 1: Average and 99th Percentile Waiting Times for FAST and GP Lanes (From Springer, 2011).

The results of the pilot project showed, as expected, a dramatic decline in system-wide average wait times when the FAST booth was opened to GP traffic. Figure 1, showing the average and ninety-ninth percentile waiting times, is reproduced from Springer (2011). It is easy to determine the end of the baseline phase and the beginning of the pilot project simply by looking at the graph: the dramatic drop in average waiting time occurs on 03/21/2011, the first day of the pilot project configuration.

While GP waiting times did drop dramatically during the pilot phase, there were limitations to directly comparing the results from the two phases. Since the underlying operating conditions were not identical during the two phases of the study, to a certain extent comparing their summary results is a matter of comparing apples to oranges. Table 1 shows the differences in overall average arrival rates and inspection times for the baseline and pilot configurations, as well as reporting those items for the 2009 study and two earlier studies of the Southbound PHC in 2006 (WCOG, 2007) and 2002 (USDOT, 2003). Note that the arrival rate of trucks to the Southbound PHC was notably higher during the pilot phase than it was in the baseline phase; this holds true for both the "raw" arrival rate and the "adjusted" arrival rate that includes an estimate of additional arriving trucks that were missed by the data collectors.[1] In addition, the overall inspection average time was slightly higher during the pilot phase. Since both higher arrival rates and longer inspection times would, with everything else being equal, lead to longer waiting times, this enables us to conclude that the waiting time differential observed in Figure 1 is understated: if the same conditions existed for the pilot phase as for the baseline phase, the difference between the average waiting times in the two phases would be greater than was observed in spring 2011.

	2002	2006	2009	2011-Base	2011-Pilot
% FAST	NA	35%	23%	23%	NA
Arrivals/Hour	78	65	51	53	64
Arrivals/Hour as % of 2011 Baseline	147%	123%	96%	100%	121%
Adjusted Arrivals/Hour	81	69	55	57	67
Adj. Arrivals/Hour as % of 2011 Baseline	142%	121%	96%	100%	118%
Inspect Time-FAST (Sec)	NA	86	75	79	NA
Inspect Time-GP (Sec)	57	120	98	106	102
Inspect Time-Overall Avg (Sec)	57	108	93	100	102
Overall Insp. Time as % of 2011 Baseline	57%	108%	93%	100%	102%
Gap Time (Sec)	NA	NA	NA	16	16
Transition Time (Sec)	NA	NA	NA	20	20

Table 1. Summary Data from Five Studies of Southbound PHC Freight.

[1] See Springer (2011) for a discussion of how these adjusted arrival rates and all other summary statistics were calculated.

Since the arrival rate and mean inspection time are difficult, if not impossible, to control from day to day, the only way to obtain an "apples to apples" comparison of the two configurations is to use a simulation model of the border crossing. With a simulation model, both systems can be examined under the exact same operating conditions. Any difference in the performance measures can then be solely attributed to the different designs of the two competing border configurations. This paper details the results of such an analysis, using an extension of the simulation model developed by Springer and Roelofs (2007) and Springer (2010). The results generally support the conjecture stated above: namely, that when conditions are held constant, the relative performance of the pilot configuration compared to the baseline configuration improves beyond that observed during the pilot project.

THE BASELINE BORDER CONFIGURATION

Consider first the baseline border configuration. As discussed above, this configuration included one approach lane and booth reserved for FAST vehicles, and one approach lane and two booths for general-purpose vehicles. As can be seen from Table 1, the inspection time for the FAST vehicles was less than that of the GP vehicles. For both FAST and GP vehicles, however, the utilization of the inspection booth was limited by the "gap time" and "transition time" incurred by each truck as it prepared to move to the inspection booth. Prior to driving up to the booth window, each truck must stop in front of the radiation portal monitor (RPM), which is several meters in front of the booth. When the truck being inspected at the booth departs, the truck waiting at the RPM must then move forward to the inspection booth before the inspection process can begin. The time required to move this distance was observed to be approximately twenty seconds and is referred to as the transition time. Clearly, while the truck is moving it is not being inspected, and the inspector is not inspecting any other truck, so this effectively lengthens the time needed to process each vehicle. In addition, there is on average a sixteen second "gap" between the departure of a truck from the inspection booth and the time that the subsequent truck begins to move to the booth; this is referred to as the "gap time" and also serves to limit the inspector's utilization.

The inspection time, gap time, and transition time distributions were consistent throughout the day and were modeled accordingly in the simulation: for each of the three different times, a single log-logistic distribution was fit to all of the data gathered under baseline conditions. The arrival rate, however, was clearly not constant throughout the day. Figure 2 shows the (adjusted) average hourly arrival rate throughout the day for both the baseline and pilot phases. While the similarity in the two profiles is notable, clearly trucks arrive most frequently early in the day. In the simulation, the arrival rate was updated each half hour based on the average observed arrival rate at that time for that phase.

