Research Report
KTC-98-17

KENTUCKY TRANSPORTATION CENTER

College of Engineering

REGISTRATION VIOLATIONS AND THE USE OF OPTICAL CHARACTER RECOGNITION TECHNOLOGY AT KENTUCKY WEIGH STATIONS

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REGISTRATION VIOLATIONS AND THE USE OF OPTICAL CHARACTER RECOGNITION TECHNOLOGY AT KENTUCKY WEIGH STATIONS

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EXECUTIVE SUMMARY

As a Model Deployment State for CVISN (Commercial Vehicle Information Systems and Networks), Kentucky is evaluating and improving its procedures related to commercial vehicle administration and enforcement. As part of this effort, the Kentucky Transportation Center (KTC) was asked to investigate the frequency of registration-related violations at Kentucky weigh stations and the potential effectiveness of a license plate recognition (LPR) system in detecting and deterring such violations. Typical violations considered in the investigation included using an expired license plate, hauling weight in excess of the truck's registered weight, or traveling in Kentucky without proper authority.

KTC researchers first examined Kentucky's current weigh station procedures. This was followed by collection of weight and license plate data for a five-hour period at the Kenton County weigh station on I-75. Over 1,100 trucks were observed, representing 34 states and 3 Canadian provinces. A total of 67 violations were observed, 52 of which would have gone undetected under current weigh station procedures. The most frequently-observed violations were for exceeding registered weight, no plate, illegible plate, and expired plate.

LPR technology is in widespread use throughout the world, but there have been very few instances of its application to commercial vehicle enforcement activities at weigh stations. Those few efforts have met with little success. Experience has shown that LPR systems are complicated and require high levels of maintenance. Integration with weigh-in-motion (WIM) equipment and appropriate databases have posed significant problems for users.

In time, LPR technology should continue to mature, and necessary national databases, such as the Safety and Fitness Electronic Records (SAFER) database and the Commercial Vehicle Information Exchange Window (CVIEW), should become readily available. With these changes, LPR systems will become a much more attractive option for electronic identification of commercial vehicles. Until then, interim measures should be considered, such as a video monitoring system on the weigh station ramp to allow enforcement personnel to detect vehicles with illegible or missing plates.

1.0 INTRODUCTION

Commercial vehicles represent 25-30% of the total traffic on urban and rural interstates in Kentucky, and this number continues to grow (1). While just over 500,000 commercial vehicles were registered to operate in Kentucky in 1991, nearly 1,000,000 were registered in 1997 (2,3). With commercial vehicles such a large part of our interstate traffic, careful monitoring of these vehicles is critical. The Kentucky Transportation Cabinet (KyTC) has long seen the need to efficiently and effectively screen these vehicles to make the roadways safer. As a CVISN (Commercial Vehicle Information Systems and Networks) Model Deployment state, Kentucky is evaluating its current methods of monitoring commercial vehicles and looking at advanced technology for improvements.

1.1 OBJECTIVES

The objective of this research project was two-fold. First, the Kentucky Transportation Center (KTC) investigated to determine if there were a significant number of registration violations or other license plate-related violations occurring at Kentucky weigh stations. (A vehicle using an expired license plate, hauling an amount in excess of its registered weight, or traveling in Kentucky without the proper authority was considered to be in violation of its registration.) Second, KTC investigated the potential effectiveness of using license plate recognition (LPR) technology to verify registration information at Kentucky weigh stations.

2.0 BACKGROUND

2.1 CURRENT WEIGH STATION PROCEDURES

Trucks entering some Kentucky weigh stations pass over a ramp weigh-in-motion (WIM) scale. (Other Kentucky weigh stations are only equipped with static or slow-rollover scales.) The weight of a truck is checked against applicable axle weight limits and the legal gross weight limit of 80,000 pounds. A truck within a certain range of these legal limits, or in excess of any of these limits, is directed to the static scale. The truck must then stop on the scale and be weighed. This scale produces a more accurate weight, and may be used as the basis for a citation. A truck that is under the legal axle and gross weight limits (and not within the designated range), may continue on the ramp.

