

Weigh Stations' Capacity Enhancement Alternatives: A Comparison of Mainline Electronic Screening and Physical Expansion

ALIREZA KAMYAB

A number of weigh stations are unable to keep pace with current truck traffic levels. In response, state enforcement agencies are compelled to seek capacity enhancements for the weigh stations. One response is to increase physical capacity by adding a ramp weigh-in-motion (WIM) scale, a sorter and a bypass lane. Electronic screening, on the other hand, is a feasible option for increasing capacity without expanding physical infrastructure of the weigh station. This study compares the impact of these two alternatives in terms of travel time savings and enhanced productivity for a selected high traffic weigh station using a simulation model. The results indicate that physical expansion could improve a weigh station efficiency to some extent in a shorter amount of time than electronic screening programs. Electronic screening, however, eliminates a weigh station inefficiencies gradually but permanently when the number of transponder-equipped trucks increase significantly. Key words: ITS/CVO, WIM, simulation modeling, weigh station, traffic modeling.

INTRODUCTION

Weigh stations are the primary regulatory compliance check points for commercial trucks. A large number of weigh stations are, however, unable to keep pace with current truck traffic levels, resulting in less efficient use of government resources and increased travel time for motor carriers. Weigh station administrators frequently close weigh stations to prevent queues from extending out on to the mainline. This queue spillover results in an inordinate number of bypasses without compliance checks (unauthorized bypasses).

In response, state enforcement agencies are compelled to seek capacity enhancements for the weigh stations. One response is to increase the physical capacity of the weigh station by adding a ramp weigh-in-motion (WIM) scale, a sorter and a bypass lane. This enables enforcement officials to monitor all arriving trucks and allow those trucks that do not exceed a set weight threshold to bypass the static scale and re-enter the mainline. Electronic screening, on the other hand, is a feasible option for increasing capacity without expanding physical infrastructure of the weigh station. Using automated vehicle identification systems and mainline weigh-in-motion scales, electronic screening allows for mainline weight checks and more targeted inspection of trucks.

The impact of electronic screening in terms of travel time savings for motor carriers and enhanced productivity of the weigh station was studied elsewhere (1). The evaluation of electronic screening at the case study weigh station indicates a substantial reduction in travel time and the number of unauthorized bypasses. However, from the states' perspective, the benefits of electronic screening are not realized until a substantial number of trucks have been equipped with transponders.

It is estimated that nationally only two percent of the trucks are currently equipped with transponders. The rate at which trucks will become equipped with transponders is difficult to predict. Those administrators who seek a more imminent solution to enhance the productivity of their congested weigh stations may consider the physical expansion alternative.

This paper examines the impact of the physical expansion alternative at a weigh station. The primary objective of this study is to conduct a side by side comparison of the two alternatives at a weigh station assuming same traffic conditions. The case study weigh station has no ramp bypass lane and currently operates under high truck traffic. This study shows that physical expansion is able to temporarily alleviate the existing operational problems at the weigh station by improving the traffic throughput within the station. Eventually the growth in truck traffic will again overcrowd the weigh station. The electronic screening evaluation, however, indicates a more fundamental solution to the weigh station's capacity problems by making the mainline part of the system.

As an integral element of Intelligent Transportation Systems for Commercial Vehicle Operations (ITS/CVO) programs, electronic screening has proven to be an effective tool in improving traffic throughput on roadways. This paper does not intend to question the effectiveness of electronic screening nor the ITS concepts at weigh stations. The purpose of this study is to examine an interim solution to improve a weigh station operations in the short term until the long term benefits of electronic screening are realized.