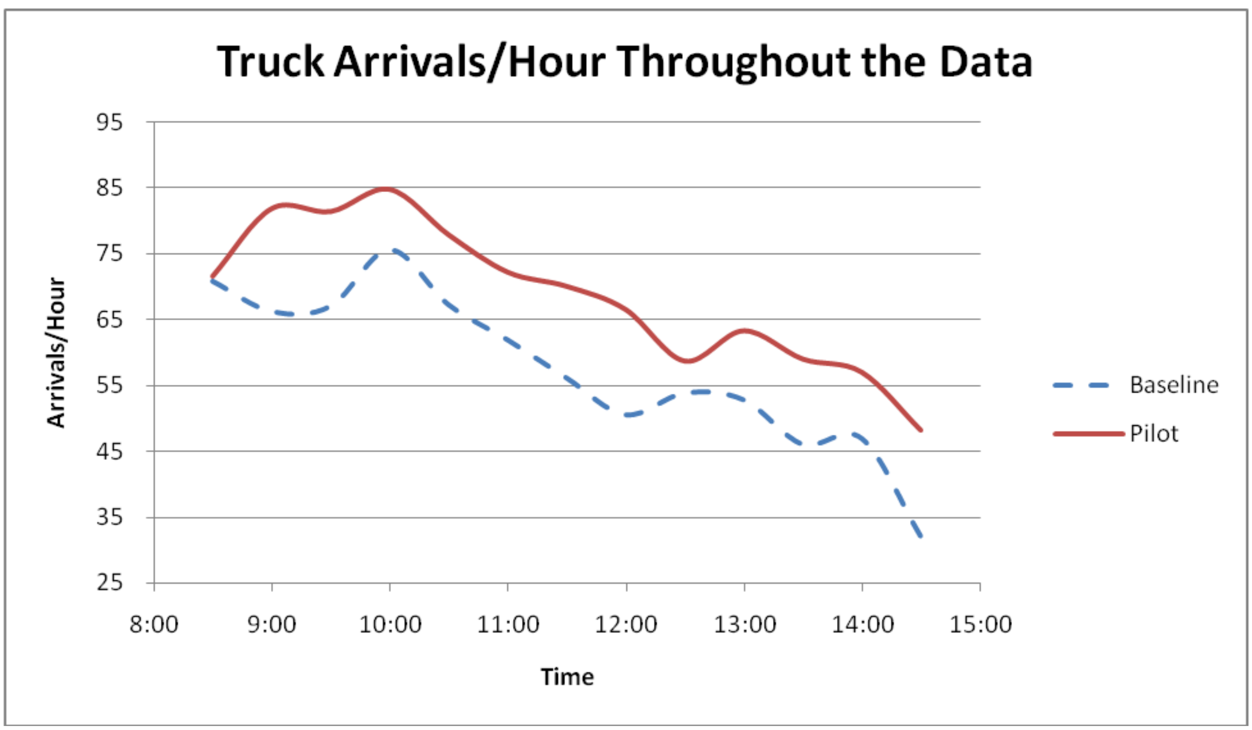

Figure 2: Arrival rate profiles for baseline and pilot phases.

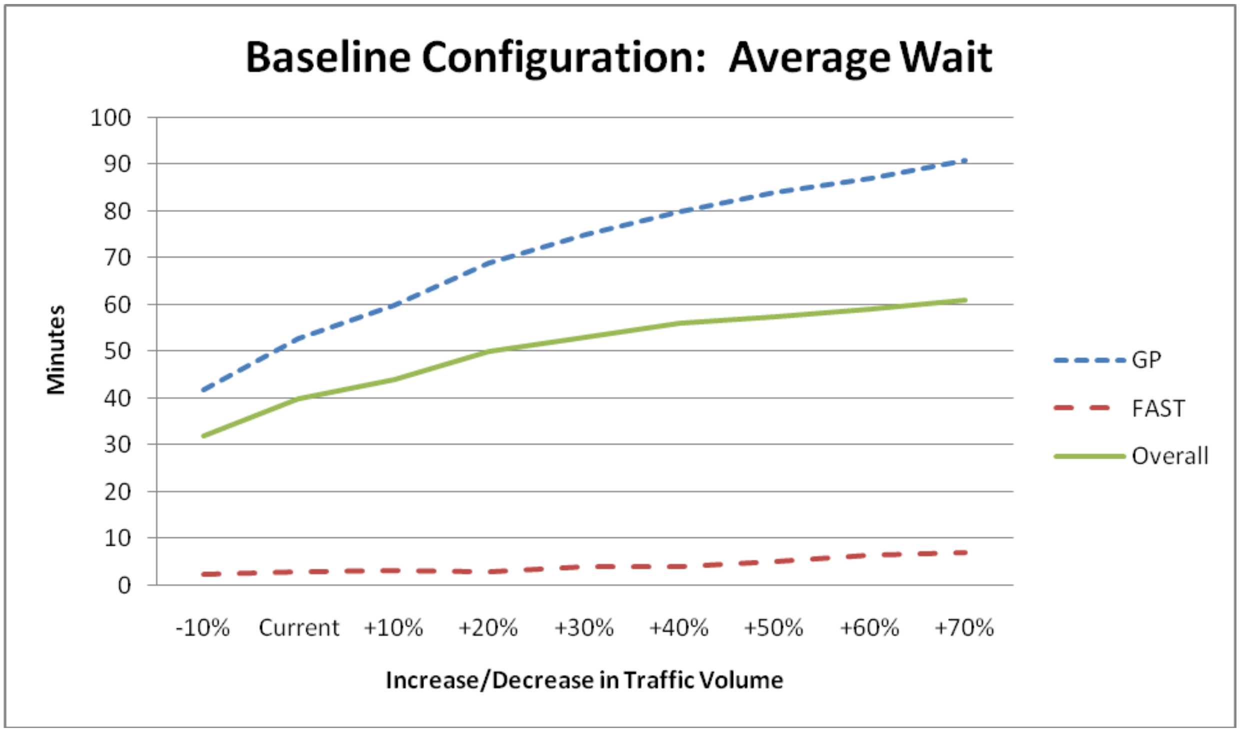

Figure 3: Average waiting times for varying levels of traffic volume: baseline configuration.

Now consider the performance of the baseline configuration. Figure 3 shows the average waiting time for nine different levels of traffic volume.[2] The current level of traffic is defined as that experienced during the baseline phase of the current project, and traffic volumes ranging from ten percent below the current level, to seventy percent above the current level, are shown on the graph. For each level of traffic volume, twenty-five days of border operation were simulated. While, for a specified traffic volume, the daily arrival rate pattern was held constant across the twenty-five simulated days, random fluctuations from day to day result in different average and maximum waiting times for each of the twenty-five days. This variability in performance imitates the actual situation where waiting times can differ between two days even though the underlying arrival rate pattern hasn't changed; in the simulation, this variability is

[2] The nine levels are those labeled across the horizontal axis of the chart. The results are presented as continuous lines to facilitate viewing.

accomplished by starting each of the twenty-five simulations with a different random number "seed." Averaging across twenty-five simulated days thus gives us a better estimate of the "typical" daily performance than just using the result of a single simulated day.

