Truck Size and Weight Enforcement Technologies

State of the Practice

U.S. Department of Transportation
Federal Highway Administration

final report

State of the Practice

Truck Size and Weight Enforcement Technologies

prepared for

Federal Highway Administration

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Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

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1.0 Introduction

The Federal Highway Administration (FHWA) contracted with Cambridge Systematics, Inc. to conduct the Truck Size and Weight Enforcement Technology Project in collaboration with personnel from the Office of Freight Management and Operations, under the guidance of a Technical Review Committee comprising representatives of FHWA, the Federal Motor Carrier Safety Administration (FMCSA), the Intelligent Transportation Systems (ITS) Joint Program Office of the Research and Innovative Technology Administration (RITA), and the Commercial Vehicle Safety Alliance (CVSA).

The primary project objective is to recommend strategies to encourage the deployment of roadside technologies to improve truck size and weight enforcement in the United States. The project consists of seven discrete but interrelated tasks. The results of each task will be described in a series of memoranda, which in Task 7 will contribute to the final deliverable, an implementation plan. The plan will identify the benefits and downsides of various roadside technologies to different stakeholders and recommend strategies to communicate benefits and mitigate issues.

This report is a deliverable of Task 2. The task objective is to evaluate the state of the practice for using roadside technologies in enforcement activities. Task 2 was supported by an expanded data collection effort designed to capture the "best practices" of states with differing approaches to utilizing technologies. Emphasis was placed on weigh-in-motion (WIM) activities during state site visits and phone interviews. Information about other technologies used by states for enforcement, especially technologies used in association with WIM, also was captured. A list of participating states is included on page 4-16. Summarized information about their usage of technologies is provided in template format in Appendix B.

The intent of Task 2 is not to evaluate WIM or any other technology, but to evaluate the activities that are built around the technology. The focus is on how a technology is deployed, and how it works with other technologies, to support roadside enforcement.

This deliverable represents collaboration between Cambridge Systematics and FHWA. The report was vetted through the participating states and the Technical Review Committee.

2.0 Overview of Roadside Activities

Task 1 of the project produced a diagram that illustrated how roadside technologies could be combined to improve the efficiency and effectiveness of various elements of the roadside enforcement process in the United States. The diagram consisted of two parts. The "Near-Term" activities view depicted technologies currently used by states at the roadside to carry out truck enforcement activities. The "Long-Term" activities view depicted activities and technologies that are planned or could be deployed within the next five to seven years. Because this report addresses the current state of the practice of roadside technologies, consideration will be limited to the near-term activities.

The near-term view is shown in Figure 1. This "American Lego diagram" was adapted from the Netherlands and applied to the roadside environment of the United States. Technologies are seen as building blocks that can be added to a truck weight enforcement program to realize greater enforcement efforts using fewer human resources. As building blocks, the technologies can be combined into different solution sets in order to serve multiple purposes at the roadside.

The American Lego diagram combines elements of FHWA's Truck Size and Weight Program with elements of FMCSA's Commercial Vehicle Information Systems and Networks (CVISN) Program. All acronyms are explained in Appendix A.

2.1 Technology Activities

Technologies are grouped around activities, arranged at the bottom of the diagram. The activities are:

- **Statistics Collection and Planning**, which entails general traffic monitoring that captures the characteristics of traffic (e.g., for freight planning, pavement management, scheduling of enforcement resources) from existing WIM systems;
- **Informed Placement,** which uses weight data from statistics collection and planning to locate new WIM systems for maximum effectiveness in enforcing truck weight regulations;
- **Preselection,** which selects potential offenders or high-risk vehicles from the real-time traffic stream for further inspection and evaluation based on sensor data (e.g., weight, height, brakes) and/or past performance (e.g., weight, safety);

- **Intervention,** which uses roadside performance records (e.g., vehicle overloads, crashes, consolidated ratings) stored in roadside or deskside systems to identify carriers for progressive intervention, such as a warning letter, company visit, or inspection, in order to target non-compliant or unsafe behavior and improve compliance; and
- **Direct Enforcement,** which executes automated enforcement of commercial vehicle weight limits (or dimension, safety-related, or credentials regulations) using electronically collected weight (or dimension, safety, or credentials) data.

2.2 Focus Activities

Weigh-in-motion applications for enforcement are the focus of this report. As Figure 1 shows, WIM is used for statistics collection and planning, informed placement, and preselection activities. WIM is not currently a component of intervention or direct enforcement activities. In preselection, WIM may be combined with vehicle identification technologies, tools to measure past performance, and/or other sensors.

WIM scales measure approximate axle weights as a vehicle moves across sensors or scales and determine the gross vehicle weight and classification based on the axle weights and spacings. WIM systems have been used for commercial vehicle operations in the United States for many years. According to Bergan, Berthelot, and Taylor[1], WIM is commonly deployed at weight enforcement facilities where static scales cannot handle truck traffic volumes. Traditionally, WIM has been used as a weight enforcement tool to sort trucks either on the approach ramp to a weigh station or on the mainline about a mile upstream of a weigh station. "Mainline WIM sorters are employed when land requirements for a ramp sorter are not available or when truck traffic volumes are too high to safely call in all trucks for ramp sorting," they maintain. Mainline WIM uses variable message signs to call in trucks suspected of exceeding maximum allowable weight limits, which are directed to the static scale for compliance weighing.

Bergan et al. assert that WIM virtually eliminates the unnecessary static weighing of trucks known to be within legal limits and "greatly improves the efficiency and effectiveness of weight enforcement facilities and minimizes delays imposed on the trucking industry." They add that the accuracy and reliability of the WIM system determines how much unnecessary static weighing of legal trucks is eliminated. Note that the range in accuracy, reliability, and cost of the various WIM technologies is beyond the scope of this report and this project.

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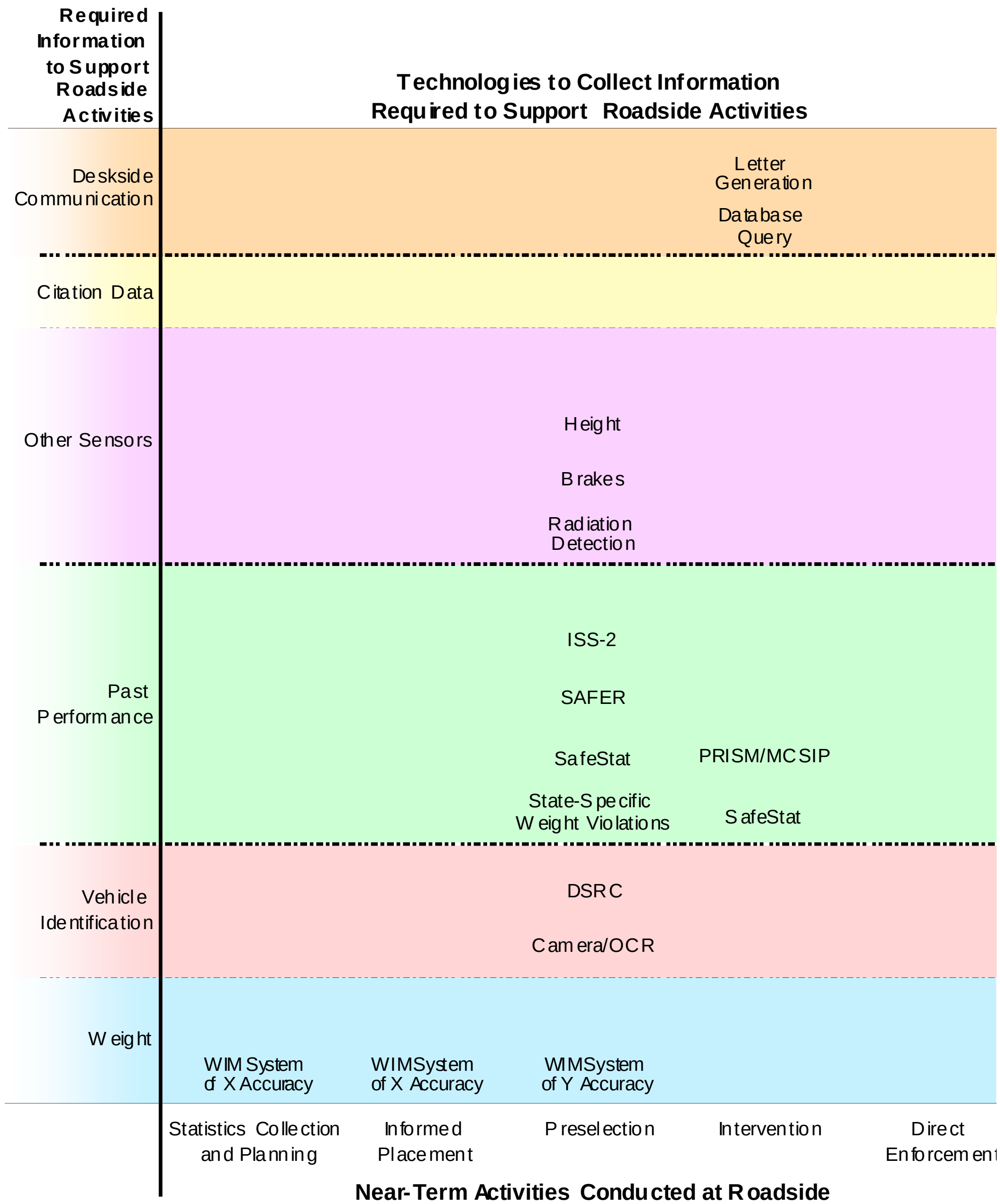
[1] A.T. Bergan, C.F. Berthelot, and B. Taylor, *Effect of Weigh In Motion Accuracy on Weight Enforcement Efficiency,* www.irdinc.com/library/pdf/effect_of_wim.pdf, n.d.

Figure 1. Technologies to Enhance the Efficiency and Effectiveness of Roadside Enforcement – Near-Term



WIM also has been widely used in highway traffic monitoring to support pavement research, facility design, infrastructure maintenance, infrastructure planning, and evaluation of congestion trends. To support monitoring of the full traffic flow, WIM devices are installed in the pavement and connected to data collection instruments. The data are sent to various program areas and agencies to support their needs for highway weight-based information.