As the truck passes through the weigh station, a clerk enters the unit number and KYU or USDOT number from the vehicle into a computer database. These observations are used to help verify that carriers are paying the appropriate taxes to the state of Kentucky. If a vehicle has a visible violation (i.e., no USDOT number) or a current tax problem (reflected in the database), the driver will be directed to park the vehicle and bring all papers into the weigh station house.

Information related to the truck's registration is not regularly verified under current weigh station procedures. To verify this type of information on every vehicle before it leaves the station, each vehicle would need to be electronically identified. Specifically, some identifying number from the truck (i.e., license plate number or USDOT and unit numbers) would have to be checked against a database of registration information. However, Kentucky does not have a database of registration information for all trucks passing through its weigh stations. Under the International Registration Plan (IRP), trucks register with their base state and the appropriate taxes and fees are forwarded to the states where the vehicle will travel (4). Therefore registration information can only be obtained through the base state or on the cab card in the vehicle.

2.2 LICENSE PLATE RECOGNITION TECHNOLOGY

License plate recognition technology is being used for electronic identification in a variety of applications in the United States and the world. These systems are often used for toll, red light and parking enforcement and at border crossings. The application of this technology at weigh stations, however, is not as common. This could be attributed to the fact that commercial vehicles are typically more difficult to identify. Because commercial vehicles deliver goods to specific locations, they often travel across different jurisdictional lines. Therefore at a weigh station, it is customary to see vehicles from a wide variety of states and provinces. The process of identifying the state or province on the license plate is perhaps the most difficult task for the LPR system. Often the name (or abbreviation) of the jurisdiction is in a very small font or may even be covered by a plate holder. Locating the plate may also be a problem since the tractor plate is not always in the same location on the front of the vehicle. For some smaller trucks (i.e., 3-axle trucks), the plate is often located on the rear of the vehicle. Also, it is not unusual for commercial vehicle plates to be missing or in poor condition due to the extensive amount of travel and extreme weather conditions they endure (5).

2.2.1 Weigh Station Deployment

Despite these challenges, LPR technology has been implemented at a few weigh stations. The MOOSE (MCSAP (Motor Carrier Safety Assistance Program) Out-of-Service Enforcement) project was an automated, real-time system for access to MCSAP out-of-service information conducted from July 1, 1995 to June 30, 1996. The LPR equipment was deployed at four sites, three in Wisconsin and one just west of the Minnesota-Wisconsin border. The system would read a plate and compare the number with the Out-of-Service (OOS) vehicle database. A computer within the weigh station would sound an alarm when a match was found. This meant that the vehicle had been placed out-of-service on its last inspection; it was not necessarily still out-of-service. The system did increase the number of vehicles screened for inspection, but nearly all out-of-service violations had been corrected. The study concluded that trucks operating out-of-service were avoiding the weigh stations.

In an evaluation of the system by the University of Wisconsin-Madison, the valid read rate for Wisconsin plates was found to be 80 to 85 percent in good weather, but the overall valid read rate was much lower at 36 to 43 percent (6). Some of the operational problems included moisture inside the housing (condensation), alignment problems due to plowed snow hitting the unit, cameras being buried under plowed snow, one lightning strike, camera field of vision was too narrow, integration with the WIM, and illegible plates (7). The equipment from the operational test is still in place, but is not currently being used (8).

Iowa is the lead state for PRISM (Performance and Registration Information Systems Management), which uses LPR technology to identify vehicles with poor performance records. These vehicles, once identified, must be inspected. Participants in the program include: Iowa, Indiana, Minnesota, Colorado, and Oregon. This also is an automated, real-time system that is in some cases integrated with the ramp WIM system. Overhead ramp signs direct the vehicle to the back of the station house if there is need for further evaluation. Most states in the program have had significant problems getting their LPR systems up and running. Some of the problems have included: narrow field of vision of the camera, slow processing of LPR data, getting continuous power to the site, integration with the WIM, lightning strikes, adverse weather conditions, and state recognition of the license plate (7). Colorado and Oregon have returned their LPR equipment to Iowa, while Minnesota and Indiana still have the equipment in place but are not using it (9,10,11). Iowa, however, has had readers running for nearly three years and has been pleased with the technology.

Although no formal evaluation of this system has been done, officials in Iowa believe the LPR technology has a read rate of about 85 to 90 percent (12). In a recent visit to the site, the authors found that the system does read a high percentage of the plates. The percent of plates that are read accurately, however, is much lower. In fact, the overall (accurate) read rate is probably very similar to the MOOSE project (35 to 45 percent).

