College of Engineering

Tradeoffs between Security and Inspection Capacity: Policy Options for Land Border Ports of Entry

Hilma Villegas
Research Assistant
Civil Engineering Department
University of Texas at El Paso
500 W. University Ave.
El Paso, TX 79968
Ph. (915) 873-8513; Email: hvillegas@utep.edu

Patrick L. Gurian
Assistant Professor
Department of Civil, Architectural, and Environmental Engineering
Drexel University
3141 Chestnut Street
Philadelphia, PA 19104
Ph. (215) 895-2889; Fax (215) 895-1363; Email: pgurian@drexel.edu

Josiah McC. Heyman
Professor of Anthropology
Chair, Department of Sociology and Anthropology
University of Texas at El Paso
500 W. University Ave.
El Paso, TX 79968
Ph. (915) 747-7356; Fax (915) 747-5505; Email: jmheyman@utep.edu

Adrian Mata, University of Texas at El Paso
Robert Falcone, Drexel University
Edward Ostapowicz, Drexel University
Steven Wilrigs, Drexel University
Michael Petragnani, Drexel University
Eric Eisele, Drexel University

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ABSTRACT
Observations of primary inspections at land border ports of entry between Ciudad Juarez, Mexico, and El Paso, Texas, indicate that the majority of inspections are of limited depth. 79% of primary inspections do not involve opening a vehicle compartment and 45% last 20 seconds or less. Slightly less than 2% of vehicles are referred to secondary inspections. Three policy options are considered for allowing more thorough primary inspections. The first would require all primary inspections to involve opening a vehicle compartment. This would increase average inspection times from 34 seconds to 70 seconds. The more thorough inspections would reduce the processing capacity of the ports of entry to roughly 50% of current peak hourly demand, creating congestion with the potential to propagate throughout the regional traffic network. The second option would limit the time in primary inspections to 63 seconds. Vehicles requiring more time to complete the inspection process would be referred to secondary inspections which would greatly increase the frequency of referrals to secondary inspections, but allow for the percentage of primary inspections that involve physical inspection of at least one vehicle compartment to be increased to 35%. The third option would increase the number of crossers in the SENTRI program, where pre-screened participants are subject to expedited inspections. Reducing the volume in the non-SENTRI lanes would allow more detailed inspections in these lanes. However, SENTRI participants currently constitute only a small portion of total border crossers. A doubling of the current SENTRI program would be required to raise the average non-SENTRI, primary inspection time from 34 to 40 seconds. This study concludes that none of these options, whether alone or in combination, have the potential to avoid conflicts between national security requirements that favor more detailed inspections and local traffic flow consideration that favor less detailed inspections. However, these strategies are amenable to incremental implementation, and such incremental implementation may increase the thoroughness of the inspection process without interfering with local traffic flows.

INTRODUCTION
Since the September 11 terrorist attacks, international ports-of-entry are increasingly being seen as a means to protect against the entry of terrorists to the United States (1-2). At the same time, land border ports of entry are often key nodes in regional traffic networks. Delays at ports of entry can propagate throughout the region and contribute significantly to overall congestion related delays. A study of the El Paso, Texas and Ciudad Juarez, Mexico border region found that closure of one of three regional ports of entry would create queues extending on to a major interstate highway, resulting in a 29% increase in regional transit times (3).

While concerns over terrorism have changed the discourse about the border (2), substantively changing operational procedures at ports-of-entry is a tremendous challenge, and it is not clear that real progress has been made. In the immediate aftermath of September 11, 2001 there appears to have been a policy requiring inspectors to open one compartment of each vehicle, plus other possible measures, although for security reasons the details of inspection policies can not be publicly confirmed by U.S. Customs and Border Protection. These more stringent inspections created substantial delays at ports of entry. At the El Paso-Ciudad Juarez ports of entry, waits of several hours at border crossings were common the fall of 2001. The heightened security combined with the recession to lower total northbound automobile crossings substantially in September 2001 (4). The border delays imposed a hardship on local residents, many of whom cross the border on a frequent basis for work, education, or to visit family members. Inspections appear to subsequently have relaxed and border wait times for 2004-2005

are usually 30 minutes or less (5-6). This suggests that the policy of more detailed inspections yielded to the needs of the local community.