More recently, WIM systems have been deployed to support real-time screening activities at locations that are unstaffed and away from weigh stations. The Technology Implementation Group (TIG) of the American Association of State Highway Transportation Officials (AASHTO) selected "virtual weigh-in-motion (VWIM) as a focus technology because several States sparked a non-traditional use: wirelessly linking WIM information to a highway patrol officer's laptop in his or her vehicle. The application of 'virtual technologies' demonstrates an innovative approach to solving size and weight enforcement issues that ranges beyond the WIM traditional role in data collection and vehicle classification."[2] Additionally, WIM is a component of many states' Commercial Vehicle Information Systems and Networks (CVISN) deployments. CVISN is a program of the Federal Motor Carrier Safety Administration (FMCSA).

Figure 2 depicts a portion of the American Lego diagram, namely, the statistics collection and planning, informed placement, and preselection activities; and the weight (weigh-in-motion) and vehicle identification (dedicated short range communications and camera/optical character recognition) technologies used in these activities. Programs and systems that utilize the given technology have been added to the table. Traffic monitoring employs WIM for statistics collection and planning purposes, mobile screening uses WIM for preselection, and so on. The complete American Lego diagram, produced as part of Task 1, includes two additional activities: intervention and direct enforcement. Neither of them is pertinent to this discussion. Direct enforcement, specifically, is not a target or a priority of FHWA or State Departments of Transportation (DOTs) or law enforcement agencies at this time.

The commercial vehicle enforcement activities in Titles 23 and 49, United States Code (23 USC and 49 USC) are described in this report. Technical evaluations of dedicated short range communications (DSRC) and optical character recognition (OCR) are beyond the project scope. NORPASS and PrePass, which utilize DSRC for automatic vehicle identification (AVI) in their electronic screening services, and USDOT number readers and license plate readers, which rely on OCR to support AVI, will be mentioned only in relation to WIM applications.

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[2] American Association of State Highway Transportation Officials (AASHTO), *Virtual Weigh-in-Motion: A "WIM-win" for transportation agencies*, http://www.transportation.org/sites/aashtotig/docs/VWIM%20Brochure%20Final%2010-27-06.pdf, October 2006.

Figure 2. Focus Activities

Activity	Technology	Program/System Name
Statistics Collection and Planning	Weigh-in-Motion	Traffic Monitoring
Informed Placement	Weigh-in-Motion	Informed Placement
Preselection	Weigh-in-Motion	Mobile Screening
		Virtual Weigh Stations
		Fixed Site-Based Mainline Weight Screening
		Ramp Sorting
	Dedicated Short Range Communications	NORPASS
		PrePass
	Camera/Optical Character Recognition	USDOT Number Reader
		License Plate Reader

3.0 Wim Technology Overview

A typical WIM system consists of the following hardware:

- A scale or set of sensors on the mainline or installed on a ramp that records the impact of the passing vehicle;
- A roadside cabinet containing a processor that converts the downward force readings of the vehicle on the scale into data estimating the vehicle's gross weight and axle weights; and
- A communication system that transmits the weight data to the computers of enforcement personnel or to an enterprise-level WIM database management system. Typically, dial-up communication is used to transmit data from WIM systems to users, but in order to support enforcement functions, high-speed wireless or digital subscriber line (DSL) technology is necessary to transmit real-time data and/or vehicle images.

The accuracy of the gross vehicle weight or axle weight estimate as computed by the roadside processor can be affected by the WIM scale technology in use. When installed on the mainline, more expensive WIM systems have less variance in their readings and may better compensate for filtering external factors that affect vehicle weight calculations. Conversely, less expensive WIM scales or sensors may not be as accurate at highway speed. When installed on a ramp, however, the quality of weight data uniformly improves and the difference in accuracy between less and more expensive WIM devices is not as great as under high speed conditions.

An example of a low-cost WIM device that has been deployed in the United States, especially for traffic monitoring purposes, is the piezoelectric sensor. More recently, several states have begun including quartz piezo WIM systems in their programs because of their usefulness in truck enforcement activities. Quartz piezo WIM devices, like electric piezos, are relatively inexpensive and not difficult to install. More expensive systems like load cell and bending plate offer more accurate weight estimates but are more expensive to procure and are significantly more intrusive to the pavement structure.

3.1 High-Speed WIM for Fixed Weigh Station Operations

WIM systems, as indicated above, are commonly used to screen vehicles on the mainline for weight compliance as they approach a weigh station. The WIM scale or sensor embedded in the pavement automatically weighs vehicles and provides an estimate of the vehicle's weight to station personnel for sorting purposes. Typically, weight screening is based on estimates from WIM sensors or scales on the mainline that are compared to a weight pass/fail threshold set to a percent of the legal weight. Thresholds are adjustable by station personnel. Trucks that exceed the threshold are directed into the weigh station to be weighed on more accurate static scales used to write citations. High WIM device accuracy results in low probability of incorrectly sorting a truck.

The data generated by a commercial vehicle passing over a WIM site includes information on number of axles and axle weights. In some states, a digital photograph of the weighed vehicle is automatically recorded and transmitted to enforcement personnel, before the truck arrives at the static scale. Many WIM sites in Europe are equipped with WIM-VID (video) digital imaging systems, which allow for direct enforcement of commercial vehicles by producing real-time vehicle images associated with vehicle data. However, in the United States, digital cameras are not standard on WIM systems.

When used as part of an electronic screening or bypass system such as PrePass or NORPASS, WIM provides real-time weight verification concurrent with safety and credentials verification for bypass eligibility. Vehicles cleared for bypass are not generally directed to pull into the weigh station. DSRC readers and WIM sensors are located far enough ahead of the station ramp to allow the screening system time to complete the necessary processing of the vehicle as it approaches. The driver is signaled to pull in or bypass via their transponder before it reaches the ramp.

Mainline weight screening produces a number of benefits. Weigh-in-motion significantly increases the capacity of weigh stations. In the absence of mainline WIM, queues may form and cause closure of weigh stations; as a result, compliance checks are not performed on the bypassed vehicles. WIM also reduces congestion within the fixed weigh station facility, focuses enforcement on high-risk operators, and provides time savings for safe and legal carriers, supporting more efficient movement of freight. For example, inspectors at Washington State weigh stations that are instrumented for CVISN electronic screening, which includes weigh-in-motion at mainline speed, reported considerable improvements in traffic flow and a reduction in congestion since electronic and mainline weight screening was deployed.

The use of mainline weight screening using WIM is increasing in the United States. There are approximately 550 WIM sites in operation nationwide from which the Federal Highway Administration receives weight-based highway data. Among PrePass sites alone, 52 percent have WIM. However, not all WIM sites nationwide are currently used for enforcement purposes.

Two of the states participating in this study offer value as examples. California supports mainline WIM for screening at 34 weigh station locations, all of which are instrumented for PrePass, and is currently constructing two new weigh stations where mainline WIM will be deployed. Washington State includes WIM technology at 14 of its weigh stations. These weigh stations weigh over 80 percent of the state's commercial vehicles. The mainline WIM system is linked to a camera that takes a picture of a vehicle as it crosses the WIM sensors; the image is recorded along with the vehicle's weight data. The integrated WIM and camera system records all vehicles regardless of whether they are equipped with a transponder (for participation in Washington's electronic screening system, NORPASS) or not. A changeable message sign located before the exit ramp directs transpondered trucks into the weigh station if their weights exceed established thresholds. All trucks without transponders must enter an open weigh station.

Washington's Commercial-vehicle Roadside Information Sorting System (CRISS) automatically identifies transpondered vehicles and queries the Commercial Vehicle Information Exchange Window (CVIEW) for up-to-date safety and credentials information about the carrier and vehicle. Generally, if the vehicle's weight and other information meet the state's defined screening criteria, the driver is signaled via the transponder to bypass the weigh station. Non-transponder equipped vehicles are handled differently because they are not automatically identified as they approach the weigh station, and all of them must exit the main highway to be weighed on the static scale. The CRISS software displays a picture and weight information for each vehicle as it approaches the weigh station. An algorithm determines if there are any potential axle weight violations, which are highlighted on the computer screen at the scale house. The system helps inspectors better identify vehicles with problems. CRISS was the first system in the U.S. to associate digital photos of trucks with their vehicle data on a weigh station computer to aid in visual identification and enforcement.

3.2 Low-Speed WIM for Ramp Sorting

WIM scales are also installed on weigh station ramps to weigh and sort vehicles at low speeds. Vehicles that have left the main highway move to the approach ramp where they are weighed by a ramp, or sorter, WIM. The ramp WIM sorts the arriving trucks based on a weight threshold set by weigh station personnel. Axle spacing, vehicle height, and vehicle classification also may be determined. Vehicles that do not exceed the threshold are signaled by a message sign to move to the bypass lane for return to the main highway. Remaining vehicles are directed to the static scale for weighing. Compared to mainline WIM systems, ramp WIM systems weigh vehicles moving at lower speeds and provide a more accurate measure of a vehicle's weight.

The deployment of ramp WIM, like mainline WIM, has increased recently. Most of the states participating in this study have installed or plan to install ramp WIM systems at their weigh stations. Kentucky, Michigan, Mississippi, and Indiana utilize ramp WIM at five or more weigh stations. Ramp sorting combined with a bypass lane can process more vehicles than could be supported by static weighing alone. Several states reported that additional sorter WIM systems are desired in order to increase throughput.

4.0 Statistics Collection and Planning

Mainline WIM systems are commonly used to collect traffic characteristics information for analysis of travel and weight trends, pavement and bridge monitoring and management, pavement design, and development of emissions models. WIM systems used for traffic monitoring may serve "double duty" for preselection as well as statistics collection and planning. Some states use the WIM information to assign enforcement resources.

The hardware requirements for the collection of WIM data for planning purposes are similar to those described in the "WIM Technology Overview" section above. Typically, the primary customer of the data is the state's Department of Transportation (DOT) or Department of Highways. The data is processed and displayed to satisfy customer needs. States may implement specialized tools and applications to provide useful information from WIM data. Data is collected continuously, which maximizes a state's ability to conduct pavement monitoring and research and make pavement design decisions. Oregon has published a report describing the use of WIM in load spectra analysis. Of the states that were interviewed, contacts from North Dakota voiced their intent to do the same.