At the current level of traffic volume, the simulated baseline average wait times of approximately fifty-three and three minutes, for GP and FAST trucks, respectively, compare favorably with the wait times observed during the baseline phase (see Figure 1). The solid line represents the overall weighted average waiting time for the system, recognizing that twenty-three percent of the trucks are FAST-qualified and that the remainder must use the GP lanes. The performance of the configuration under increased demand is of interest since, as Table 1 illustrates, truck arrival rates at the Southbound PHC vary from year-to-year in concert with the business cycle. If demand were to increase to the levels seen in 2002, that would be a jump of between forty and fifty percent over the levels observed during the 2011 baseline phase. The relative performance of the two competing configurations during different levels of traffic is therefore an important question.

As discussed above, randomness causes the average wait to vary from day to day: we therefore would also like to know how "bad" the waiting time could get under the different traffic levels. Figures 4 and 5 consider two related but different ways of answering this question. Figure 4 shows the *maximum average waiting time* across all twenty-five days for each traffic level, i.e. the graph shows the "worst" day observed for that traffic level out of all twenty-five simulated days. This is roughly equivalent to the expected waiting time on the most congested day of the month. Once again, a check of Figure 1 confirms that these estimates for the current traffic levels are within the observed range of maximum average waiting times observed during the baseline phase.

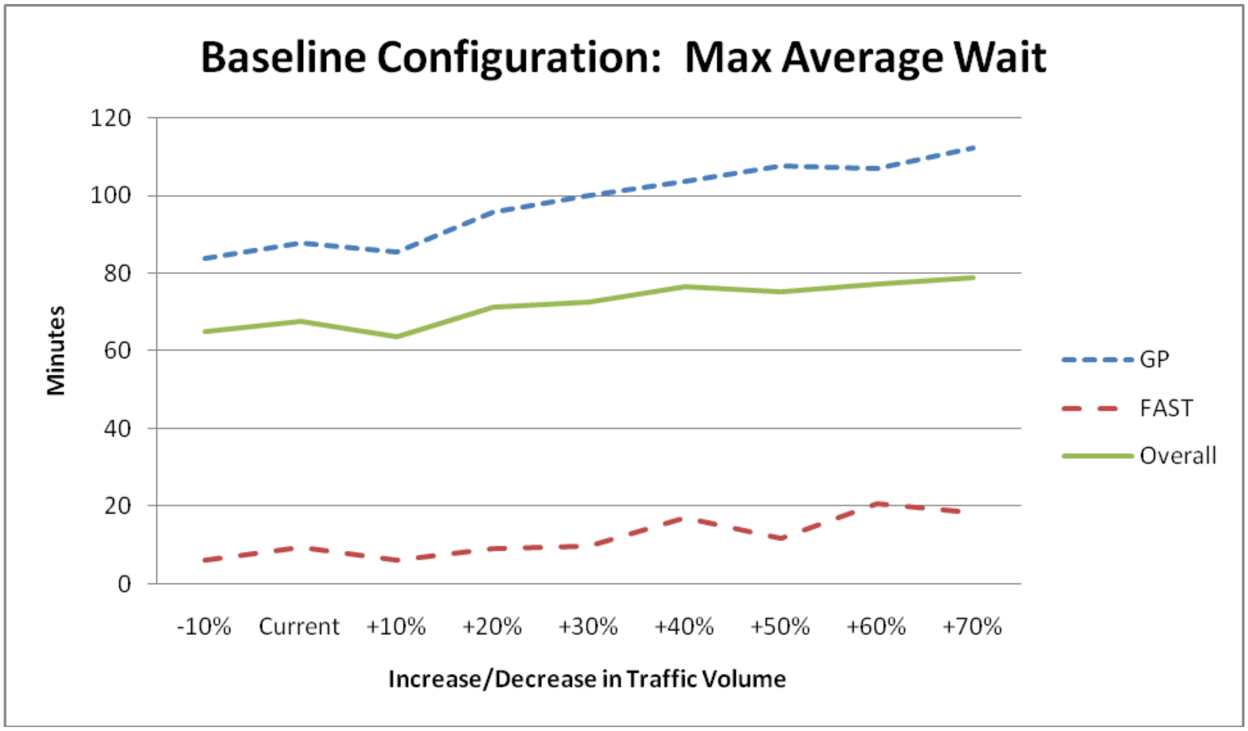

Figure 4: Maximum average waiting times for varying levels of traffic volume: baseline