ALTERNATIVE APPROACHES

Trading off security for mobility is clearly problematic. Previous researchers have recommended the use of new technologies as a means to achieve both improved security and address concerns over congestion. A variety of options, including radioactivity monitors, pulsed fast neutron analysis, and biometric identification, have been proposed (2). However, the feasibility of incorporating these technologies into the non-commercial inspection process has not been studied in detail, at least in the open literature.

Policy changes have also been proposed to improve the border inspection process. One strategy is to pre-screen frequent border crossers and then to permit these pre-screened individuals to go through an expedited inspection process. This approach has been implemented in a program known as the Secure Electronic Network for Travelers Rapid Inspection (SENTRI). Participants are required to pass a criminal background check and pay a fee. Participants are then allowed to cross in dedicated lanes with minimal wait times and less stringent inspections (1). In the El Paso-Ciudad Juarez region, roughly 10% of all crossings are in a single dedicated SENTRI lane at the Paso del Norte port of entry (7). The cost to participants is significant (~$400), but the program has generally been successful in reducing waiting times for participants. Further expansions to this program are evaluated in this study.

Mass transit has also been proposed as a method of facilitating the border crossing process. Travelers on public transit would presumably have less opportunity to hide contraband than those driving their own automobiles. Experience has shown that transit riders can be vulnerable to terrorist attacks which would argue for conducting inspections before passenger boarding. A reduction in the volume of private automobiles crossing the border would allow for more thorough inspections of the remainder and reduce the congestion caused by the inspection process. Currently private buses cross the border on both long-distance and local trips, but account for less than 1% of all vehicles (7). A cross-border public bus service has been evaluated and found to be economically feasible if demand for the service is sufficient (*Smart Borders* report by Robert Falcone et al. 2005). Given that there is relatively little basis for estimating future demand, public transit options are not evaluated in this study, but they remain a potentially important mechanism of facilitating cross-border mobility. Further research is needed to develop estimates of demand by survey work, pilot studies, or traveler decision modeling.

SCOPE OF STUDY

This study is an effort to evaluate the feasibility of alternative inspection strategies. The El Paso-Ciudad Juarez area is used as a case study, but the strategies considered here are generally applicable to land border points of entry. El Paso-Ciudad Juarez is considered here, because it is the largest of the border cities with a correspondingly large volume of cross-border traffic. A total of over 1 million vehicles cross at the three ports of entry each month (Thomas Fullerton, unpublished data from the Border Region Modeling Project).

In order for this study to evaluate alternative inspection strategies, it is first necessary to characterize the throughput rate of the current inspection process. There is relatively little information on this available in the literature, and much of what previous work is available is focused on commercial inspections (8-10), although one study is available with information on

non-commercial vehicle inspections at three U.S.-Canada ports of entry in northern New York State (11). This study reported average processing times of 21, 34, and 35 seconds at the three different ports of entry. Of the total processing time, an average of 6.7 to 7.7 seconds (depending on the port of entry) was required for vehicles to move up to the inspection booth after the departure of the previous vehicle. This "move-up time" represents a substantial fraction of the overall processing time. The applicability of these results to the U.S.-Mexico border in the post-9/11 era is not clear. Thus this study began by gathering data on the inspection process through observations of the normal operations of the El Paso-Ciudad Juarez ports of entry.

Once the inspection process was characterized, capacity calculations were performed for the three border crossings in the area and compared to data on current traffic volumes at the ports of entry. The effects of three policy changes on inspection time were considered: 1) the effect of increasing the proportion of inspections involving opening a compartment of the vehicle, 2) the effect of limiting time spent in primary inspections and making more frequent referrals to secondary inspections 3) the effect of shifting crossers from normal, non-commercial lanes to dedicated SENTRI lanes. These scenarios were selected by the authors for their current policy relevance given the concern over the security of the nation's borders. In addition, the data and analytical framework presented in this paper provide a straightforward approach for policy analysts to evaluate the impacts on capacity of a wide range of alternative scenarios for inspections at land border ports of entry, such as the use of novel inspection technologies (2).