Continuous data collection also facilitates assignment of enforcement resources based on occurrences of recorded weight violations, as used in Michigan and North Dakota. Historical data from WIM systems can be used to focus inspections at locations where non-compliant and overweight trucks are known to travel. Factors such as levels of truck traffic and frequency of overweight trucks at a site broken down by day and time of day are used to determine the most productive locations, days, and times for scheduling mobile enforcement teams.

One example of software used for enforcement purposes includes the data processing tool called "WIMCAT" (WIM Compliance Assessment Tool). WIMCAT is used in Indiana and Minnesota to determine violations from raw data, to recommend optimal hours for enforcement, to facilitate estimates of damage from overweight vehicles, and to flag data anomalies. In Indiana, such reports are issued on a weekly and monthly basis. Another best practice example, Michigan's Truck Weight Information System (TWIS), processes and analyzes truck weights collected at the WIM sites for use in targeting areas, days, and times of overweight activity. TWIS will be enhanced with mapping and other new functionality as funds are available in the future.

Some states have enhanced their data management operations by developing enterprise-level WIM database management systems. Both Minnesota and California are developing a data warehouse to manage their accumulating WIM data and make data accessible to more users. Several states indicated that having a plan for managing and utilizing the WIM data is as critical as assuring the proper operation of the equipment. However, states also reported difficulty in acquiring and maintaining resources for operating and maintaining data processing and management software.

The number of WIM systems used for statistics collection and planning varies considerably from state to state. California has 190 WIM scales from which data is collected (the state has an additional 88 scales used for enforcement that do not provide data from all lanes). Many states' WIM systems originated as part of FHWA's Strategic Highway Research Program (SHRP) or Long-Term Pavement Performance (LTPP) Program. These programs, focused on pavement research, placed an emphasis on collecting locally- or segment-specific vehicle loadings. States also have applied State Planning and Research (SPR) funds to deploy WIM systems used for traffic and pavement monitoring purposes. Data from all these sites is collected continuously. In some states, WIM data supplements classification and volume data collected from automatic traffic recorder (ATR) sites for design purposes.

4.1 Informed Placement of WIM Systems

In some states, the DOT will utilize its weigh-in-motion database to identify locations that regularly experience high incidences of overweight trucks. It can then base its future installation of WIM systems according to this data, to more effectively enforce truck weight regulations. This activity is generally referred to as informed placement. Data collected as part of a state's traffic monitoring and pavement monitoring programs can be used to advance informed placement activities. High incidences of overweight trucks at existing WIM locations are analyzed, and routes with expected increases in truck loadings are generally considered to be leading candidates for additional WIM installations. New weigh stations are constructed for a variety of reasons, but patterns of weight violations observed or presumed to exist at a site play a role in locating a new facility.

A state can further the benefits of informed placement activities by using data from existing WIM sites to determine the sites' suitability for preselection and enforcement activities. Michigan used data from traffic monitoring WIM sites to decide at which of the locations real-time screening would be deployed. At the outset, the Michigan State Police reviewed TWIS data gathered from traffic monitoring sites and envisioned the utility of using them for screening. The State Police worked in concert with the Michigan DOT (which purchases and installs WIM systems and manages TWIS) to identify locations for wireless access to the WIM data for enforcement officers. The two agencies formed a Commercial Vehicle Strategy Team consisting of five members from the DOT and four members from the State Police whose collaborative efforts include identifying locations for new WIM systems and "safe enforcement sites" that can be used by the State Police for weight and/or safety inspections in a safe environment, as well as locations where existing WIM systems can be enhanced for screening.

To date, Michigan has enhanced nine WIM systems for screening purposes by deploying a radio transmitter at the WIM location, a wireless air card in the patrol car, and specialized software on the officer's laptop computer. All existing sites that are given screening capabilities in Michigan are also upgraded to quartz piezo WIM technology devices. After a WIM site in Michigan is upgraded and given screening capabilities, all traffic monitoring and enforcement data is continuously captured by TWIS.

States that reported plans to install new WIM systems intend to locate the new scales for enforcement uses (i.e., locations for screening, virtual weigh station, or weigh station), with concomitant data collection. One state reported that WIM systems should be placed where they can "provide good information on what happens on the [road] system and for pavement decisions, and good locations for enforcement." Another state said, "WIM without enforcement does not make sense."

4.2 Preselection — Mobile Screening at WIM Sites

Preselection, or screening, is a method used to sort traffic to distinguish between legal vehicles and potential violators in order to focus inspection and evaluation on high-risk operators. Screening is deployed to make more efficient use of enforcement resources. Mobile screening at WIM sites is an example of preselection. Virtual weigh stations, described below, are another example of preselection. In a typical mobile screening environment, an officer at the roadside with a laptop computer receives individual axle weights and gross vehicle weights that are wirelessly transmitted from the WIM device on the mainline to the mobile officer's laptop. The officer physically monitors the real-time WIM data on the laptop and visually identifies the trucks that are overweight according to the data received. The potentially overweight trucks are then intercepted for inspection after traveling past the WIM site. Having quantifiable performance measurements avoids stopping vehicles that are legal according to weight thresholds established by the State.

WIM sites used for mobile screening operations are not continuously monitored. Enforcement personnel may conduct screening operations at a site according to a schedule or on a day-to-day basis, often as resources permit. Mobile screening also can be distinguished from other enforcement-related WIM operations, such as mainline or ramp screening at weigh stations, which were previously described, and virtual weigh stations, which are described later. States may call mobile screening by different names, including wireless access to WIM readings, "prescreening," or even "virtual weigh station."

In many cases, WIM systems chiefly used for data collection can be upgraded to contain mobile screening capabilities at relatively low cost. Traffic monitoring functions have remained intact, while the addition of preselection capabilities is attractive to the state's enforcement agency and optimizes the utility of the WIM equipment. Several states (e.g., Indiana, Michigan, Minnesota) have upgraded one or more of their WIM systems to support preselection. Two states, Minnesota and Indiana, have expressed their desire to eventually expand all of the state's WIM systems into preselection sites, either for mobile screening or as virtual weigh stations. Generally, existing WIM equipment can be utilized for screening when enhanced with wireless connectivity, specialized software, and user-selected data for viewing purposes.

When states upgrade (or retrofit) WIM sites for enforcement purposes, communication capabilities, computer operating systems, and data processing applications are all generally improved. Other states, like North Dakota, designed all its WIM sites to support data collection and screening. As a result, the state does not distinguish between WIM sites used for data collection and WIM sites used for screening. Moreover, none of North Dakota's 12 WIM systems were funded by SHRP or LTPP; rather, state construction funds supported the deployments.

Typical mobile screening sites require the following pieces of hardware: a WIM scale or sensors, a roadside processor, wireless connectivity via Wi-Fi (wireless fidelity) or other short-range communication, generally using a transmitter at the WIM location and a receiver in the patrol car, and a laptop capable of handling data. The laptop must have specialized software that can display the WIM data generated in real-time by trucks passing over nearby scales. Visual and sound alerts help identify possible violators.

One-person (vehicle) enforcement units are most commonly deployed at a typical mobile screening site. The officer monitors the weights of passing trucks via laptop computer, intercepts suspect trucks, and weighs the trucks on portable scales at the roadside to record legally enforceable weights. When two patrol vehicles are deployed, the first vehicle monitors WIM readings via laptop and communicates visual descriptions of suspect vehicles to a partner downstream. The second enforcement unit then intercepts the suspect vehicles for roadside weighing with portable scales. Two-person teams are likely to be deployed at higher volume locations.

Regardless of whether one- or two-person teams are deployed, a mobile screening operation has limitations. Radio signals, commonly used to transmit the data from the WIM system, are effective for one-half to three-quarters of a mile as long as there is line-of–sight between the officer and the WIM scale or device. This facilitates the visual matching of a vehicle with its associated WIM data.

One state reported its enforcement agency was initially apprehensive about using truck traffic counts and WIM data because they felt the data might be skewed. The concern with data quality was due to its perception that carriers may be avoiding WIM locations being used for enforcement-related screening. However, the state no longer believes this to be the case. Another state, which has not yet deployed any enforcement-related activity at a WIM site, believes that the character of traffic changes when enforcement is applied, affecting "typical" truck traffic patterns.

In order to visually verify the offending vehicle, inconspicuous enforcement may not be possible. Because screening is a visual process, inclement weather and heavy truck volumes adversely impact operations. Positioning of patrol vehicles also is limited by concerns about the officers' safety in close proximity to moving traffic, as "good spots" for viewing trucks may not be the safest locations. Michigan reported the following requirements for mobile screening:

- Ability to collect and report accurate information;
- Proximity to a safe place to weigh trucks;
- Potential for overweight trucks; and
- Commitment to deployment.

States with mobile screening operations report considerable satisfaction with the deployments. Mobile screening provides increased opportunity for enforcement by providing added capacity for resources, allowing for enforcement that is not disruptive to the travel stream, and guaranteeing more efficient delivery of enforcement actions through targeted intervention. Michigan reported that during the first week of enforcement at the most recently deployed location (Interstate 75 near Vanderbilt), the officer on duty cited 10 overweight vehicles, nine of which he said he would never have been able to identify using visual indicators alone. A best practice state, Michigan plans to install new WIM systems specifically for screening operations, rather than upgrading existing WIM sites used for traffic monitoring.

Minnesota's assessment is similar. According to the state, mobile screening makes it much easier to identify overweight trucks. Moreover, screening keeps the industry moving. Carriers that have many trucks that are legally loaded are happy not to be stopped and weighed. Minnesota has three elements in its weight enforcement program: weigh stations, mobile patrols, and Relevant Evidence. Mobile enforcement includes mobile screening at WIM sites. Two WIM sites in northwest Minnesota, both on U.S. Highway 2 (mileposts 8 and 91), are used for screening by one mobile State Trooper. The officer physically monitors the real-time WIM data on the laptop and visually identifies the trucks that are overweight according to the data received from the WIM. Traffic is light at both locations, which facilitates the visual identification of suspect trucks. There is strong interest in expanding the use of WIM systems for enforcement purposes. Concomitantly, Minnesota is "moving away" from fixed sites for weight enforcement because they are expensive to build and maintain. Seven weigh stations exist in the state; of these, six are operational.