BACKGROUND: ELECTRONIC SCREENING

Electronic screening systems use Automatic Vehicle Identification (AVI) technology to identify a participating vehicle as it approaches a weigh-station. Typically, an AVI tag (a transponder) is read by a roadside reader. The roadside reader identifies the truck and links its identification to the truck's weight and axle spacing information that is collected by a mainline WIM scale. Based on the identification of the truck, the WIM measurement, and decision rules coded into the roadside computer, a determination is made as to whether

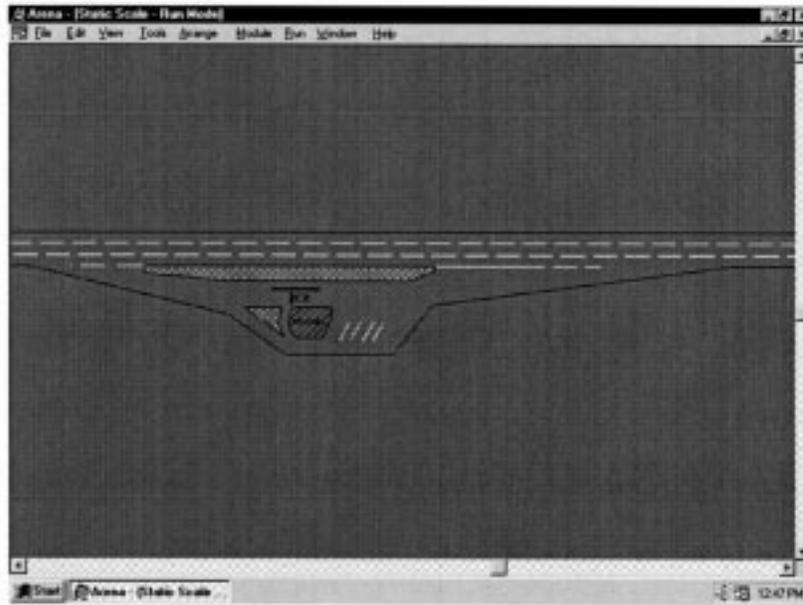


FIGURE 1 Static scale weigh station.

the truck is to be signaled into the weigh station or allowed to bypass. The in-cab transponder, in turn, signals the driver with either a green light to bypass or a red light to pull into the weigh station. Transponder-equipped trucks that are electronically cleared do not have to leave the mainline and thus benefit from fuel and time savings. By reducing the number of vehicles that have to pull into facilities that are operating at or near capacity, mainline screening also reduces frequency of full queues at weigh stations. Full queues result in either the line of trucks backing on to the mainline, a dangerous situation, or the waiving of trucks past the weigh station without performing compliance checks (unauthorized bypasses).

Electronic screening improves the efficiency of a weigh station. Because trucks participating in the electronic screening programs are not routinely stopped at weigh stations, they are able to minimize or entirely avoid the delay that results from manual checks. Enforcement officials do not routinely inspect compliant trucks participating in electronic screening. Because participating trucks are not waiting in the queue at the weigh station, the queue is diminished, resulting in fewer unauthorized bypasses.

The impact of electronic screening at weigh stations was examined by a new simulation model (1). The weigh station simulation is a microscopic, stochastic, model with a powerful animation capability. The simulation model is built in Arena simulation language (2). The model is developed for a conventional weigh station with a static scale and no ramp bypass lane as shown in Figure 1. It is built based on actual truck traffic patterns and geometry data collected at the weigh station site. The simulation results are compared to the real data, collected at the field, to validate the model.

The system performance of electronic screening at the weigh station is evaluated by conducting a “before and after” study using the weigh station simulation model. In the absence of an electronic screening system all trucks must enter the weigh station (base model). With the engagement of electronic screening systems, most of the transponder-equipped trucks are electronically cleared at the

mainline (screening model). By comparing the results obtained from the simulation model run under the two described scenarios, the system performance of electronic screening at the weigh station is evaluated at different levels of transponder-equipped truck participation.

CASE STUDY: PHYSICAL EXPANSION

The case study involves a weigh station with a high volume of truck traffic (i.e., 440 trucks per hour). The collected field data at this site indicates that more than two thirds of trucks on the mainline are currently bypassing the weigh station due to a full queue at the weigh station (unauthorized bypasses). It also shows that under the weigh station’s existing operation the average queue delay (i.e., delay time for being weighed) is about five minutes per truck.