METHODS

Observations of non-SENTRI northbound traffic inspections were made at the Santa Fe Bridge of the Paso del Norte port of entry in downtown El Paso. Observations of SENTRI traffic were made at the adjacent Stanton Street Bridge which is also part of the Paso del Norte port of entry. A team of two researchers worked in half-hour shifts and recorded the duration and nature of the inspection for each vehicle. Duration was measured from the when one vehicle departed the inspection station to when the next one departed (i.e., move-up time was included). The time measured included time only in primary inspections (inspections occurring at the initial booth). The percentage of vehicles referred to secondary inspections (more detailed inspections occurring in a dedicated area out of the main stream of traffic) was recorded. Primary inspections were classified as "high attention" inspections, when the inspector left the booth and examined the vehicle, generally opening either the trunk or hood. As described above, inspections of this nature are believed to have been policy in the immediate aftermath of the September 11 terrorist attacks. "Low attention" inspections involved the inspector remaining in the inspection booth. In some cases inspections classified as low attention in this study may have included detailed questioning or examination of documents, as neither of these activities would require the inspector to leave the booth.

Observations of non-SENTRI traffic were made on December 16 and December 18, 2004, and on January 6, April 23, June 15, and June 18, 2005 starting at between 8:00 am and 8:30 am. Observations of SENTRI traffic were made on June 6 and June 13, also starting at between 8:00 and 8:30 am. There was evidence of variation between inspectors, even inspectors working side by side simultaneously, but no clear evidence of differences between weekends or weekdays or effects due to queue length. For the non-SENTRI data the average inspection times varied from 17 to 52 seconds during the 10 half-hour observation periods on weekdays, compared to the range of 23 to 57 seconds for the 12 observation periods on weekends. For the

purposes of this study the data was pooled. Because the ports of entry have multiple lanes, and therefore multiple inspectors, variations between inspectors will tend to average out.

The observed average inspection times were combined with publicly available information on the number of lanes at each port of entry (5) to develop overall hourly capacity figures for each port of entry. Demand was based on monthly crossing figures of 10,971 for the Paso del Norte, 19341 for Bridge of the Americas, and 8,846 for Ysleta (Thomas Fullerton, personal communication of unpublished data from the Border Region Modeling Project, figures are the monthly average from the most recent 12-month period available in the dataset, November 2003 to October of 2004 for Paso Del Norte and Ysleta and June 2004 to May 2005 for Bridge of the Americas, see reference 4 for a description of the dataset) divided by 30 (variation between weekdays and weekends was not considered) and distributed over hourly intervals using a temporal profile of hourly traffic demand for the El Paso-Ciudad Juarez region. Based on a recent regional traffic modeling study (3), the peak hourly demand was associated with the 3-4 pm period, and this period was assigned 8.5% of the total daily crossing demand (data from Jorge Villalobos, personal communication 2005).

PRIMARY INSPECTION OBSERVATIONS

A large variation in primary inspection times for non-SENTRI crossers was observed, ranging from 1 second to 249 seconds, as shown in Figure 1. The 1,228 observations of inspection times had a mean of 34 seconds and a median 23 seconds (Table 1). Slightly over half the inspection times are clustered in the 10-30 second range. Inspections of 10 seconds or less are rare but not unheard of (about 6% of the total). The distribution has a lengthy "right tail" as some inspections require much longer than the typical case. Inspections longer than about 100 seconds are relatively uncommon, as complicated cases would typically be referred to secondary inspections, but the maximum time observed in primary was 249 seconds. 2% of the total non-SENTRI crossers were referred to secondary inspections.