2.2.2 Database Requirements

In order for LPR technology to be applied in an effective way, the license plate numbers must be checked against a database of accurate and up-to-date information. Thus, the availability of such databases, with real-time interfaces, is critical to effective deployment of LPR (7).

Johns Hopkins University's Applied Physics Lab is developing a national database for FHWA that will contain out-of-service information, registration information, and much more. SAFER (Safety and Fitness Electronic Records) will contain information on all interstate vehicles and may be accessed by states through CVIEW (Commercial Vehicle Information Exchange Window). CVIEW software has already been installed in the two CVISN prototype states, Maryland and Virginia. The current version allows for on-line queries for interstate carrier safety records (13).

3.0 PROCEDURES

3.1 DATA COLLECTION

The license plate and weight data for this study was collected on August 26, 1997, a Tuesday, at the Kenton County Weigh Station on Southbound I-75. Data was collected for five hours, from 10:00am to 3:00pm, using two video cameras.

The first camera was focused on the WIM screen inside the weigh station house. Information including: class of the vehicle, speed, axle weights and spacings, gross weight, and the time (to seconds) was recorded. The second camera was used outside the weigh station house and positioned to record front-mounted license plates on trucks as they crossed the ramp WIM. This camera displayed the time (to seconds) as it recorded the plates. By synchronizing this time with the time displayed on the WIM screen, a license plate could be correlated with its corresponding weight. With rear-mounted plates, the plate number and jurisdiction were read into the camera microphone by KTC personnel.

3.2 DATA COMPILATION

To compile and evaluate the data from this study, the two video tapes (from the two cameras) were viewed simultaneously. From these tapes, the physical description of the plate, plate number, jurisdiction, WIM weight, and time were recorded onto a spreadsheet.

Information on each vehicle was obtained by contacting its base state (or province) with a license plate number. Each jurisdiction performed a license plate search, revealing: 1) the validity of the plate, 2) the proper registration to operate in Kentucky, and 3) the registered weight of the vehicle.[1]

For a few states, registration information for a commercial vehicle could not be obtained if that information had changed since the date of the study. These states could only provide current registration information. Two jurisdictions charged a fee to do a license plate search, Ontario charged $12.00 (Canadian) per license plate and Ohio charged $1.50 per plate.

4.0 FINDINGS

Over the course of the five-hour study, 1185 trucks were observed, representing 34 states and 3 Canadian provinces. One thousand and seven plates, or 85%, could be associated with a jurisdiction. Of those identified to a specific state or province, over half (56%) were from Illinois, Kentucky, Ohio, or Tennessee. Over three-fourths of the vehicles could be associated with one of eight different jurisdictions. A detailed list of the various jurisdictions and the frequency at which they were seen can be found in Table 1.

Of the 1185 plates seen, only 147 (12%) were classified as “indeterminate”. For these plates, the status of the vehicle, whether it was in violation or compliance with its registration and license plate laws, could not be determined with the available information. Most of these “indeterminate” plates were a result of not being able to identify the complete license plate number and/or jurisdiction of origin from the plate. The remaining 1038 (88%) vehicles had plates that were classified as “determinate”, because their status could be determined. (Note: Some plates could not be associated with a particular jurisdiction, but were determined to be in violation.) Figure 1, on the following page, illustrates the ratio of “indeterminate” to “determinate” plates.

4.1 “INDETERMINATE” PLATES

Incomplete information on the license plate number and/or the jurisdiction of origin left 98 of the 147 plates unidentified. When the ramp WIM camera battery unexpectedly died, license plates had to be recorded manually. Power was re-established shortly thereafter, but many plates were missed during that period. A high number of rear-mounted plates led to several missed plates, because the task of

[1] Tennessee provided information on registered weights only.

manually reading and recording the complete number and jurisdiction of origin proved to be more difficult than anticipated. Adjustments with the camera also resulted in some plates being completely missed. Others were just very difficult to read due to the quality of the picture obtained from the video camera.