Relevant Evidence, which also is known as the civil weight program, is a uniquely Minnesota form of weight enforcement. It allows state enforcement officials, under statutory authority, to examine weigh bills and issue civil penalties for overweight loads. The weigh bill is "relevant evidence" of an overweight violation. By law, all parties that weigh goods (e.g., receiving sites such as grain elevators, gravel and quarry operations, refineries, milk products plants, paper mills) must retain weight bills, bills of lading, and other freight documents for 14 days, and must allow access to enforcement officers (no search warrant is needed). Civil penalties for excessive weight may be applied if the enforcement officer has inspected and copied the record within 14 days of the date the shipment was received by the party in possession of the record. The program was established in 1980, and amended in 2002 to include the 14-day limit on civil penalties and a $10,000 maximum fine. Currently, approximately 100 Troopers and Commercial Vehicle Inspectors of the Minnesota State Patrol are trained to conduct the civil weight operations. According to the Minnesota DOT, the program works so well that nearly every year there is a bill before the State Legislature to change the law.

North Dakota's assessment of mobile screening is that it is "great" and works well, but availability of staff to conduct the operations is an ongoing problem. As indicated previously, all of North Dakota's WIM sites were designed to support both data collection and screening. Troopers position themselves by the WIM sites and screen trucks as they pass by, monitoring the WIM data that has been transmitted by radio communication to their laptop that displays the data and presents color or sound alerts to notify them of potentially overweight vehicles. In North Dakota, the majority of trucks that are pulled over are weighed on portable scales, although six of the WIM sites are located in the vicinity of a weigh station. WIM screening is conducted on a week-to-week schedule because of manpower constraints. In a good example of "double duty" uses, the data collected by the WIM systems is used to assign enforcement resources according to the incidence of recorded weight violations. North Dakota is interested in enhancing its screening operations by implementing a digital imaging system so photos of potential overweight violators can be sent to officers, relieving the dependence on visual association. North Dakota, a leader in the advancement of "virtual WIM" systems, is the chair of the Virtual WIM Lead States Team of the Technology Implementation Group (TIG) of AASHTO.

California is very interested in deploying mobile screening to replace weigh stations. Mobile officers of the California Highway Patrol are members of the Mobile Road Inspection Program, who are spread out on the mainline roadways (not freeways) and typically use visual indicators to select vehicles for weighing and/or inspection. The Highway Patrol reported that these officers would be interested in conducting screening operations at WIM sites. According to evidentiary information, states not contacted for this study also are interested in deploying mobile screening. By adding screening functionality to existing traffic monitoring WIM sites, New Jersey will stop trucks for inspection in a selective rather than random manner. Once a truck is stopped, the New Jersey State

Police will determine if a full safety inspection should be conducted in addition to weighing. Initially, 11 sites will be upgraded with wireless communications and new computer operating systems to allow them to be used for screening.

Among the lessons learned from states' deployments of mobile screening, it was observed that although screening can lead to more efficient use of resources, a full complement of size and weight enforcement officers is essential to support effective screening operations. This is because personnel must be available to statically weigh suspect trucks on portable or semi-portable scales. Moreover, systems that require human monitoring such as mobile screening are of limited value during staffing shortages. In this vein, it was noted that the lack of automatic identification of vehicles suspected of being overweight severely limits the efficiency and effectiveness of roadside enforcement.

Generally, states consider mobile screening to be well worth the costs, especially when existing WIM systems are utilized. One state reported $160,000 for deployment of four lanes of quartz piezo sensors, WIM controller, roadside cabinet, computer, radio frequency transmitter and receiver, and utilities. Another state offered that only "limited incremental costs" are needed to upgrade a WIM site used for data collection to one used for enforcement as well.

4.3 Preselection — Virtual Weigh Stations

For purposes of this report, mobile screening is distinguished from a virtual weigh station. The hardware requirements of a virtual weigh station are similar to that of a mobile screening site, but a virtual weigh station includes the addition of a digital imaging system, at minimum, and possibly additional technologies. Other technologies present at the site may eliminate the need for digital imaging. A virtual site has no permanent (continuous) on-site staff, therefore, WIM used for mobile screening is a simple version of a virtual weigh station site. While in use for enforcement purposes, however, both a mobile screening site and a virtual weigh station require human monitoring.

At this time, our definition of a virtual weigh station is as follows:

A virtual weigh station is a roadside enforcement facility that does not require continuous staffing and is monitored from another location. Typical hardware deployed at a virtual weigh station includes a WIM installation, a camera system, and high-speed communications for use in real-time truck screening operations.

Virtual weigh stations are intended to mimic the capabilities of a fixed weigh station. Typically, one is located where a fixed weigh station would not be feasible for environmental or cost reasons. For example, virtual sites can be located in urban areas more readily than fixed, staffed weigh stations. They also may be located where a fixed, staffed site is not needed, but where violators are likely to travel. Depending on the technologies present, virtual weigh stations provide at least the same information about a vehicle as does a traditional weigh station.

In virtual weigh station operations, an enforcement officer views the real-time WIM data linked with a vehicle photo on a laptop computer in the patrol vehicle located downstream of the WIM site. Multiple photos also may be displayed in thumbnail form so the officer can easily select from different views of the vehicle of interest. Suspect vehicles are identified on the laptop, facilitated by visual and/or sound alerts. In this scenario, the officer monitors the data and images and intercepts the violators. The same data and images may be viewed by enforcement personnel in a fixed facility. Instead of an officer located downstream performing monitoring and weighing functions, personnel viewing the WIM data and images at another location such as a central office or weigh station could dispatch nearby enforcement units to intercept and weigh suspect vehicles identified on the monitor.

At bypass route locations where vehicles frequently exit the main highway to avoid weighing at a weigh station, virtual operations can be integrated with the operations of the weigh station, allowing the enforcement agency to more effectively allocate their limited resources. An officer on duty at the weigh station can monitor the virtual weigh station operations on a computer screen (that will include vehicle images and associated weight information) and dispatch another officer also located at the station to intercept a suspected overweight vehicle bypassing the weigh station facility. Alternatively, an officer may be located downstream of the virtual weigh station and can be radioed to pull over the suspect vehicle.

The virtual weigh station at Punta Gorda, Florida was deployed to evaluate the incidence of trucks bypassing the nearby weigh station. Two WIM systems and four cameras were installed north and south of the weigh station to monitor trucks leaving Interstate 75, using U.S. Highway 41 (a parallel highway west of the weigh station), and re-entering the interstate. The virtual weigh station elements are as follows:

- WIM and camera on the northbound interstate exit ramp south of the weigh station;
- Camera on the northbound interstate entrance ramp north of the weigh station;
- WIM and camera on the southbound interstate exit ramp north of the weigh station; and
- Camera on the southbound interstate entrance ramp south of the weigh station.

The virtual weigh station can reveal if trucks that leave the interstate, travel on Highway 41, and re-enter the interstate are bypassing the weigh station. The camera takes a photograph of a truck leaving the interstate; the co-located WIM is used to determine if the truck is overweight. On the other side of the weigh station, a camera takes a photograph of the truck entering the interstate (from Highway 41), which is compared to the photograph of the truck exiting the interstate. The time between photographs is compared to determine if bypassing was likely. For example, if the time between photographs is one hour, it is assumed that the truck had a legitimate reason (e.g., fuel or food stop) to exit the interstate and was not bypassing the weigh station. Short durations arguably indicate bypassing. Monitoring and evaluation are performed at the weigh station scale house. Beyond its original objective of assessing the incidence of bypassing, the Punta Gorda virtual weigh station is used to identify overweight trucks, which are intercepted, weighed, and if warranted, cited for weight violation.

In Minnesota, line-of-sight limitations of mobile screening led to deployment of a digital camera as part of a demonstration project. The digital camera allowed an officer to be located at a much greater distance from the site, affording lower visibility of enforcement activities. Flexibility in the positioning of the patrol vehicle was mentioned by other states as a key benefit of digital imaging deployment at a virtual weigh station. Furthermore, in areas with high truck volumes, a suspect vehicle can be identified by its photo integrated with its WIM record.

In addition to a WIM scale and a vehicle detection system, hardware requirements of a virtual weigh station include the following:

- WIM controller that collects weight data and passes it to the computer in the roadside cabinet,, and triggers the camera;
- Computer loaded with software that interfaces with the controller and camera, e.g., integrates the digital image with the WIM data;
- Wireless cellular network to a file transfer protocol (FTP) or web server, or to the WIM cabinet through the Internet, to access the data and images;
- Laptops loaded with specialized software capable of presenting weight information; and
- Digital camera(s), which may be concealed (e.g., in the roadside cabinet) or visible (e.g., on a mast arm).

Associated software can vary in its degree of complexity depending on the user's needs. At minimum, images of the vehicles must be correctly associated with the corresponding weight readings. A Remotely Operated Compliance Station (ROCS), such as the one at Sneads, Florida, collects total vehicle weight, axle weights and spacings, dimensions, USDOT number, container number, speed, and sequential ID, and displays the data along with vehicle photos. Indiana's WIMCAT, previously described, estimates exceedances in gross vehicle or axle weight limits from the raw data. The system also uses historical data to suggest optimal hours for enforcement, and produces data that can be used to estimate pavement wear and bridge damage. The WIMCAT also features quality assurance and quality control (QA/QC) checks on the data, highlighting anomalous values.

A license plate reader (LPR) or USDOT number reader provides the virtual weigh station with digital image capture and identification through a digital camera or cameras augmented with specialized optical character recognition (OCR) software to isolate and identify specific characters and numbers making up a license plate number and/or USDOT number. LPRs and USDOT number readers are forms of automatic vehicle identification (AVI). AVI relieves the need for any kind of manual visual recognition, whether it is based on direct observation of the vehicle itself or examining a photo of the vehicle. The LPR or USDOT reader can interface with a state's Commercial Vehicle Information Exchange Window (CVIEW) to retrieve safety and credentials information associated with the vehicle identified automatically by its license plate or USDOT number. Additionally, license plates can be searched in the National Crime Information Center (NCIC) or other database or list, further expanding the screening factors. AVI deployment allows screening on safety, credentials, and criminal justice information as well as weight by associating WIM readings and can considerably reduce the time required to retrieve additional information about a suspect vehicle.