High-attention inspections (as defined in the Methods section above) have a mean of 70 seconds (Table 2), which is almost three times the low-attention inspections mean of 24 seconds. The relatively large amount of time required for such inspections appears to limit the frequency with which they can be undertaken. 79% of the inspections were classified as low-attention inspections.

In the SENTRI lane, inspections are much less detailed, as one would expect since the crossers in this program have been pre-screened. The mean of the 789 observations of inspection times was 15 seconds, the median 12 seconds. (Note that SENTRI crossings were over-sampled relative to their proportion of total crossing as they constitute almost 40% of the dataset but only about 10% of crossers.) Only 5% of SENTRI inspections were classified as high attention inspections. The high attention inspections had a mean of 41 seconds while the low attention inspections averaged 14 seconds.

Due to security concerns and the inherent difficulties in quantifying illegal activities not detected by law enforcement, there is little information publicly available on how effective inspections are as a function of time. Thus, these data need to be interpreted cautiously. Nevertheless, it appears that the attention given to many vehicles is quite cursory. Of the non-SENTRI inspections, 79% did not involve any physical inspection of the vehicle, and 45% lasted 20 seconds or less, even including move up time. Inspection times do not appear to be substantially longer than those reported for pre-9/11 inspections at two out of three U.S.-Canada ports of entry studied by previous researchers (11, average inspection times of 35, 34, and 21

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seconds were reported, as described above). This appears to confirm the anecdotal evidence (described in the Introduction) that inspection processes have largely reverted to pre-9/11 practices (although of course direct comparisons at a single port of entry would provide stronger evidence).

INSPECTION CAPACITY AND DEMAND

The average inspection times obtained from the observations can be converted to throughput rates and compared to demand figures (derived as described in the Methods section above). This analysis does not consider queue formation and dissipation effects, and therefore gives capacity under the assumption of a constant queue. Table 3 shows a comparison of demand and capacity for each of the three ports of entry in the El Paso-Ciudad Juarez region (from west to east): Paso del Norte, Bridge of the Americas, and Ysleta. Only the Paso del Norte port of entry has facilities for the SENTRI program. Capacity appears to exceed demand for the SENTRI program. For the non-SENTRI, non-commercial inspections, demand is in rough correspondence with the capacity of the three ports of entry, even during the hour with the highest demand (3-4 pm). At Paso del Norte peak demand of 938 is modestly below the capacity of 952 vehicles/hour. Similarly, at Ysleta, peak demand of 756 is below the capacity of 1270. At Bridge of the Americas peak demand of 1650 exceeds the capacity of 1480 by 170. A queue of 170 vehicles, distributed over 14 lanes would cause only a 7-minute delay. These figures are rough estimates and do not include substantial variability due to seasonality as well as other effects. These figures suggest that the physical capacity of the border is largely sufficient to meet average demand. In reality queues will form periodically during periods of above average demand or when staffing levels are not sufficient to operate all lanes that are physically available. Given the close match between peak demand and capacity, it is clear that simply increasing in inspection times will cause capacity to drop below demand and cause congestion. For example, requiring exclusively high attention inspections would decrease the capacity by 50% (the average inspection time would increase from 34 seconds to 70 seconds). This would create a queue of 933 vehicles at the Bridge of the Americas during peak hour alone. Over an hour (78 minutes) would be required to clear the queue just from this single hour of arrivals. These figures correspond with anecdotal accounts of waiting times of substantially more than an hour in the immediate aftermath of the 9/11 terrorist attacks. Thus both these capacity estimates and the observed post-9/11 traffic behavior indicate that increasing the time allotted to primary inspections will create serious congestion, unless some offsetting efforts are undertaken.

Perhaps the most obvious approach would be to increase the number of inspection stations. While the figures on inspection time and demand provided here may be used to evaluate planned expansions, these straightforward capacity increases are not considered in detail as part of this study. Instead the emphasis is on novel approaches that may increase throughput without requiring substantial expansions to existing infrastructure, as described in more detail below.