The weigh station simulation model is modified to include a ramp WIM and a bypass lane (expansion model). The new weigh station design is shown in Figure 2. It is noted that a ramp bypass lane is added by widening the existing narrow lane adjacent to the static scale (see Figure 1) which is currently used for clearing trucks with wide or empty loads. This physical modification substantially reduces travel time and the number of unauthorized bypasses. However, more comprehensive physical and policy changes are required to completely eliminate the mainline unauthorized bypasses.

Similar to the electronic screening systems evaluation, the impact of physical enhancements at the weigh station is evaluated by conducting a “before and after” study using the weigh station simulation model. By comparing the base simulation model results with the ones obtained from the expansion model, the system performance of physical enhancements at the weigh station is evaluated. The study indicates that by allowing fifty percent of trucks to leave the weigh station via the bypass lane, the number of mainline un-

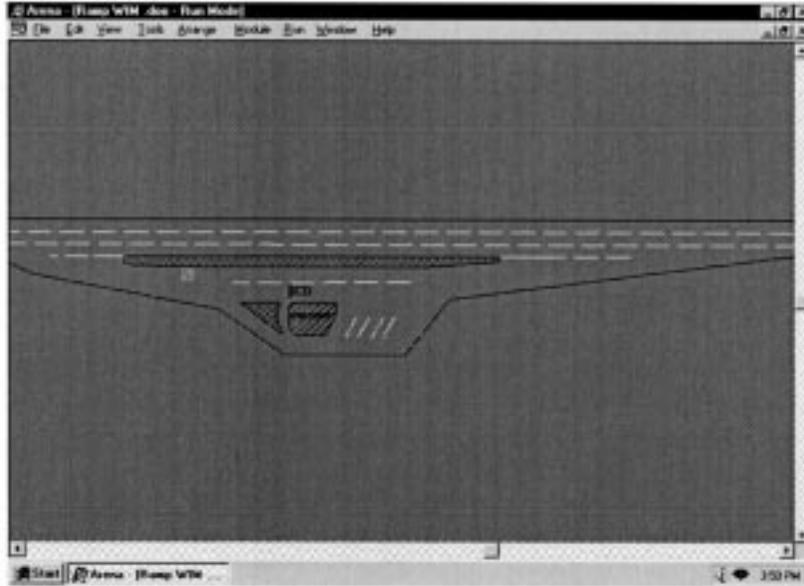


FIGURE 2 Static scale weigh station with a ramp bypass lane.

TABLE 1 Electronic Screening Versus Physical Expansion Alternatives

Transponder %	Travel Time (sec/trk)		Savings	Unauthorized Bypasses (percent)		Efficiency
	Screening	Expansion		Screening	Expansion	
0	337	337	0	65	65	0
2	337	140	197	63	24	62
5	337	140	197	60	24	60
15	334	140	194	50	24	52
25	328	140	188	40	24	40
35	323	140	183	31	24	23
45	305	140	165	22	24	(8)
55	274	140	134	13	24	(37)
65	189	140	49	6	24	(75)
80	147	140	7	0	24	(100)

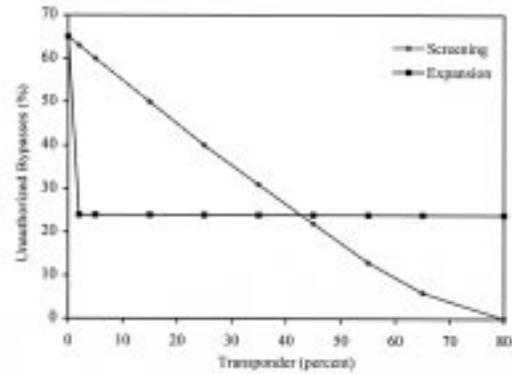


FIGURE 4 Comparison of the alternatives - unauthorized bypass.