Indiana soon will have installed three virtual weigh stations with typical camera systems. The roadside computer software marries the WIM record with the vehicle image and transmits it via a wireless cellular network to an FTP site, where it can be accessed by authorized parties. Downstream of the WIM site, an enforcement officer views the real-time WIM data linked with the vehicle photo on a laptop computer in the patrol vehicle. With this information, the officer can pull the truck over for weighing and inspection. WIMCAT, which is loaded on a computer in the roadside cabinet and determines violations from the raw WIM data, also can be used to recommend optimal hours for enforcement, facilitate estimates of damage from overweight vehicles, and flag data anomalies. The state estimates the cost of retrofitting an existing WIM site (no new sensors) as approximately $30,000. Indiana will also install quartz piezo WIM sensors at all new sites. Future plans also include OCR deployment for automatic vehicle identification. As stated previously, Indiana would like to use the entirety of its 50 traffic monitoring WIM sites for enforcement as virtual weigh stations. None of the 50 WIM sites is located on a weigh station bypass route. As part of the state's long-range planning for weigh stations, which includes participation of the Indiana DOT and the Indiana State Police, it is likely that new WIM systems will be installed on "troublesome" routes and these WIM sites will serve as virtual weigh stations. Weigh stations will be more effective in improving compliance, according to the State Police, when WIM technology is deployed on bypass routes.

Florida has deployed several virtual weigh stations, including a USDOT number reader at JAXPORT which supports a comprehensive vehicle information system for truckers that is capable for enforcement but is not currently used for this purpose. Punta Gorda, where a camera system is employed, is used for enforcement, as described previously. A third site, Sneads, was designed to test technologies and is used for demonstration and data gathering purposes.

License plate readers also are deployed at all of Florida's weigh stations on the station ramps and at some of the state's agricultural inspection stations at location of the inspection station building.

JAXPORT's system (also called ROCS, as at Sneads) was designed to show drivers what their trucks weigh as they leave the container port. This alerts them to the possible need for a permit if they exceed their established weight. Despite Florida DOT's concerns about overweight containers, weight violations have not been reported, only speed violations. Truckers realize that the system is not used for enforcement, and they like it. The ROCS architecture is the same for both JAXPORT and Sneads, although JAXPORT has more technologies and greater physical infrastructure. Basically, the system has two components: capture systems in the field connected to the main computer, and query and display functions provided by the central server and interface that integrate all the data. ROCS is "self-healing," so if the central server goes down, all files are saved. A primary objective has been to ensure that all the technologies and computers work together. These elements include the following:

- WIM quartz piezo sensor in the right-hand lane of traffic;
- Dimensioning sensor that provides height and width, with radar to provide length;
- Low resolution camera for vehicle images;
- USDOT number camera and computer;
- Container number camera and computer;
- PTZ (pan, tilt, and zoom) camera to remotely view the area;
- Dynamic message sign that displays the truck's weight; and
- Weather station.

Real-time enforcement screening on the vehicle parameters produced by the available sensors and technologies could be accomplished by accessing the data through wireless Internet access. As stated, neither the JAXPORT nor Sneads sites are used for enforcement. The estimated cost of ROCS at JAXPORT was $250,000 (with an additional $100,000 for the mast arm and pole).

The Sneads virtual weigh station is used to demonstrate technologies and collect data. ROCS at this location captures speed, overall weight, axle weights, and three photographs of the vehicle, and stores the information in a database. The Sneads weigh station is nearby. At the weigh station, static weights of individual trucks can be measured that can be compared with WIM readings. The Sneads weigh station supports PrePass electronic screening. The high-speed weigh-in-motion device and roadside digital camera image capture system of the Sneads virtual weigh station are not integrated into the weigh station, or PrePass, operations.

Florida's agricultural inspection stations support a unique suite of advanced technologies. Twenty-three inspection stations are operated by the Florida Department of Agriculture and Consumer Services (DACS), through its Office of Agricultural Law Enforcement. By statute, all trucks must enter an agricultural station and submit for inspection. The agricultural inspection station at Yulee on Interstate 95 in Nassau County is one of 17 stations equipped with a license plate reader. The LPR extracts the plate number and transmits it to the Florida Crime Information Center (FCIC)/NCIC to check for stolen equipment, Amber Alerts, warrants, etc. A container reader utilizing OCR software also has been deployed, which reads the container identification number from the container and passes it to DACS' central server in Tallahassee. A container will appear in the Tag Recognition System if there is an alert on the container. The vehicle and cargo inspection system (VACIS) deployed at the Yulee agricultural inspection station is a gamma ray imaging system that uses radiographic images to help trained inspectors examine the closed contents of trucks, containers, and cargo for hidden compartments containing contraband. VACIS is deployed at the four Interstate agricultural inspection stations, located in Suwannee, Hamilton, Escambia, and Nassau Counties.

Yulee is also one of six "AgPass" sites in Florida (two at each of the agricultural inspection station locations on Interstates 10, 75, and 95). PrePass Ag, as it also is called, is a partnership of PrePass and DACS that allows eligible enrolled commercial carriers to bypass the six inspection stations in the same way they bypass PrePass-equipped weigh stations (i.e., through the use of a transponder). Only carriers that do not haul dedicated agricultural cargo are approved by DACS for the program. Carriers' bills of lading are provided to DACS electronically by PrePass Ag. On Interstate 10 the Florida DOT weigh station and the DACS agricultural inspection station are closely located. Trucks without transponders must pull in to both stations. On the other hand, trucks enrolled in both PrePass and PrePass Ag are eligible to bypass the stations.

California deployed a prototype virtual weigh station, including LPR, at Cordelia. The Cordelia virtual weigh station is located on eastbound Interstate 80, halfway between Sacramento and San Francisco, at a point of congestion that is not easily or cost effectively bypassed by commercial vehicles. It is located in the same place as the PrePass transponder reader in advance of the Cordelia vehicle inspection station. PrePass uses the WIM data collected at this location to help determine the eligibility of enrolled vehicles to bypass the inspection station.

The Cordelia virtual weigh station's in-pavement technical components include a bending plate WIM scale, a vehicle detection system, and a camera triggering system. Data integration is performed by computer systems located in three roadside cabinets. The first cabinet contains the control systems for the side fire camera and license plate camera, as well as the OCR computer; in the second cabinet, digital images are converted into picture images, vehicle images are matched with weight measurements, weight limits are checked and weight compliance is determined, data are formatted for transmission and remote viewing, and weight data only is transmitted to a PrePass computer also at roadside; the third cabinet holds the PrePass computer. The PrePass computer integrates the vehicle identification information obtained from the vehicle's transponder with the WIM data and sends the results to the PrePass computer at the Cordelia inspection station, which verifies safety and credentials status and subsequently notifies the driver to bypass the inspection station or pull in for inspection.

Considerable discussion has centered on the need for OCR capability, and it is unclear if future enforcement-related WIM sites in California will support OCR.

The first virtual weigh station in Kentucky was installed in 2003 and utilized quartz piezo WIM sensors and a digital camera system. The digital images of the truck could be used by personnel at a nearby weigh station to read the USDOT number. The site is no longer in operation. Kentucky has since deployed virtual weigh station technologies such as license plate and USDOT number readers at operational weigh stations, as part of ongoing research, testing, and development efforts. The technologies are components of the Integrated Security and Safety Enforcement System (ISSES), which is deployed at three of Kentucky's weigh stations. ISSES includes a license plate reader, a USDOT number reader, radiation portal monitors, and an infrared camera for detection of brake deficiencies. The technologies operate within the weigh station after the truck has been weighed on the ramp WIM and its dimensions scanned by the height, width, and length detector. The weigh stations also are instrumented to provide electronic screening capabilities, including bypass privileges for eligible NORPASS carriers. As situated, the ISSES technologies are too close to the scale building to be practical for automated screening, and as a result, human monitoring and data entry (keying in of the license plate and USDOT numbers) are still required. The LPR and USDOT number reader are not currently being used for enforcement purposes at these locations. Kentucky reports that the individual ISSES technologies work well, but it has been a challenge to integrate them into one system with one user interface.

Kentucky plans to incorporate the LPR and USDOT number reader into an automated ramp screening system for a weigh station. This system will use weight data from the ramp sorter WIM along with the license plate number and/or USDOT number to access the Kentucky CVIEW and make an automated screening decision. This scenario will be the prototype for Kentucky's "next generation" virtual weigh station that will include an LPR and USDOT number reader linked with the state's CVIEW, at an unstaffed site on a non-Interstate route. The goal is to continuously monitor trucks that do not routinely pass through a weigh station.

Washington State indicated its intention to deploy virtual weigh stations, which would include LPR, at one or more locations in the eastern part of the state. Mississippi intends to pilot a LPR-equipped virtual weigh station at one or two sites. Mississippi has numerous WIM sites throughout the state that are used for traffic monitoring and planning purposes. The CVISN team is examining multiple sites to assess their suitability for screening operations. In some cases, a WIM site may be used for mobile screening, whereby the enforcement officer at the WIM uses weight data displayed on the laptop computer to screen passing trucks. The ultimate step is to implement virtual weigh station capabilities in the form of a license plate reader. One promising location is a heavily traveled route (Highway 82 near the Port of Greenville on the Mississippi River) that does not support a weigh station. This location originally was considered for a traditional weigh station. The pilot project may be expanded to include an additional virtual weigh station at a location where trucks routinely bypass the weigh station, specifically on Interstate 10. States not contacted for this study, such as Montana and Colorado, evidently also plan to deploy virtual weigh stations.

It was observed by a best practice state that the more technologically complex the project is, the more essential the teamwork becomes among project partners. In most cases, more than one agency is involved, and close planning is needed to assure that all parties' objectives and requirements are met by the project. Different "pieces" of the project (e.g., WIM, LPR, container number reader) may have different affected stakeholders (who may be within the same agency), each of whom has a different reason for being interested in the data that is produced. Furthermore, each technology may have multiple stakeholders. Needs of all stakeholders must be taken into consideration when planning and selecting technologies, and working as a team is arguably the most effective way of achieving this.

All states commented on the cooperative relationship that has to be in place, or built, to support the successful deployment of roadside technologies. In Michigan, cooperative efforts between the DOT and the State Police (meeting as the Commercial Vehicle Strategy Team) determined the best locations for all WIM systems, both for traffic monitoring and screening purposes. North Dakota reported that collaboration between the DOT and the Highway Patrol in planning and constructing WIM sites for dual purposes was essential for success. In the late 1990s the State Police and the DOT collaborated on the deployment of Indiana's first WIM site that was enhanced for real-time screening. Today, the two agencies participate in a committee for long-range weigh station planning, which develops weight enforcement strategies involving virtual weigh stations as well as weigh stations.