LIMITING THE DURATION OF PRIMARY INSPECTIONS

The lengthy “right tail” of the distribution indicates that a small number of complicated, time-consuming cases are contributing disproportionately to overall inspection delays. If these cases were diverted earlier to secondary inspections, then this would improve the throughput of the primary inspection process, although naturally this would require that more resources be devoted to secondary inspections. To evaluate this quantitatively, all inspections exceeding 63 seconds in

duration were replaced with a value of 63 seconds (to simulate a maximum time limit for primary inspections) and the mean of the modified distribution was computed to be 30 seconds, a 14% decrease (before rounding) from the original value of 34 seconds. The mean of the high attention inspections was reduced from 70 seconds to 51 seconds.

This reduction in time devoted to the more complicated cases in primary may be used to either reduce the average inspection time or to allow a larger proportion of primary inspections to be more thorough. It is assumed here that the priority is to increase the percentage of high-attention inspections. As noted above, there is little information publicly available on the effectiveness of inspections, but providing some physical inspection of the vehicle would seem desirable. Opening a single vehicle compartment is still a fairly cursory inspection, but would at least allow the inspector to check for gross alterations to the vehicle or large amounts of illicit materials. It would also provide an opportunity for the inspector to observe the driver's reaction to the inspection and note any signs of nervousness or unusual behavior. If the overall inspection mean is to be maintained at 34 seconds, then the proportion of high attention inspections may be increased from 21% to 35%. If the primary inspection time could be increased to 51 seconds then 100% of all primary inspections could be high-attention inspections. In this scenario, primary inspections would become a relatively standardized process with a fairly narrow distribution of inspection times, in contrast to the current situation where primary inspections vary greatly in character and duration at the discretion of the inspector. This standardization would assure some level of scrutiny for all crossers. The standardization of the procedure might also address concerns over ethnic profiling (although discretion would still be needed in determining which vehicles to refer to secondary inspections). The major drawback to this option is that it would vastly increase the number of secondary inspections. A total of 14% of all inspections currently exceed 63 seconds in length. If all these vehicles were referred to secondary then this would increase the secondary inspection rate from roughly 2% to 13-15% of all vehicles (depending on how much overlap there is between the vehicles that are currently referred to secondary and the vehicles currently spending more than 63 seconds in primary). This would have major implications for the physical capacity and staffing levels required in secondary inspections. While secondary inspection areas frequently appear to operate at small fractions of their physical capacity (i.e., available parking spaces), additional staffing is likely to be costly. Standardization of primary inspections without an increase in overall inspections resources could be counterproductive, as it would deprive inspectors of the discretion to investigate potentially problematic crossers. Clearly much more detailed study would be necessary to assess the feasibility of this strategy.

Another approach would be to limit primary inspections to 90 seconds. This would reduce the high-attention mean to 64 seconds and would result in 5 to 7% of vehicles being referred to secondary inspections (Table 1). While this approach would be less likely to exceed the capacity of secondary inspections, it could increase the proportion of high-attention inspections to 24%. While attaining 100% high-attention inspections may not be feasible, the strategy of limiting primary inspections to somewhere in the range of 63 to 90 seconds, coupled with increased referrals to secondary inspections, could increase the proportion of high-attention inspections in primary.

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EXPANDING THE SENTRI PROGRAM

The inspection data indicate that inspection times are much lower for participants in the SENTRI program than for non-SENTRI crossers (Table 2). Thus shifting crossers to the SENTRI

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program would allow time for more detailed inspections of the remaining non-SENTRI crossers. Figure 2 shows the average inspection time in the non-SENTRI lanes as a function of the number of vehicles crossing in the SENTRI program for the Paso del Norte port of entry, the only port of entry in the region which currently has a SENTRI lane. Currently, about 142 vehicles cross in the SENTRI lane during the peak hour (Table 3). As crossers are diverted from the non-SENTRI lanes, to the SENTRI lanes, it becomes possible to increase the average duration of primary inspections for the remaining non-SENTRI crossers.