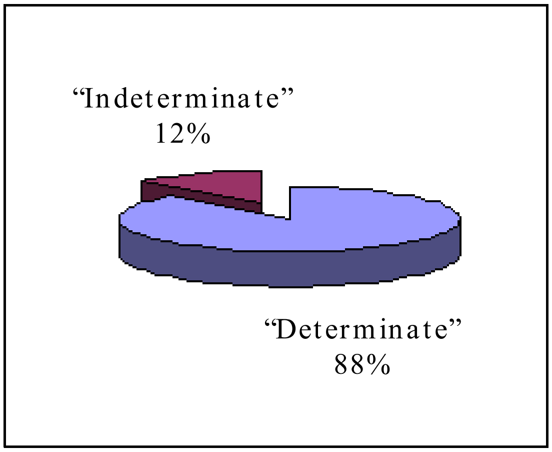

Figure 1: The Ratio of "Indeterminate" Plates to "Determinate" Plates

For the remaining 49 plates, the complete number and state of origin had been identified, but no vehicle registration information could be obtained from the state. Although it is possible that these were invalid plates, it is more likely that the plates were identified incorrectly. The condition of the plates combined with the quality of the video made identification difficult in some cases. There were also some states that could only provide current registration information; therefore, the status on the day of the study could not be determined.

4.2 "DETERMINATE" PLATES

Of the 1038 "determinate" plates, 971 (93.5%) were in compliance with license plate laws and their vehicle registration.[2] These vehicles had a valid and legible plate, appropriate authority to operate in Kentucky, and were operating at or below their registered weight. The remaining 67 plates (6.5%) were in violation of one or more of these laws. Table 1 shows the frequency of violations for each jurisdiction. Figure 2 depicts the ratio of vehicles in compliance to vehicles in violation with the violations by type.

[2]This includes 101 Tennessee plates where registered weight is the only registration information that has been verified.

Table 1: The Number of Trucks and Violations Seen by Jurisdiction

State	Trucks	Violations	State	Trucks	Violations
Alabama	24	0	New Jersey	5	0
Alberta	1	0	New York	1	0
California	7	0	North Carolina	40	0
Florida	9	0	Ohio	161	13
Georgia	23	0	Oklahoma	74	3
Idaho	1	0	Ontario	33	0
Illinois	160	2	Oregon	2	0
Indiana	65	0	Pennsylvania	11	1
Iowa	24	2	Rhode Island	1	0
Kansas	2	0	South Carolina	8	0
Kentucky	143	13	Tennessee	101	1
Maine	1	0	Texas	10	0
Manitoba	2	0	Utah	4	0
Maryland	4	0	Virginia	3	0
Massachusetts	1	0	Washington	2	0
Michigan	23	0	West Virginia	2	0
Minnesota	11	0	Wisconsin	15	0
Mississippi	3	0	Unidentified	178	31
Missouri	9	0	Totals	1185	67
Nebraska	21	1			

4.2.1 Weight Violations

Registered weight violations were the leading cause with 24 occurrences. For the benefit of this study, the registered weights of the vehicles will be grouped into two categories, vehicles registered at 80,000 pounds and vehicles registered at less than 80,000 pounds.

About 90% of all vehicles seen were registered at 80,000 pounds and yet only thirteen violations can be attributed to this group. (Only one of these violations was more than 5% above the 80,000 pounds weight limit.) Under normal weigh station enforcement procedures, these vehicles would have been directed to the static scale and possibly cited for a weight violation.