One state said plainly that the state's enforcement agency must "make partners" with the DOT in order to obtain the tools it needs for enforcement. Without the DOT's help and cooperation, the tools will not be made available to enforcement personnel. Finding the common ground, such as improving commercial vehicle safety, and in so doing, improving overall highway safety, is the first step in developing a partnership.

States also mentioned the importance of support from the motor carrier industry. To the extent that activities such as mobile screening and virtual weigh stations "take the bad guys off the road," make the roads safer, and level the playing field between carriers that are safe and legal, and those that are not, state trucking associations can be strong advocates and allies. Mississippi reported that the trucking association recognizes the value of virtual weigh stations in addressing and correcting problems with overweight trucks on routes with heavy commercial vehicle traffic and thin enforcement resources. Other states such as Washington and Kentucky commented on the strong support their CVISN program has received from the state trucking association. Support from the trucking association in these and other states involves participation in planning processes and marketing programs to motor carriers.

4.4 Summarized Information on Usage of Technologies

Information on WIM, DSRC, and camera/OCR technologies that was gathered in the task data collection effort is presented in template format in Appendix B. Summaries of functionality, technical requirements, locations, advantages and disadvantages, enhancements, and lessons learned are available for programs and systems that utilize WIM, DSRC, and camera/OCR technologies in the states participating in this study (listed on the next page). Where a description or entry is unique to a state, the state is identified. Otherwise, statements are generally applicable to the participating states.

The "template" was populated almost exclusively with information gathered from the participating states. Where cells are "empty," states did not provide information. Limited information from other sources was included for clarification. Acronyms used in the report or template are explained in Appendix A.

Participating States

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Appendix A – Acronyms

AASHTO	American Association of State Highway Transportation Officials
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
ATR	Automatic Traffic Recorder
AVI	Automatic Vehicle Identification
CMV	Commercial Motor Vehicle
CRISS	Commercial-vehicle Roadside Information Sorting System
CVIEW	Commercial Vehicle Information Exchange Window
CVISN	Commercial Vehicle Information Systems and Networks
CVSA	Commercial Vehicle Safety Alliance
DACS	Department of Agriculture and Consumer Services
DOT	Department of Transportation
DSL	Digital Subscriber Line
DSRC	Dedicated Short Range Communications
FCIC	Florida Crime Information Center
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FTP	File Transfer Protocol
GIS	Geographic Information System
ISS	Inspection Selection System
ISSES	Integrated Safety and Security Enforcement System
ITS	Intelligent Transportation Systems
LPR	License Plate Reader
LTPP	Long-Term Pavement Performance
MCSIP	Motor Carrier Safety Improvement Process
MACS	Mainline Automated Clearance System
NCIC	National Crime Information Center
NLETS	National Law Enforcement Telecommunications System
NPTC	National Private Truck Council
O&M	Operations and Maintenance
OCR	Optical Character Recognition
PRISM	Performance and Registration Information Systems Management

PTZ	Pan Tilt Zoom
QA	Quality Assurance
QC	Quality Control
RFID	Radio Frequency Identification
RITA	Research and Innovative Technology Administration
ROCS	Remotely Operated Compliance System
SAFER	Safety and Fitness Electronic Records
SafeStat	Safety Status Measurement System
SHRP	Strategic Highway Research Program
SPR	State Planning and Research
TIG	Technology Implementation Group
TWIS	Truck Weight Information System
USDOT	United States Department of Transportation
USC	United States Code
VACIS	Vehicle and Cargo Inspection System
VID	Video
VWIM	Virtual Weigh-in-Motion
VWS	Virtual Weigh Station
Wi-Fi	Wireless Fidelity
WIM	Weigh-in-Motion
WIMCAT	Weigh-in-Motion Compliance Assessment Tool

Appendix B – WIM System Technologies

Technology: **WIM System**
Activity: **Statistics and Planning**
Program/System Name: **Traffic Monitoring**

Metric	*Details*
Functionality	Collect traffic characteristics information for travel trends, weight trends, pavement monitoring/management, pavement design, emissions models Provide data for assignment of enforcement resources Serve dual use for data collection and weight screening
Hardware Requirements	WIM scale - single load cell, piezo, Kistler quartz. Trend toward Kistler quartz for new WIMs WIM processor (collects scale data for transmission) Land-line telephone or wireless communication to DOT
Software Requirements	Process/display data to satisfy user needs, e.g., weights and overloads per site by time periods (month, day, time of day) Record data for every truck passing over WIM, i.e., historically complete (Michigan TWIS) Determine violations from raw data, recommend optimal hours for enforcement, facilitate estimates of damage from overweight vehicles, flag data anomalies (Indiana/Minnesota WIMCAT) Download data for load spectra analysis (North Dakota)
Manpower Requirements (Roadside)	None
Deployed Locations	Indiana, 50 WIMs North Dakota, 12 WIMs Michigan, 40 WIMs Florida, 1 WIM Minnesota, 11 WIMs California, 190 WIMs Mississippi, 20 WIMs

Planned Locations	"Baselined" WIMs (one year) available for screening operations (Minnesota) New WIMs, if any, will support enforcement activities (screening, virtual weigh station, weigh station) and data collection
Existing Linkages	
Technology Limitations	Dial-up communication used in most WIM systems. High speed wireless or DSL required for transmission of real-time data and/or vehicle images
Legislative or Regulatory Changes (Yes/No)	No
Cost (Low/Mod/High with $ if available)	Many have roots in SHRP and LTPP (Federal $), or SPR (State $) 4-lane Kistler quartz WIM = $187,000 (Minnesota)
Activity Performance (Excellent/Good/Fair/Poor)	Excellent
Technology Performance (Excellent/Good/Fair/Poor)	95% accuracy for Kistler quartz 95% accuracy for single load cell 85% accuracy for piezo
Proven Technology (Yes/No)	Yes
Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	Good Kistler quartz adjusts to weather and easy to install
Level of Industry Resistance (Low/Med/High)	Low
Level of Agency Resistance (Low/Med/High)	Low
Standards (Yes/No)	ASTM E1318-02 (WIM)
Other Advantages	Easy to expand traffic monitoring WIMs into screening WIMs, e.g., no additional equipment, deploy aircard or other wireless communication, user-selected data for viewing Continuous data collection. Assign enforcement resources based on occurrences of violations, i.e., targeted enforcement (Michigan, North Dakota) WIM data supplements classification and volume data, used for design, from ATR sites
Other Disadvantages	Difficult to acquire and retain resources for software O&M (Michigan TWIS)

Planned Enhancements	Desire to upgrade <u>all</u> WIMs to virtual weigh stations (Indiana), to weight screening (Minnesota) Maximize utility of WIMs, i.e., migrate additional sites to weight screening (Michigan, Minnesota) or virtual weigh stations (Indiana) Incorporate GIS/map based capability for reports (Indiana) Incorporate WIM data into design processes, including load spectra analysis (North Dakota) WIM data warehouse to manage data (Minnesota) Truck data warehouse to make data accessible to more users; GIS, ad hoc reports (California)
Lessons Learned	Deploy WIMs where they can provide good information on what happens on the system and for pavement decisions, and good locations for enforcement (Minnesota) Planning does not end when data is collected; you need to have a plan for managing and utilizing the data

Technology: **WIM System**
Activity: **Informed Placement**
Program/System Name: **Informed Placement**

Metric	*Details*
Functionality	Use weight data from traffic monitoring WIMs to locate new WIM systems
Hardware Requirements	See "Traffic Monitoring" WIM
Software Requirements	See "Traffic Monitoring" WIM
Manpower Requirements (Roadside)	None
Deployed Locations	Data from traffic monitoring WIMs used to locate weight screening WIMs (Michigan)
Planned Locations	
Existing Linkages	
Technology Limitations	See "Traffic Monitoring" WIM
Legislative or Regulatory Changes (Yes/No)	No
Cost (Low/Mod/High with $ if available)	See "Traffic Monitoring" WIM
Activity Performance (Excellent/Good/Fair/Poor)	Excellent
Technology Performance (Excellent/Good/Fair/Poor)	See "Traffic Monitoring" WIM
Proven Technology (Yes/No)	Yes
Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	See "Traffic Monitoring" WIM
Level of Industry Resistance (Low/Med/High)	Low
Level of Agency Resistance (Low/Med/High)	Low
Standards (Yes/No)	ASTM E1318-02 (WIM)

Other Advantages	Optimal data for choosing new locations for screening
Other Disadvantages	Difficult to acquire and retain resources for software O&M (Michigan TWIS)
Planned Enhancements	
Lessons Learned	Cooperative effort between DOT and State Police determined best locations for all WIMs, both traffic monitoring and screening (Michigan)

Technology: **WIM System**

Activity: **Preselection**

Program/System Name: **Mobile Screening**

Metric	*Details*
Functionality	View real-time WIM data on laptop in patrol vehicle downstream of WIM. Suspect vehicles identified by visual association with WIM data. Potential axle and/or gross weight violators weighed on portable scale or at nearby weigh station Serve dual purpose for weight screening and data collection
Hardware Requirements	WIM scale - single load cell, piezo, Kistler quartz. Trend toward Kistler quartz for new sites WIM processor (collects scale data for transmission) Wireless connectivity via Wi Fi or other short-range communication, using transmitter at WIM location (transmits WIM data), receiver in patrol car (receives read-only WIM data) Laptops capable of handling data
Software Requirements	Process WIM data and display data on laptop computer (with visual and sound alerts to identify possible violators). Programmed to display specified vehicle classes
Manpower Requirements (Roadside)	One or two vehicles Two vehicle team at higher traffic volume locations (Michigan)
Deployed Locations	North Dakota, 12 sites; weigh stations waning, WIM-based enforcement up Michigan, 9 sites Minnesota, 2 sites; weigh stations waning, WIM-based enforcement up
Planned Locations	Two being readied, monitoring by two vehicle teams; only Kistler quartz for new sites (Michigan) Interest in screening WIMs to replace weigh stations (California)
Existing Linkages	WIM linked to data processing software
Technology Limitations	High speed communication to support real-time data transfer where truck volumes are moderate to heavy Patrol vehicle in line of sight of transmitter (within 1/2 to 3/4 mile); however, for one-person team, positioning apt to be "at WIM site" to best identify vehicle
Legislative or Regulatory Changes (Yes/No)	No