Substantial increases in the SENTRI program appear to have a modest potential to increase the average inspection times in the non-SENTRI lanes. If the program were doubled, to 280 vehicles during the peak hour, the inspection time in the non-SENTRI lanes could be increased to around 40 seconds per vehicle, an increase of 18% but still well below what would be needed to provide high attention inspections to all non-SENTRI crossers. Quadrupling the program to 560 vehicles during peak hour would allow non-SENTRI inspections to increase to over 60 seconds per vehicle, closer to what is required for high-attention inspections. This would require diverting 45% of non-SENTRI crossers into the SENTRI program. This would constitute a huge shift from current practices and would almost certainly require a reduction in the fees for the program. However, a large percentage of border crossers are frequent border crossers (roughly 60% of all crossers in non-SENTRI lanes cross on a weekly or daily basis, based on unpublished data from the *2004 Border Crosser Survey* provided by Cheryl Howard and Leticia Fernandez, manuscript in preparation). It could be argued that the current practice of constantly re-inspecting these frequent crossers, but rarely in a thorough fashion, is grossly inefficient and just such a major procedural shift is justified.

DISCUSSION

The results presented above suggest that there are no easy solutions to this situation. Current inspections appear to be largely cursory, providing so little time for such a large fraction of the entering vehicles that effective inspections would not appear to be possible. Two approaches to allowing more detailed primary inspections were considered in this study, placing a ceiling on the amount of time in primary inspections and diverting more traffic into the SENTRI program. Both approaches would require major operational changes from existing practices, changes that may not be feasible. Limiting the time in primary inspections would dramatically increase the number of secondary inspections. Increasing the SENTRI program many fold would require a much lower fee to attract sufficient enrollment and the construction of dedicated inspection facilities at the Bridge of the Americas and Ysleta ports of entry. Even using these approaches in combination it would be difficult to achieve 100% high attention inspections (for the Paso del Norte port of entry, roughly a four-fold increase in the SENTRI program and a seven-fold increase in secondary inspections would be required).

This situation suggests that the tradeoffs between depth of inspections and throughput, described at the start of this paper, are likely to be a persistent issue in port management. Requiring high-attention inspections roughly doubles the inspection time (from 34 to 70 seconds) with a corresponding decrease in the throughput capacity of the port. Figure 3 shows how higher levels of overcapacity must be tolerated to permit longer inspection times. Under current conditions, the use of exclusively high-attention inspections would cause demand to exceed the Paso del Norte's processing capacity by nearly a factor of two. An inspection time of 51 seconds (the case when high-attention primary inspections are limited to 63 seconds or less) would cause demand to exceed capacity by nearly 50%. If 50% of normal, non-commercial crossers can be

enrolled in the SENTRI program (this would require most of the people who cross on a weekly or more frequent basis to enroll in the program), then shifts to high-attention inspections in non-SENTRI lanes will be much less disruptive (at a 51 second primary inspection time demand would not exceed capacity, at a 70 second inspection time demand would exceed capacity by about 15%).

The values in Figure 3 are a simple comparison of existing peak hour demand with port capacity. In reality, queue formation and dissipation affect capacity, and demand is elastic and will drop in response to increases in waiting times at the border. Thus the values in Figure 3 are not intended as quantitative estimates of overcapacity in response to specific inspection policies. However, it does provide a qualitative basis for assessing the relative amount of stress more rigorous inspection policies will place on the local transportation network.

The absence of a single, definitive solution to this problem should not discourage incremental efforts to improve the situation. Both diverting more problematic cases to secondary inspections and increasing the use of SENTRI program are amenable to incremental implementation as they do not require the construction of new infrastructure or development of new programs. For example, port managers could increase efforts to publicize the SENTRI program or work to reduce the enrollment fee. Managers could also give guidance to primary inspectors to avoid lengthy primary inspections and refer marginally more vehicles to secondary inspections. While the goal of 100% high attention inspections may not be feasible, even partial implementation of these options would allow for the proportion of high-attention inspections to be increased over its current value of 21%.