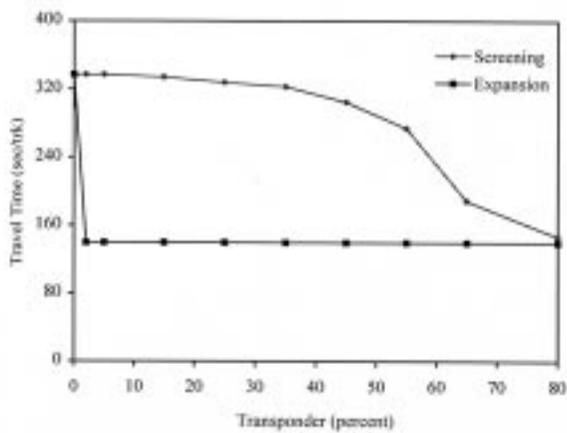


FIGURE 3 Comparison of the alternatives - travel times.

authorized bypasses and travel times are reduced by about 60 percent.

CAPACITY ENHANCEMENT ALTERNATIVES

The “before and after” study of the two proposed alternatives indicates that they both are capable of improving the efficiency of the weigh station. Table 1 presents a side by side comparison of the alternatives in terms of travel times and percent of unauthorized bypasses. The percentage of trucks with transponders is treated as a variable in the electronic screening model. The table shows electronic screening programs gradually decrease both travel time in-

side the weigh station and number of unauthorized bypasses. The physical expansion results, on the other hand, indicate a sudden drop in travel time and unauthorized bypasses. Table 1 also shows the travel time savings and added enforcement efficiency-deficiency of the physical expansion model as compared to the screening model results. The enforcement deficiency of the physical enhancements alternative is noted when the transponder usage reaches 45 percent in electronic screening programs.

The differences between the two alternatives are more visible in Figures 3 and 4. The area between the screening and expansion travel time, shown in Figure 3, presents the additional travel time savings that physical expansion at the weigh station could provide before the transponders market penetration reaches the 80 percent mark.

In a hypothetical situation, assume a progressive transponders market penetration rate of 80 percent in nine years. During this time period, the addition of a ramp bypass lane results in 54 years of additional travel time savings for the more than twelve millions trucks which will be traveling through the case study weigh station in nine years (i.e., an average of 2.3 minutes of travel time savings per truck).

Figure 4 compares the two alternatives in term of number of unauthorized bypasses. This figure shows that once more than forty percent of trucks participate in electronic screening programs, the resulting number of unauthorized bypasses in electronic screening case plunge under the ones in the physical expansion case. In other words, the screening weigh station design will become more efficient than the expansion model at the forty percent transponders market penetration.

CONCLUSIONS

The weigh station simulation model holds great potential as an evaluation tool for decision makers. Simulation demonstrates and quantifies the effect of electronic screening and physical expansion for a particular weigh station factoring in its unique geometrical and functional characteristics.

The weigh station simulation results indicate the effectiveness of the two proposed weigh station capacity enhancement alternatives in reducing the travel times and number of unauthorized bypasses. The comparison of these two alternatives indicates that physical expansion could improve a weigh station efficiency to some extent in a relatively shorter amount of time than electronic screening programs. Electronic screening, however, eliminates a weigh

station inefficiencies gradually but permanently when the number of transponder-equipped trucks increase significantly.

The superior operability of electronic screening should also be emphasized. A ramp WIM sorts out the arriving trucks based on a set weight threshold. Those trucks that do not exceed the threshold weight are signaled by an overhead sign to return to the mainline through the bypass lane. The electronic screening system, on the other hand, monitors the weights and safety records of all approaching trucks on the mainline. The overweight trucks and those flagged for credential and/or safety problems are signaled by in-cab transponders to pull into the weigh station for a thorough inspection. Therefore, in terms of potential benefit to the state, electronic screening is the preferred method.

Electronic screening is seen as a key Intelligent Transportation Systems (ITS) function in pursuit of the Federal Highway Administration's ITS for Commercial Vehicle Operations (CVO) program vision (3). If one assumes that the majority of trucks eventually will be equipped with transponders, adding physical enhancements at a weigh station must carefully be examined prior to any investment. A thorough economic analysis should be carried out to determine the economic feasibility of adding a bypass lane as an interim solution and whether the resulting travel time savings and added enforcement efficiency can justify the implementation costs.

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