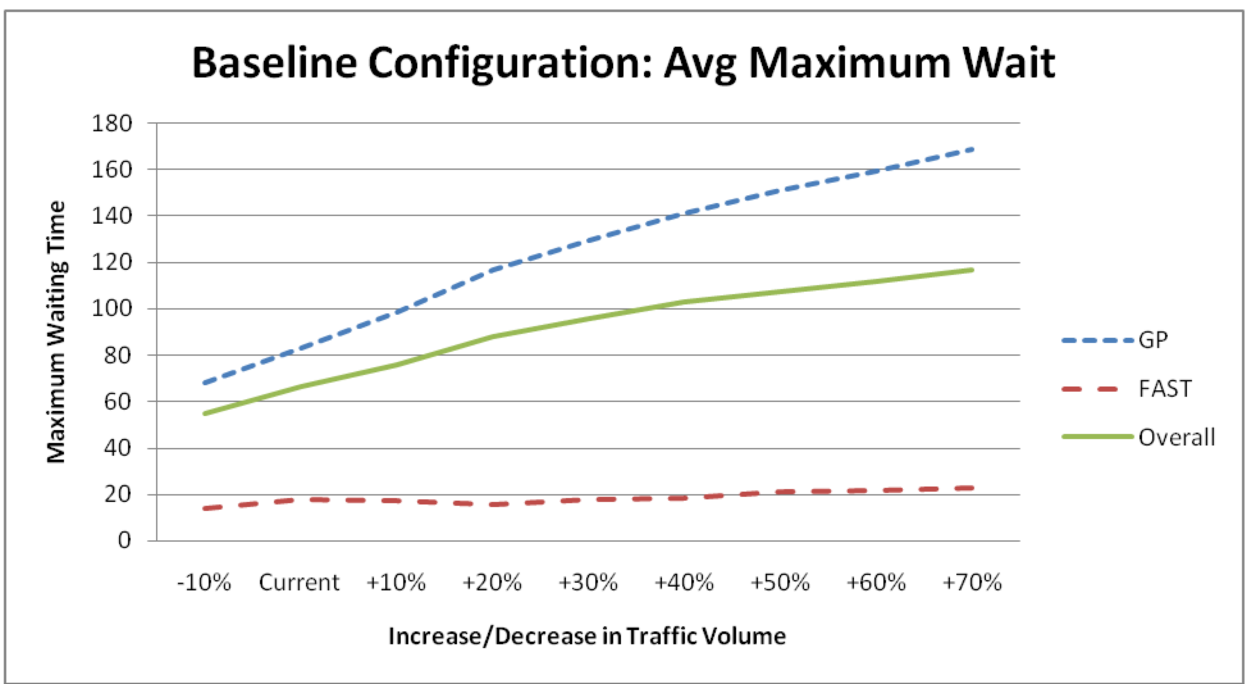

Figure 5: Average maximum waiting times for varying levels of traffic volume: baseline.

In addition, within each simulated day we can determine the *average maximum wait*: this is the average, across all twenty-five simulated days for a given set of conditions, of the "worst" wait experienced by a truck each day. This is therefore an estimate of the longest wait experienced each day by a single truck. As shown in Figure 5, this time grows dramatically worse as traffic levels increase.

Finally, consider the utilization of the GP and FAST inspection booths under the baseline configuration. Figure 6 shows that under the current configuration, the GP booths utilization seems stuck at seventy-five percent, while the FAST booth utilization is currently quite low (thirty-five percent) but grows as the traffic volume increases.

The GP booth utilization of seventy-five percent shows that under the baseline configuration and current demand, the inspectors working the GP booths have little to no slack capacity: the thirty-six seconds needed, on average, for gap time and transition time for each truck, uses up roughly twenty-five percent of the inspectors' available time. The low utilization

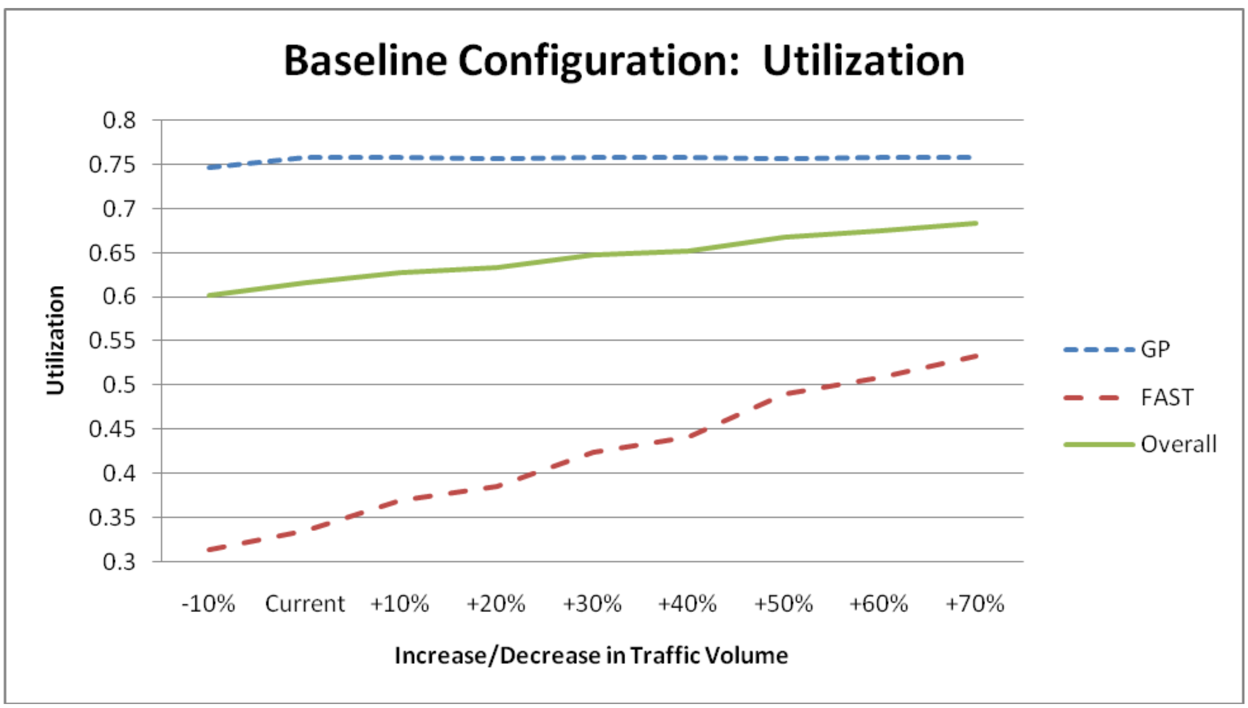

Figure 6: Booth utilization for varying levels of traffic volume: baseline.

of the FAST booth, of course, is what keeps the FAST waiting times low. Since the GP booths are working near capacity, on the other hand, an increase in demand simply builds up the queue until it can be cleared when demand slackens later in the day.