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LIST OF TABLES AND FIGURES

TABLE 1 Summary statistics for northbound inspections

	Regular Inspections	**Primary Inspections Truncated at 63 sec**	**Primary Inspections Truncated at 90 sec**
Mean, s	34	30	32
Median, s	23	23	23
Mode, s	18	63	18
Standard Deviation, s	31	19	24
5th Percentile, s	10	10	10
95th Percentile, s	88	63	88
% Referred to secondary	2	13-15	5-7

TABLE 2 Comparison of high-attention and low-attention primary inspections

	Low Attention Normal (non-SENTRI)	Low Attention SENTRI	High Attention Normal (non-SENTRI)	High Attention SENTRI
Sample Size	972	746	256	43
Median, s	20	11	66	33
Mean, s	24	14	70	41

TABLE 3 Demand and capacity for northbound El Paso-Ciudad Juarez ports of entry

Type of Border Crosser	Number of Lanes	Inspection Time (sec)	Maximum Throughput (Veh/hr)	Demand	
				Off Peak Hour [3-4 am]	Peak Hour [3-4 pm]
Paso del Norte Bridge					
SENTRI	3	15	720	4.7	142
NORMAL (Non-SENTRI, non-commercial)	9	34	952	31	938
Bridge of the Americas					
NORMAL (Non-SENTRI, non-commercial)	14	34	1480	55	1650
Ysleta					
NORMAL (Non-SENTRI, non-commercial)	12	34	1270	25	756

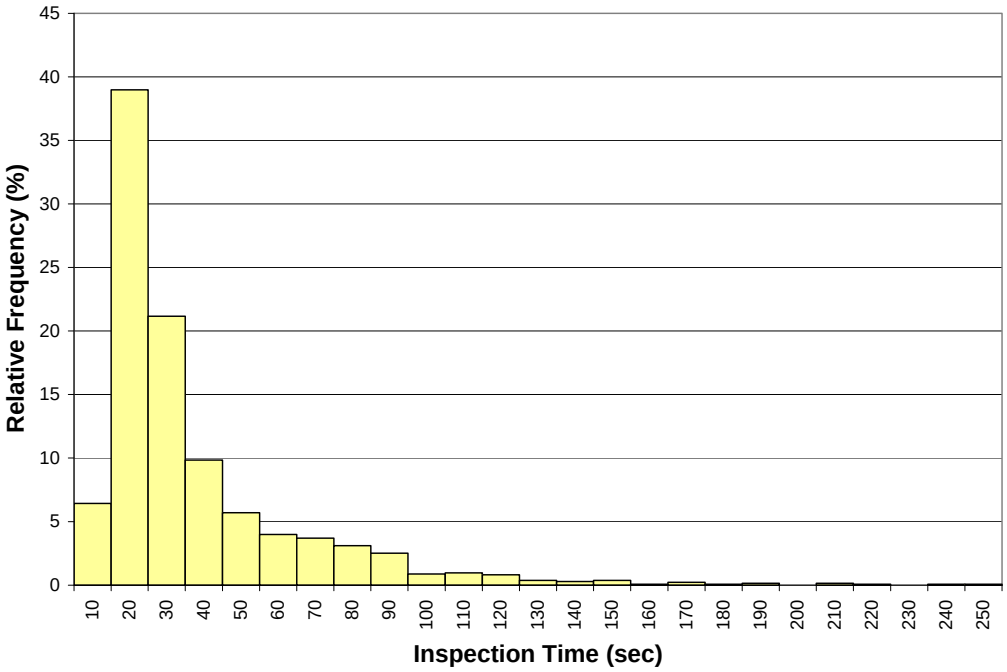

FIGURE 1. Histogram of observed primary inspection times for northbound, non-SENTRI traffic at the Paso del Norte port of entry, El Paso, Texas.