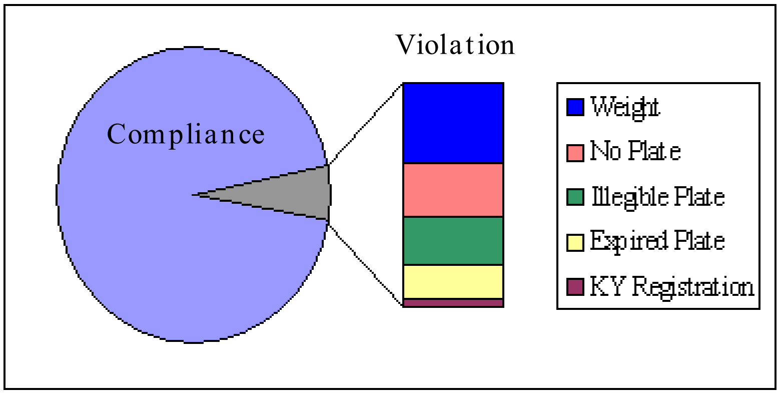

Figure 2: The Ratio of Compliance to Violation with Violations by Type

The remaining eleven weight violations were to trucks registered at less than 80,000 pounds. These trucks comprised only about 10% of the truck traffic, yet they were responsible for more than 45% of the weight violations. Eight of these vehicles were exceeding their registered weight by more than 10%. Under normal procedures, five of the eleven vehicles would have been directed to the static scale. (These vehicles were close enough to the 80,000 pounds limit that they would have to be weighed by a more accurate scale.) If they were exceeding the legal weight limit, they would have to be stopped and cited for both legal and registered weight violations. If they were under the legal weight limit, their registered weight violation would probably go undetected.

4.2.2 Other Plate-Related Violations

Forty-three vehicles had other license plate-related violations. Two of these vehicles did not have the authority to operate within the state of Kentucky. There were fifteen vehicles using illegible plates, and another sixteen vehicles with no plate at all. Ten vehicles seen at the Kenton County weigh station were using expired plates.

5.0 CONCLUSIONS

There are a significant number of violations going undetected at Kentucky weigh stations under normal enforcement procedures. Registration and plate-related violations are occurring for two reasons.

1) License plates are not being monitored visually, allowing trucks with no plates or illegible plates to pass through weigh stations undetected.

2) Registration information is not being verified as trucks pass through weigh stations, allowing expired plates, registered weight violations, and non-apportioned vehicles to go undetected.

Only fifteen of the 67 apparent violations occurring during the five-hour, data-collection period would have been caught under normal enforcement procedures. Some carriers are obviously not abiding by those laws where their compliance is not being checked. For instance, there was only one significant weight violation (>10%) to vehicles registered at the legal weight limit of 80,000 pounds (1 violation out of 899 vehicles). There were eight significant weight violations (>10%) to vehicles registered at less than 80,000 pounds (8 violations out of 99 vehicles). Vehicles registered at less than 80,000 pounds are not monitored based on their registered weight and, as might be expected, they violate it more often.

With visual monitoring and electronic identification of license plates, as many as ten or eleven violations could be caught in a typical hour. Obviously over time, the number of these violations would decrease as carriers began to be cited for plate and registration violations. With monitoring, compliance with license and registration requirements would probably begin to resemble carriers' compliance with the legal weight limit.

LPR technology is an attractive method of electronic identification because it can be used on all vehicles. Unfortunately, application at weigh stations has been minimal and the success of the technology has been limited. From the ongoing and past projects, the following can be concluded:

- Adverse weather conditions can have severe effects on the physical condition of the equipment and the images collected with the equipment.

- LPR systems are not simple; extensive maintenance and downtime should be expected.

- Integrating WIM equipment with the LPR technology can pose significant problems.
- Recognition of the state issuing the license plate is one of the most difficult tasks for the LPR system.
- Increasing the number of states that the system must recognize will increase the complexity of the system and therefore decrease the overall read rate.
- For the system to be valuable, there must be a database of accurate information for the comparison of license plate numbers.
- Short weigh station ramps may not allow for the real-time verification of license plate information.
- Even moderate to low levels of accuracy allow for additional vehicles to be screened to improve safety and credentials compliance.

6.0 RECOMMENDATIONS

To deter registration and other plate-related violations, certain enforcement procedures should be considered for implementation. However, due to the immaturity of the technology and the database requirements, an LPR system is not recommended at this time. As the technology improves and the SAFER/CVIEW databases are fully implemented, an LPR system could significantly reduce the number of violations. Currently, the high cost, maintenance and upkeep of an LPR system could not be justified by its minimal benefits to the enforcement community. Steps can be taken, however, to reduce the number of plate related violations occurring at the weigh station.

A video monitoring system located on the ramp would allow for visual verification of plate information from the weigh station house. The cost would be considerably less than for an LPR system, because there is no automated reading or checking of the license plate number. Officers would simply be able to see the license plates, detecting vehicles with illegible or missing plates. These types of violations represent more than half of all the undetected violations monitored in this study, and could result in an additional five to six detected violations per hour. A reduction in these types of violations would also make any future implementation of an LPR system more effective.

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