THE PILOT BORDER CONFIGURATION

In the pilot configuration, one approach lane and three booths were open for general-purpose truck traffic; any FAST-qualified trucks moved through the border crossing mixed in with the GP trucks. The same arrival rate profile was used for the simulation analysis of the pilot phase as for the baseline phase. While this profile was based on data collected during the baseline phase, it was necessary to use the same profile to enable an "apples to apples" comparison between the two phases. Fortunately, the average daily arrival rate profile was very similar for the two phases, as shown in Figure 3: the chief difference was one of scale. The closest approximation of the actual demand conditions experienced during the pilot phase may therefore be found on the chart for a traffic volume twenty percent greater than the "current" level. The transition time and gap time distributions were also identical to those used for the baseline phase, as no meaningful difference was noted for these times between the two configurations. The inspection time distribution for the pilot phase, of course, was modeled separately using data gathered from the pilot phase of the project. The data fit a log-logistic distribution, and as can be seen in Table 1 the average overall inspection time was slightly higher in the pilot phase than in the baseline phase.

Figure 7 shows the average, the maximum daily average, and the average daily maximum for different traffic levels under the pilot configuration. As can be seen from the graph, *under the same demand conditions experienced during the baseline phase, the average expected waiting time per truck is less than ten minutes.* The maximum daily average across twenty-five

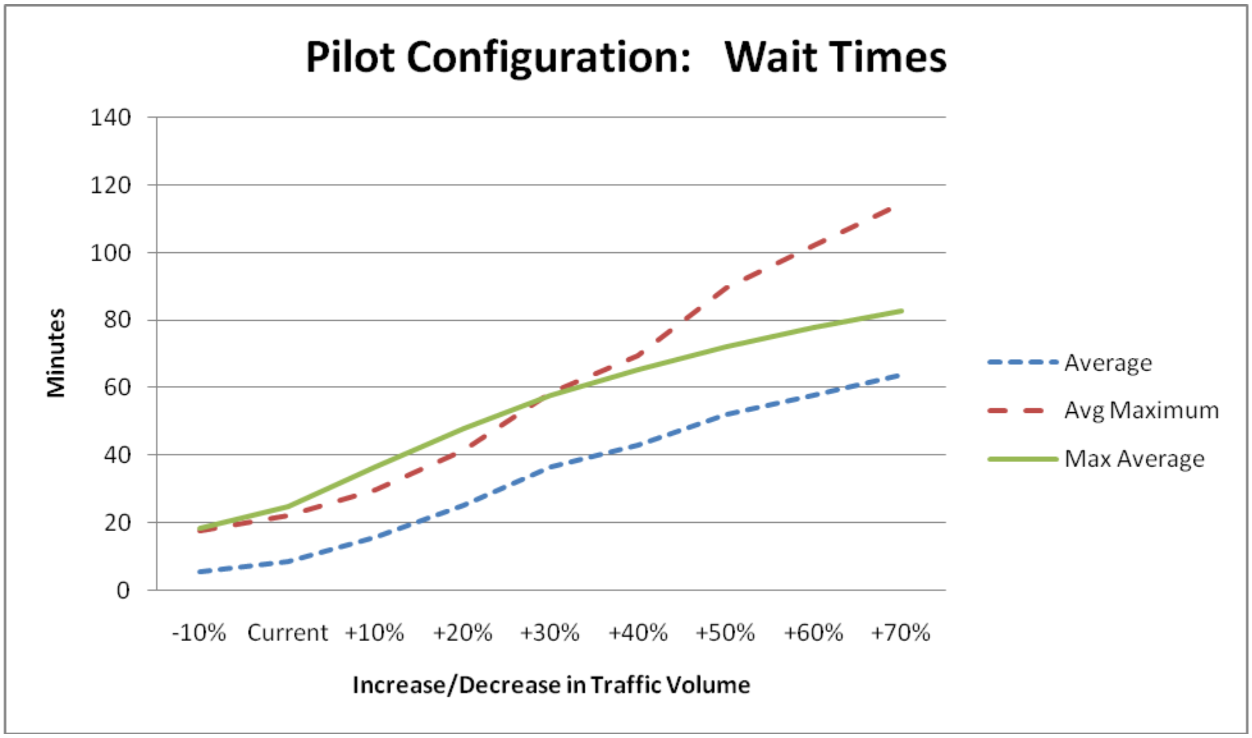

Figure 7: Average, maximum average, and average maximum waiting times for varying levels of traffic volume: pilot.

days and the average of twenty-five "worst case" waiting times are both less than thirty minutes under the same demand conditions. As the traffic rate rises, the average maximum wait deteriorates more severely, reaching nearly ninety minutes under 2002 traffic volume conditions (Current + 50%). Therefore, at current or similarly low traffic volumes there appears to be a very modest penalty imposed on FAST trucks to gain the system-wide reduction in waiting time, but at higher traffic levels the difference between the worst-case wait times for FAST vehicles in the baseline configuration and in the pilot configuration are over an hour.

The impact of the additional capacity that is made available to GP trucks in the pilot configuration is evident in Figure 8. At current – that is, baseline current – levels of traffic volume, the utilization of the three GP booths is less than the maximum of seventy-five percent. At this traffic level, the system has used some of the excess FAST booth capacity to reduce GP wait times and still has capacity left over, resulting in the sub-ten minute waiting times. As the