Cost (Low/Mod/High with $ if available)	1 lane = $105,000 2 lanes = $125,000 4 lanes = $160,000 Quartz & all screening equipment (North Dakota) 1-lane piezo WIM = $16,000 1-lane quartz WIM = $29,000 (Michigan)
Activity Performance (Excellent/Good/Fair/Poor)	Excellent
Technology Performance (Excellent/Good/Fair/Poor)	95% accuracy for Kistler quartz 95% accuracy for single load cell 85% accuracy for piezo
Proven Technology (Yes/No)	Yes
Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	Good Kistler quartz adjusts to weather and easy to install
Level of Industry Resistance (Low/Med/High)	Low
Level of Agency Resistance (Low/Med/High)	Low
Standards (Yes/No)	ASTM E1318-02 (WIM)
Other Advantages	Non-intrusive enforcement Legal trucks not disturbed Expansion of stop based on weight to include safety inspection, e.g., use ISS-2 to decide to inspect
Other Disadvantages	Within sight distance of WIM cabinet essential to match WIM data and a moving vehicle; limits covert operationsAbility to enforce weights is visual, with impacts of weather, heavy truck volumesPositioning of patrol vehicles limited by safety concernsTurn-out areas should be constructed to facilitate weighings and inspections; otherwise, rest areas or wide shoulders are necessary
Planned Enhancements	Deploy camera system to provide vehicle image linked to WIM record

Lessons Learned	Full complement of size and weight enforcement dedicated Troopers is essential to support prescreening operations. Even with camera systems deployed at WIM sites, personnel must be available to weigh trucks Systems requiring continuous human monitoring are of limited value during staffing shortages Lack of automated identification of vehicles severely limits efficiency and effectiveness of roadside enforcement Collaboration between DOT and Highway Patrol in planning and constructing WIM sites for dual purposes is essential for success (North Dakota) Program buy-in by State Police increased after DOT demonstrated greater accuracy of Kistler quartz vs. piezo (Michigan) WIM without enforcement "does not make sense" (California)

Technology: **WIM System**
Activity: **Preselection**
Program/System Name: **Virtual Weigh Stations**

Metric	*Details*
Functionality	View real-time WIM data linked with vehicle photo on laptop in patrol vehicle downstream of WIM. Suspect vehicles identified on laptop screen. Potential axle and/or gross weight violators weighed on portable scale. Same data may be viewed in a fixed facility View WIM data and images on a computer monitor at a central location. Suspect vehicles identified on monitor. Enforcement units dispatched to intercept and weigh potential axle and/or gross weight violators Deploy WIM and cameras at highway exit and re-entrance ramps to determine incidence of weigh station bypassing In addition, deploy license plate reader or USDOT number reader for automatic vehicle identification
Hardware Requirements	WIM scale - single load cell, piezo, Kistler quartz. Trend toward Kistler quartz for new sites WIM controller (collects scale data and passes to computer, triggers camera) (alternatively, also performs computer functions) Field grade computer (interface with controller and camera, e.g., merges digital image with WM data) Wireless cellular network to FTP site or Web server, or to WIM cabinet through Internet. System may be hard-wired (JAXPORT) Laptops capable of handling data Camera, which may be covert (e.g., in roadside cabinet) or evident (e.g., on mast arm); number of images varies among systems Main computer fed by WIM sensor, dimensioning sensor, cameras (vehicle, container, PTZ), i.e., field "capture" systems; feed to central server and interface for display (JAXPORT)

Software Requirements	Match vehicles with weight measurements Determine violations from raw data, recommend optimal hours for enforcement, facilitate estimates of damage from overweight vehicles, flag data anomalies (Indiana WIMCAT) Determine total weight, axle weights/ spacings, speed, vehicle photos, sequential ID, etc., i.e., user "query and display" systems (Florida, ROCS at Sneads and JAXPORT) Optional OCR capability for AVI
Manpower Requirements (Roadside)	One vehicle, i.e., images and data monitored by personnel individually in vehicles, who also intercept violators One person could monitor images and data from multiple sites at a central location and dispatch strategically located enforcement units
Deployed Locations	Indiana, one site waiting for completion of retrofitting; two sites being outfitted. Possibly use all 50 traffic monitoring WIMs for enforcement Florida, test facility at Sneads, weight information system for truckers at JAXPORT - no enforcement at these sites; Punta Gorda used for enforcement California, prototype at Cordelia, with LPR
Planned Locations	Eastern Washington probable location for ~2 sites; Kistler quartz for new sites (Washington) Pilot LPR site(s), no location set - look at heavily traveled routes with no weigh station (Mississippi) OCR site on non-Interstate route with no weigh station (Kentucky)
Existing Linkages	WIM linked to camera for real-time vehicle images and data processing software Weights, axles, dimensions, USDOT number, container number, speed, and photos all linked in one record (JAXPORT)
Technology Limitations	High speed communication required to transmit images
Legislative or Regulatory Changes (Yes/No)	No
Cost (Low/Mod/High with $ if available)	Retrofit existing site into VWS (no new sensors) = $30,000 (Indiana) New piezo= $40,000 New 4-lane single load cell = $350,000 (Indiana) Total system = $250,000 (add $100,000 for mast arm/ pole) (JAXPORT)

Activity Performance (Excellent/Good/Fair/Poor)	Prevailing belief in VWS as better choice for enforcement than weigh stations (Indiana) Excellent (Florida)
Technology Performance (Excellent/Good/Fair/Poor)	95% accuracy for Kistler quartz 95% accuracy for single load cell 85% accuracy for piezo
Proven Technology (Yes/No)	Yes
Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	Good Kistler quartz adjusts to weather and easy to install
Level of Industry Resistance (Low/Med/High)	Low for non-enforcement sites
Level of Agency Resistance (Low/Med/High)	Low - medium
Standards (Yes/No)	ASTM E1318-02 (WIM)
Other Advantages	Continuous data collection. Assign enforcement resources based on occurrences of violations. Numerous data analyses, e.g., monthly weight violators, percentage of trucks Measurable basis for identifying overweight trucks. Especially useful in identifying habitual offenders Non-intrusive enforcement Areas of considerable truck volumes Legal trucks not disturbed Flexibility to position patrol vehicle
Other Disadvantages	Turn-out areas should be constructed to facilitate weighings and inspections; otherwise, rest areas or wide shoulders are necessary Using WIMs for enforcement changes character of traffic, i.e., atypical loadings (Mississippi)
Planned Enhancements	Deploy OCR to automatically read USDOT or plate numbers to relieve visual recognition Monitor virtual weigh stations from fixed weigh stations Link USDOT and container numbers to databases, e.g., NLETS, PRISM Deploy RFID and license plate reader at JAXPORT (Florida)

Lessons Learned	Sufficient staffing is key to any enforcement operation. Weigh stations cannot operate 24/7 due to lack of staff. Virtual weigh stations with cameras require staff to weigh vehicles on portable scales Systems requiring continuous human monitoring are of limited value during staffing shortages Lack of automated identification of vehicles severely limits efficiency and effectiveness of roadside enforcement Teamwork is essential, especially between State Police and DOT. Technologies will not be successfully deployed in absence of a team concept Focus on the technology, not the vendor. Aim is to obtain technology that the State needs

Technology: **WIM System**

Activity: **Preselection**

Program/System Name: **Fixed Site-Based Mainline Weight Screening**

Metric	*Details*
Functionality	Automatically weigh vehicles on mainline highway as they approach weigh/inspection station. Provide real-time weight verification concurrent with safety and credentials verification for bypass eligibility. Potential weight violators signaled in for weighing on static scale
Hardware Requirements	WIM scale - single load cell (Washington) Control unit with processor and transmitting elements Hard-wired communication, or wireless communication
Software Requirements	
Manpower Requirements (Roadside)	Weigh station personnel
Deployed Locations	Kentucky, 1 site California, 34 sites Washington, 14 sites
Planned Locations	California, new weigh stations at Tecate and Mountain Pass
Existing Linkages	Frequently associated with DSRC electronic screening projects Mainline WIM linked to camera for real-time vehicle images associated with vehicle data - capture all CMVs on mainline approaching weigh station (Washington)
Technology Limitations	
Legislative or Regulatory Changes (Yes/No)	
Cost (Low/Mod/High with $ if available)	
Activity Performance (Excellent/Good/Fair/Poor)	Excellent. Activity is commonplace in North America
Technology Performance (Excellent/Good/Fair/Poor)	95% accuracy for single load cell
Proven Technology (Yes/No)	Yes

Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	
Level of Industry Resistance (Low/Med/High)	
Level of Agency Resistance (Low/Med/High)	
Standards (Yes/No)	ASTM E1318-02 (WIM)
Other Advantages	Capacity enhancement Reduced congestion within facility
Other Disadvantages	
Planned Enhancements	
Lessons Learned	

Technology: **WIM System**
Activity: **Preselection**
Program/System Name: **Ramp Sorting**

Metric	*Details*
Functionality	Automatically weigh vehicles moving on weigh station ramp. Potential violators signaled for weighing on static scale At DSRC electronic screening locations, used to sort non-transpondered vehicles
Hardware Requirements	WIM scale Control unit with processor and transmitting elements Hard-wired communication, or wireless communication
Software Requirements	
Manpower Requirements (Roadside)	Weigh station personnel
Deployed Locations	Indiana, 5 sites Kentucky, 8 sites California, a few sites Mississippi, 6 sites Michigan, 7 sites
Planned Locations	Additional sorter WIMs desired to increase throughput at stations
Existing Linkages	
Technology Limitations	
Legislative or Regulatory Changes (Yes/No)	
Cost (Low/Mod/High with $ if available)	
Activity Performance (Excellent/Good/Fair/Poor)	Excellent. Activity is commonplace in North America
Technology Performance (Excellent/Good/Fair/Poor)	
Proven Technology (Yes/No)	Yes

Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	
Level of Industry Resistance (Low/Med/High)	
Level of Agency Resistance (Low/Med/High)	
Standards (Yes/No)	ASTM E1318-02 (WIM)
Other Advantages	Capacity enhancement Reduced queuing for static scale
Other Disadvantages	
Planned Enhancements	
Lessons Learned	

Technology: **DSRC**

Program/System Name: **NORPASS**

Metric	*Details*
Functionality	Automatically identify enrolled vehicles at weigh/inspection stations, allowing automatic screening for safety, credentials, and optionally, weight, compliance, and signal driver with pull-in decision
Hardware Requirements	Transponder mounted in vehicle Readers mounted at roadside to detect and notify transponder-equipped vehicles and optionally to confirm compliance
Software Requirements	Determine pull-in rates, perform selective enforcement actions on specific carriers, interface with CVIEW (Kentucky ModelMACS) Gather information from DSRC and WIM; validate credentials, axle weights, bridge weights, random pull-ins; display results and photo images; make final bypass/report decisions (Washington CRISS)
Manpower Requirements (Roadside)	Weigh station personnel
Deployed Locations	Kentucky, 12 screening sites Washington, 11 screening sites
Planned Locations	Washington, Spokane POE
Existing Linkages	Mainline WIM Mainline WIM linked to camera for real-time vehicle images associated with vehicle data (Washington) CVIEW or other screening database (credentials, safety, weight violations, etc.)
Technology Limitations	Technically, none for electronic screening; limits imposed by voluntary motor carrier participation
Legislative or Regulatory Changes (Yes/No)	
Cost (Low/Mod/High with $ if available)	E-screening system = $70,000 - $80,000 (Kentucky)
Activity Performance (Excellent/Good/Fair/Poor)	Good; improves with increased participation
Technology Performance (Excellent/Good/Fair/Poor)	Excellent
Proven Technology (Yes/No)	Yes

Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	
Level of Industry Resistance (Low/Med/High)	Low within State association, ATA, NPTC (Kentucky) Low within State association (Washington)
Level of Agency Resistance (Low/Med/High)	
Standards (Yes/No)	Yes
Other Advantages	"Reward" for good safety performance Reduced congestion within facility Improved traffic flow Focus inspection resources on trucks most likely to be in violation of regulations Time and fuel savings for carriers
Other Disadvantages	Voluntary motor carrier participation, limiting benefits to congestion and leveling of playing field
Planned Enhancements	Possibly capture digital images for information on vehicle condition, e.g., flat tire, proper placard
Lessons Learned	Increased time from detection to notification allows for enforcement intervention to override screening decision Deployment requires support of entire CVISN team, including industry, which helps project move forward

Technology: **DSRC**
Program/System Name: **PrePass**

Metric	Details
Functionality	Automatically identify enrolled vehicles at weigh/inspection stations, allowing automatic screening for safety, credentials, and optionally, weight, compliance, and signal driver with pull-in decision
Hardware Requirements	Transponder mounted in vehicle Readers mounted at roadside to detect and notify transponder-equipped vehicles and optionally to confirm compliance
Software Requirements	Site level capability to screen enrolled carriers based on safety, credentials, and random selection
Manpower Requirements (Roadside)	Weigh station personnel
Deployed Locations	Florida, 18 screening sites, 6 agricultural screening sites California, 34 screening sites. 11 sites provide statistics/planning data Mississippi, 12 screening sites
Planned Locations	California, Tecate and Mountain Pass
Existing Linkages	Mainline WIM
Technology Limitations	Technically, none for electronic screening; limits imposed by voluntary motor carrier participation
Legislative or Regulatory Changes (Yes/No)	
Cost (Low/Mod/High with $ if available)	AVI equipment and software, installation, maintenance, and repair provided by HELP, Inc.
Activity Performance (Excellent/Good/Fair/Poor)	Good; improves with increased participation
Technology Performance (Excellent/Good/Fair/Poor)	Excellent
Proven Technology (Yes/No)	Yes
Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	
Level of Industry Resistance (Low/Med/High)	

Level of Agency Resistance (Low/Med/High)	
Standards (Yes/No)	Yes
Other Advantages	Resources "saved" on credentials checks and Level 1 inspections Reduced congestion within facility Improved traffic flow Focus inspection resources on trucks most likely to be in violation of regulations Time and fuel savings for carriers
Other Disadvantages	Voluntary motor carrier participation, limiting benefits to congestion and leveling of playing field
Planned Enhancements	
Lessons Learned	

Technology: **Camera/OCR**
Program/System Name: **USDOT Number Reader**

Metric	*Details*
Functionality	Automate screening based on USDOT number (Weigh stations or virtual weigh stations)
Hardware Requirements	Special lighting for USDOT camera Server to run OCR software and communicate with database host Personal computer with web browser screen
Software Requirements	Recognition software
Manpower Requirements (Roadside)	Monitor/responder, or monitor and responder if different persons Kentucky, manual data entry at two locations
Deployed Locations	Kentucky, 3 weigh station sites with LPR and USDOT reader, no enforcement use. Manual keying of USDOT numbers at 2 sites Florida, 1 VWS site, no enforcement use (JAXPORT)
Planned Locations	Automated ramp screening using ramp WIM data, license plate and USDOT numbers, linked to CVIEW, to monitor trucks not routinely passing weigh stations; a prototype, controlled environment, as precursor to OCR deployment at virtual weigh station on secondary road (Kentucky)
Existing Linkages	CVIEW or other screening database (credentials, safety, weight violations, etc.) Component of ISSES, Kentucky Component of JAXPORT, Florida
Technology Limitations	Difficult to capture images when speeds vary widely Timing and lighting adjustments necessary for USDOT readers; with adjustments, accuracy could approach 75% (Kentucky)
Legislative or Regulatory Changes (Yes/No)	
Cost (Low/Mod/High with $ if available)	ISSES package = $500,000 per site
Activity Performance (Excellent/Good/Fair/Poor)	Can be used to screen all vehicles

Technology Performance (Excellent/Good/Fair/Poor)	57-60% accuracy (Kentucky) 65% accuracy (Florida)
Proven Technology (Yes/No)	Evolving
Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	
Level of Industry Resistance (Low/Med/High)	
Level of Agency Resistance (Low/Med/High)	
Standards (Yes/No)	No
Other Advantages	Removal of dependence on manual keying
Other Disadvantages	Difficult to read improperly displayed numbers
Planned Enhancements	Link to NLETS, PRISM, etc. (Florida)
Lessons Learned	Most efficient, effective solution to automatically identify vehicles is a simple, low-cost electronic identifier on every truck. OCR may be viewed as interim solution until electronic identifier is implemented Systems requiring continuous human monitoring are of limited value during staffing shortages Individual technologies can work well, but integration into one system with one user interface can be major and continuing challenge (Kentucky) Funding may be available for deployment and evaluation, but can be difficult to find for O&M, especially when budgets become tight (Kentucky)

Technology: **Camera/OCR**
Program/System Name: **License Plate Reader**

Metric	*Details*
Functionality	Automate screening based on license plate (Weigh stations or virtual weigh stations)
Hardware Requirements	Camera, illuminator, triggering system Server to run OCR software and communicate with database host Personal computer with web browser screen
Software Requirements	Recognition software
Manpower Requirements (Roadside)	Monitor/responder, or monitor and responder if different persons
Deployed Locations	Kentucky, 3 weigh station sites with LPR and USDOT reader, no enforcement use Florida, LPRs on all weigh station ramps, plus 17 agricultural inspection stations California, prototype at Cordelia VWS
Planned Locations	Automated ramp screening using ramp WIM data, license plate and USDOT numbers, linked to CVIEW, to monitor trucks not routinely passing weigh stations; a prototype, controlled environment, as precursor to OCR deployment at virtual weigh station on secondary road (Kentucky) Washington, eastern part of state
Existing Linkages	CVIEW or other screening database (credentials, safety, weight violations, criminal justice information, etc.) Linked to PRISM (Kentucky) Component of ISSES, Kentucky
Technology Limitations	Dependent on precise triggering and proper illumination
Legislative or Regulatory Changes (Yes/No)	
Cost (Low/Mod/High with $ if available)	ISSES package = $500,000 per site

Activity Performance (Excellent/Good/Fair/Poor)	Can be used to screen all vehicles
Technology Performance (Excellent/Good/Fair/Poor)	80% accuracy for "readable" license plates (Florida)
Proven Technology (Yes/No)	Evolving
Equipment Reliability or Maintenance (Excellent/Good/Fair/Poor)	
Level of Industry Resistance (Low/Med/High)	
Level of Agency Resistance (Low/Med/High)	
Standards (Yes/No)	No
Other Advantages	Removal of dependence on manual keying
Other Disadvantages	Lack of standardized license plates Same license plate number in different jurisdictions Bad condition of license plates License plate found on back of single unit trucks, not readable by front-reading LPR
Planned Enhancements	
Lessons Learned	Most efficient, effective solution to automatically identify vehicles is a simple, low-cost electronic identifier on every truck. OCR may be viewed as interim solution until electronic identifier is implementedSystems requiring continuous human monitoring are of limited value during staffing shortagesFunding may be available for deployment and evaluation, but can be difficult to find for O&M, especially when budgets become tight (Kentucky)

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This report is a deliverable of Task 2 of FHWA's Truck Size and Weight Enforcement Technology Project. The primary project objective was to recommend strategies to encourage the deployment of roadside technologies to improve truck size and weight enforcement in the United States. The objective of Task 2 was to evaluate the state of the practice for using roadside technologies in enforcement activities. Task 2 was supported by an expanded data collection effort designed to capture the "best practices" of states with differing approaches to utilizing technologies. Emphasis was placed on weigh-in-motion (WIM) activities during State site visits and phone interviews. Information about other technologies used by states for enforcement, especially technologies used in association with WIM, also was captured. A list of participating states is included toward the end of the report. Summarized information about their usage of technologies is provided in template format at the end of the report.

WIM applications for enforcement are described for the best practice states that participated in this project. These applications include high-speed WIM used in fixed weigh station operations; low-speed WIM used for sorting on weigh station ramps; and screening at WIM sites using any of a number of vehicle identification methods, including unaided visual identification, camera (digital imaging) systems, and automatic vehicle identification (AVI) such as license plate readers and USDOT number readers. Virtual weigh stations, which employ digital imaging that may be augmented with AVI capabilities, are featured in the report.</td></tr>
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