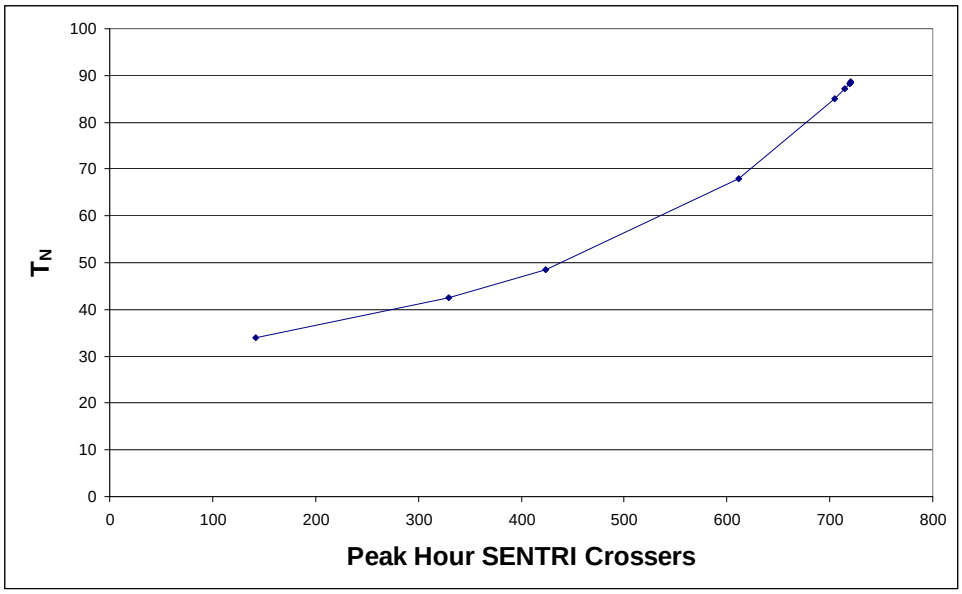

FIGURE 2. Inspection time in non-SENTRI lanes vs. number of crossers in SENTRI lanes.

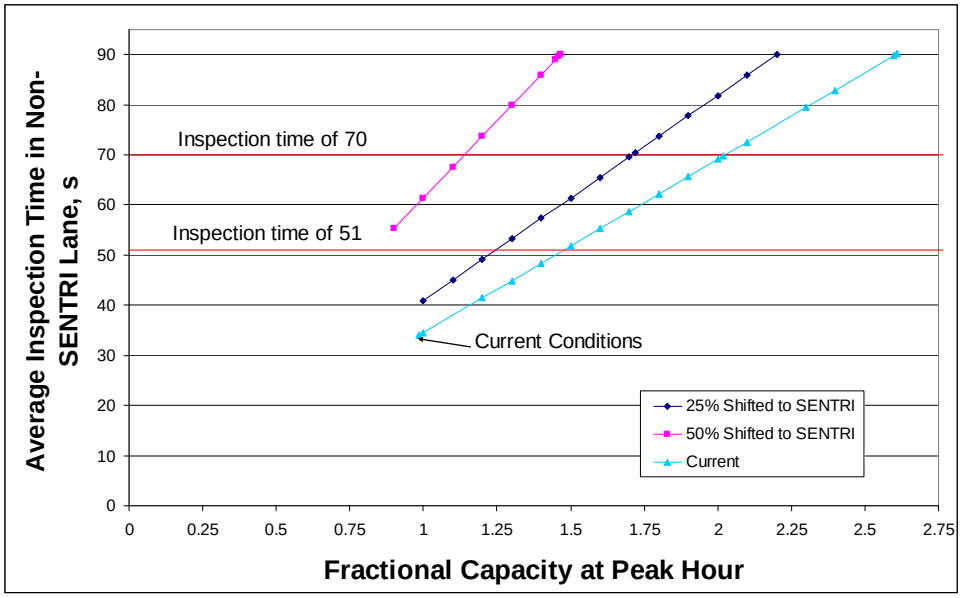

FIGURE 3. Inspection time as a function of the percentage overcapacity for the Paso del Norte port of entry.