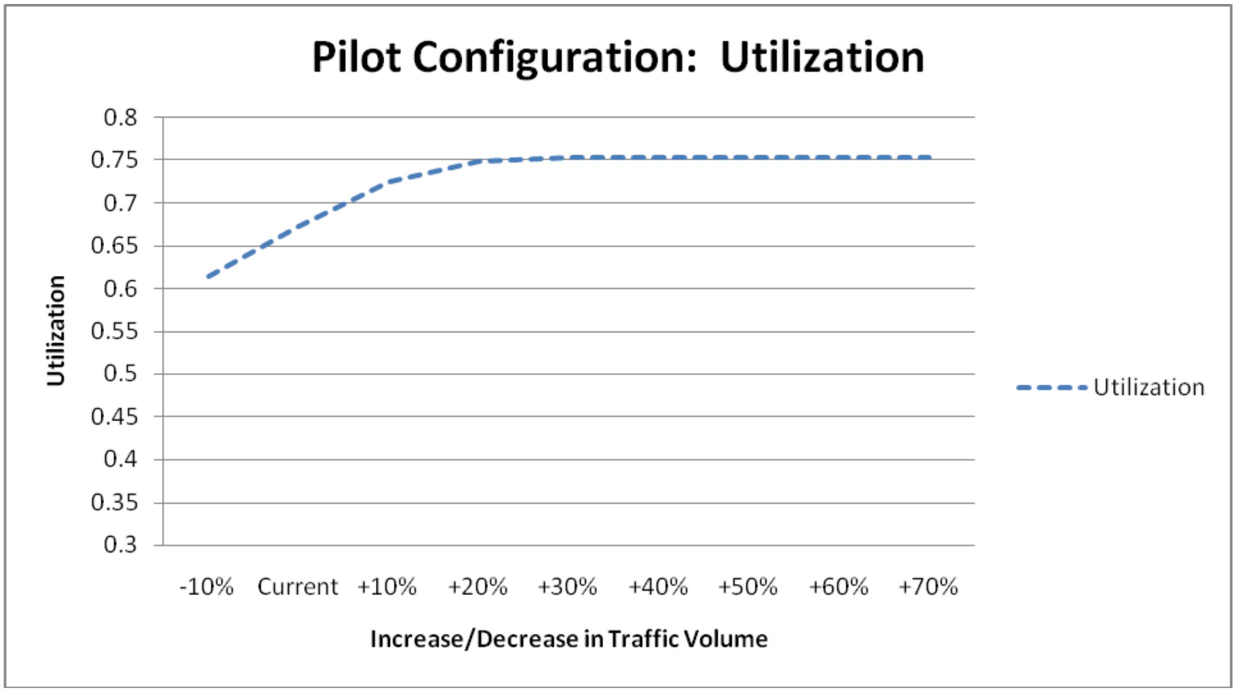

Figure 8: Booth utilization for varying levels of traffic volume: pilot.

traffic level increases, the seventy-five percent utilization level is reached, leading to queues that are longer but still much shorter than the GP queues in the baseline configuration. The shorter queues will also result in the system clearing out faster once the arrival rate begins dropping later in the day.

POSSIBLE ADDITIONAL SOURCES OF SYSTEM CAPACITY

Under current traffic volumes, opening the FAST booth to GP traffic dramatically reduces waiting times for GP trucks at the price of a modest waiting time increase for FAST-eligible trucks. Before closing, it should perhaps be noted that there may be other sources of "hidden" capacity in the system which could be revealed at the expense of a system redesign. For example, Table 1 shows that the average inspection time has fluctuated significantly from year to year. This is likely the result of job changes – adding or subtracting tasks from the inspector's duties – and changes to this time can have an impact on system performance. Figures 9 and 10 show the average waiting time under the baseline and pilot configurations if the inspection *rate* (the speed with which vehicles are inspected) in each configuration were to increase by ten percent. As can be seen from comparing Figures 9 and 10 with Figures 3 and 7, such a change would have a modest impact at lower levels of traffic, dropping average wait times in the baseline configuration by almost ten minutes. At higher levels of traffic intensity, however, the benefit shrinks, suggesting that a small increase in the inspection rate is not likely to result in a great reduction in waiting times.

Another potential source of additional capacity is the roughly twenty-five percent of the time that the booths are waiting for queued trucks to arrive at the booth. Such a change would likely require a significant physical re-layout of the border area, so it is perhaps impractical as a short term solution. However, while the movement required by the transition time may be hard to eliminate, the gap time – the time from when the booth is available to when the waiting truck begins to move towards it – could perhaps be reduced with better signaling.

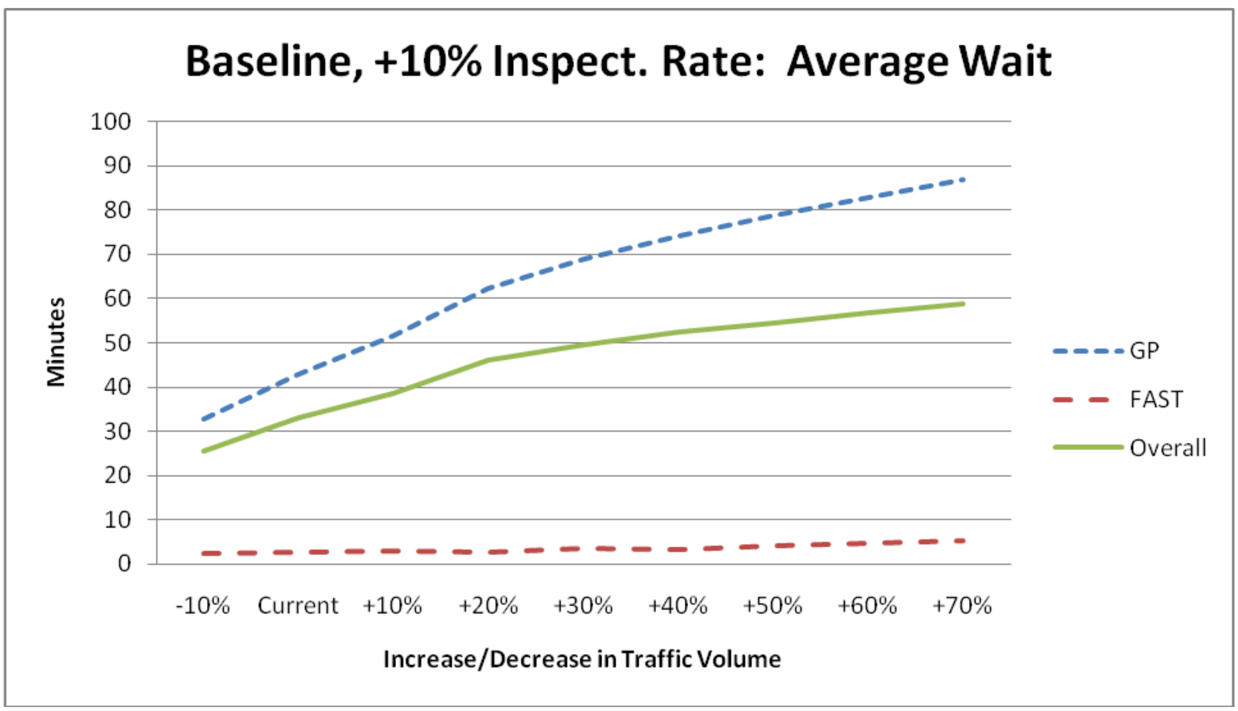

Figure 9: Average waiting times with 10% increase in inspection rate: baseline

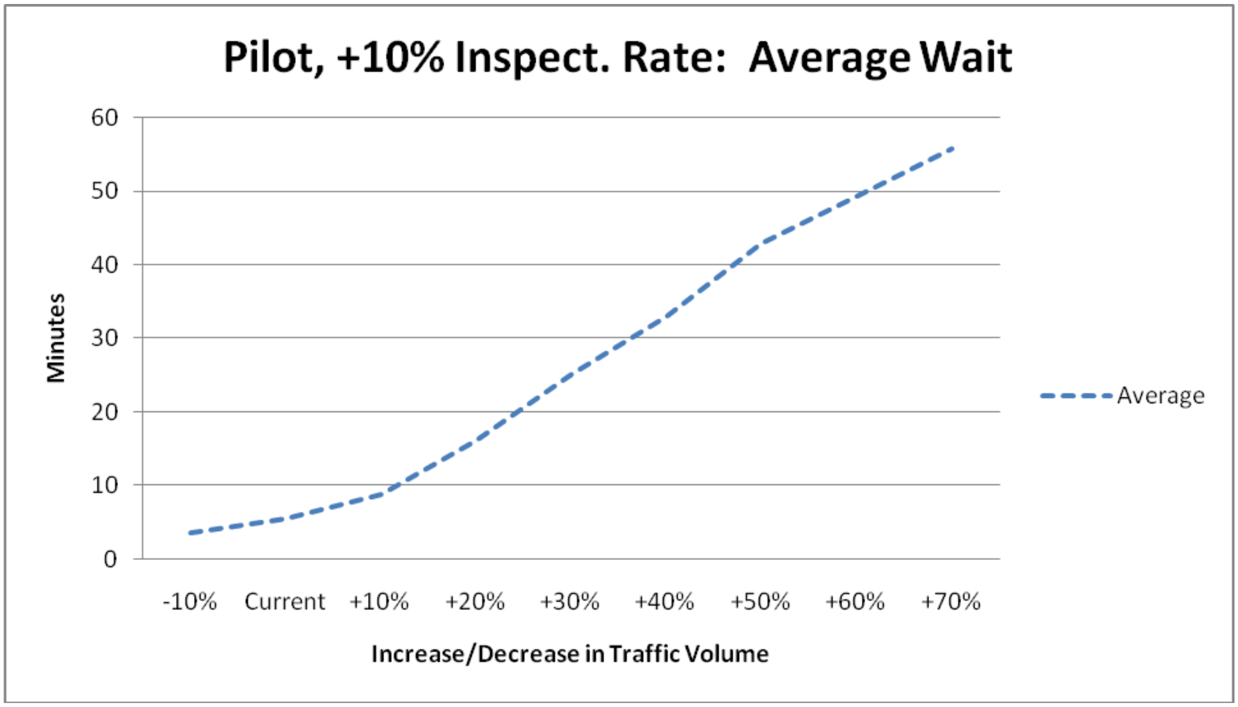

Figure 10: Average waiting times with 10% increase in inspection rate: pilot.

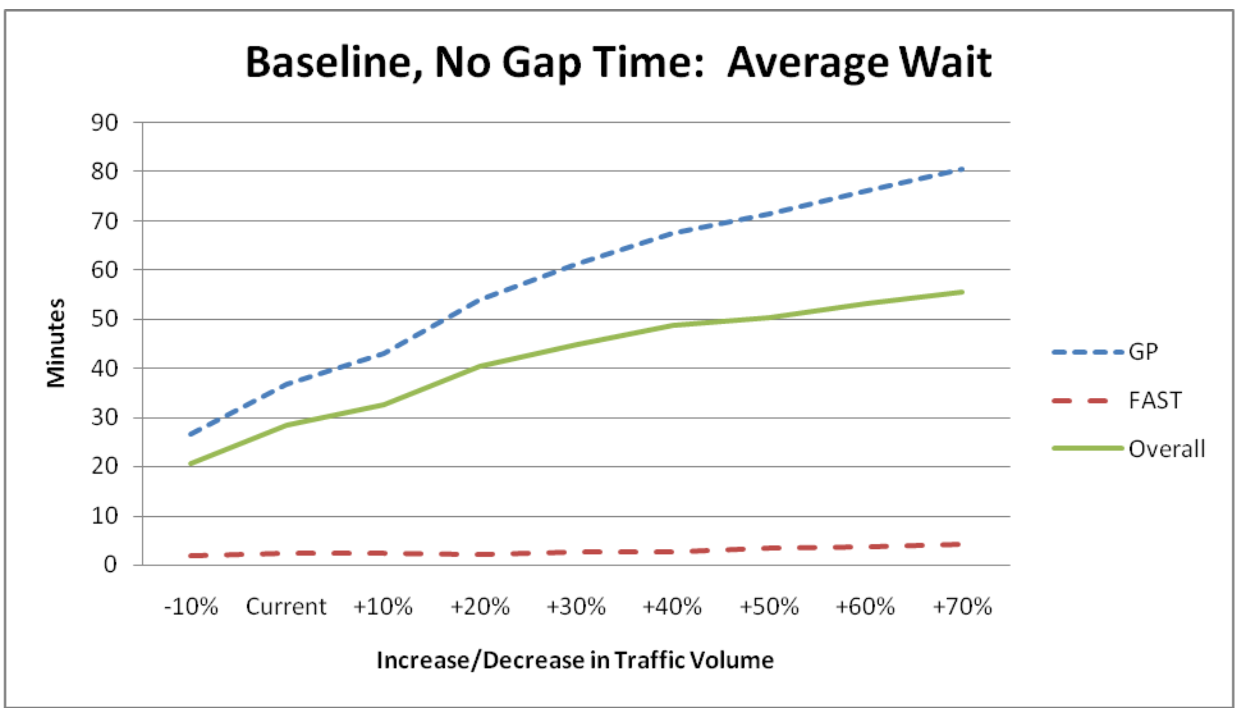

Figure 11: Average waiting times with no gap time: baseline.

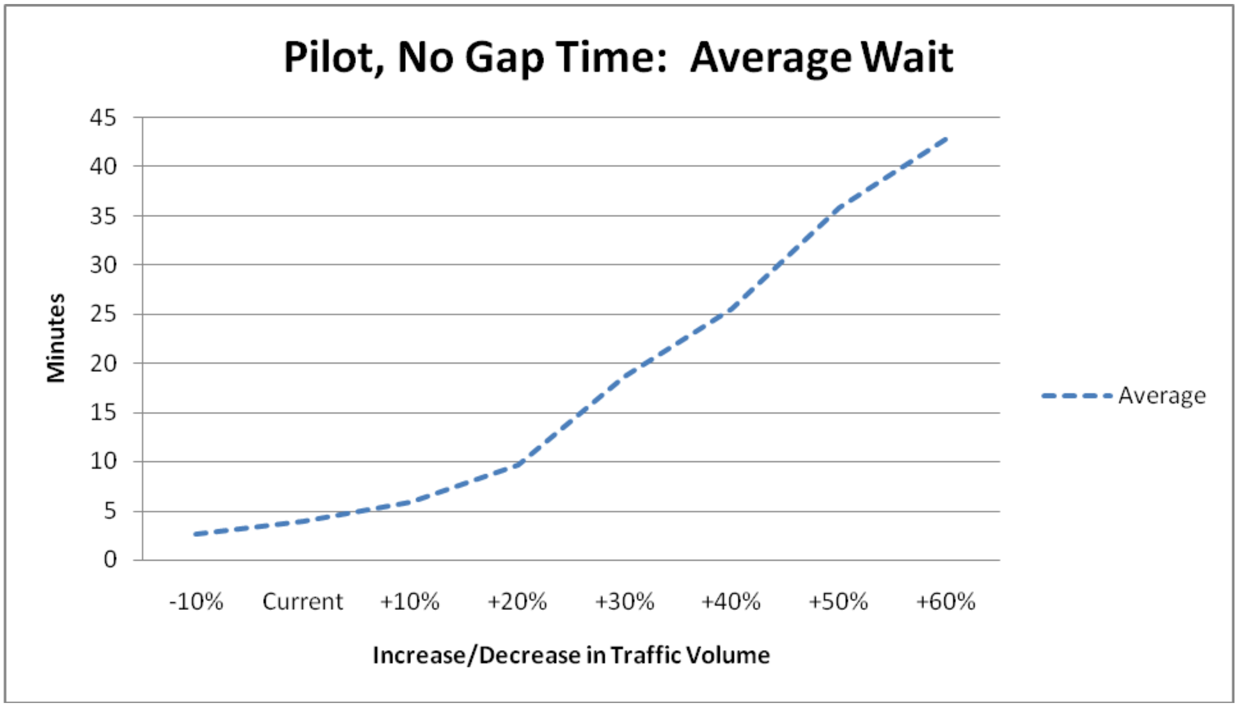

Figure 12: Average waiting times with no gap time: pilot.

Figures 11 and 12 show the average waiting times for the baseline and pilot configurations if the gap time could be eliminated. As can be seen in comparison with the preceding figures, eliminating the gap time would result in a greater increase in system capacity than increasing the inspection rate by ten percent. Even at higher levels of traffic, average wait times are at least ten minutes less in both configurations when the gap is eliminated.

CONCLUSION

A pilot project conducted in Spring 2011 compared the current baseline configuration of the Southbound PHC with a new pilot configuration that opened up the FAST booth to general purpose-traffic. During the experiment, background conditions worsened during the pilot phase of the project: traffic volume was markedly higher, and inspection times were slightly higher. Nonetheless, wait times dropped dramatically for GP trucks in the pilot configuration: average waiting times of over an hour dropped to twenty minutes for the same time of day. This led to expectations that, if operating conditions were held constant, the relative benefits for GP traffic of switching to the pilot configuration would be even greater. This simulation analysis has essentially confirmed this hypothesis: under the arrival rate profile observed during the baseline phase of the project, average waiting times for GP trucks dropped from over fifty minutes to under ten minutes when the PHC configuration was changed. Furthermore, this was accomplished at a small penalty for FAST-qualified trucks, which saw their expected waiting time increase by five minutes in the new configuration. As traffic levels increase, the pilot configuration still delivers notably shorter GP and system-wide average waiting times than the baseline configuration, although at such higher volumes the penalty in the pilot configuration for FAST enrollees compared to the baseline configuration is significant. Thus, while the costs and benefits of the pilot configuration compared to the baseline configuration are clear-cut, determining the relative importance of those costs and benefits requires the judgment of the U.S. Customs and Border Protection service.

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