Technical Report

For

Kentucky Commercial Vehicle Safety Applications Evaluation

U.S. Department of Transportation
Washington, DC 20590

January 31, 2008

U.S. Department of Transportation
Research and Innovative Technology Administration

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-08-025		

4. Title and Subtitle
Kentucky Commercial Vehicle Safety Applications Evaluation: Technical Report

5. Report Date
January 31, 2008

6. Performing Organization Code
G604618

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8. Performing Organization Report No.

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10. Work Unit No. (TRAIS)

11. Contract or Grant No.
DTFH61-02-C-00134; Task BA34018

12. Sponsoring Agency Name and Address
United States Department of Transportation
ITS Joint Program Office
1200 New Jersey Avenue SE
Washington, DC 20590

13. Type of Report and Period Covered
Technical Report
6/2005 to 1/2008

14. Sponsoring Agency Code
EDL No. 14400

15. Supplementary Notes
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16. Abstract
An advanced-technology Integrated Safety and Security Enforcement System (ISSES), now deployed at three commercial vehicle inspection sites along interstate highways in Kentucky, was evaluated from the point of view of system performance, potential effects on inspection selection efficiency (choosing the highest-risk trucks from the stream of commerce), user acceptance, and costs. Overall, despite the fact that commercial vehicle law enforcement staffing levels in Kentucky did not allow for full-time, dedicated use of the ISSES by inspectors at the time of the evaluation, the subsystems that were under evaluation in this task were found to be performing effectively in a stand-alone mode. The ISSES software and components now deployed, though operational, are considered to be in a development mode. The roadside system was not yet integrated with in-state or national databases of historical safety information on carriers or vehicles, so the ISSES was not able to provide instant, "actionable" historical information that the inspectors could apply in their decision-making. Such integration has the potential, if implemented, to afford significant benefits in vehicle screening and safety enforcement. Kentucky's current inspection selection methods were compared with potential applications of ISSES technology across a set of scenarios, used to model improvements in commercial vehicle safety. Applying various combinations of inspection selection strategies and available or envisioned technologies for real-time vehicle identification and safety information exchange at the roadside, in a hypothetical statewide deployment supporting about 44,000 vehicle inspections and 86,000 driver inspections in a year, the ISSES was estimated to contribute to incremental reductions of between 63 and 629 commercial vehicle-related crashes per year, reductions of between 16 and 163 personal injuries, and reductions of up to 7 fatalities. Overall, to the extent that they had been exposed to the ISSES, the users were positive toward it and appeared to recognize its potential, but within their current organizational environment, they regarded it as more of a developmental test or research device than as a tool that they wanted to use immediately in their day-to-day commercial vehicle inspection and law enforcement duties.

17. Key Words	18. Distribution Statement
Intelligent Transportation Systems, Safety, CVISN, Commercial Truck, Motor Carrier, Inspection, Weigh Station Bypass, Electronic Screening, Law Enforcement, Nuclear Monitoring, Thermal Imaging, Infrared	No restrictions. This document is available to the public.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	146	N/A

Form DOT F 1700.7 Reproduction of completed page authorized.

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Acknowledgments

The authors acknowledge the significant time and effort contributed by the deployment team, including the Kentucky Transportation Center, Kentucky Vehicle Enforcement, Kentucky Transportation Cabinet, and the system vendor, all of whom consulted on planning, participated in interviews, and provided information for this evaluation.

Executive Summary

An advanced-technology Integrated Safety and Security Enforcement System (ISSES), now deployed at three commercial vehicle inspection sites along interstate highways in Kentucky, was evaluated from the point of view of system performance, potential effects on inspection selection efficiency (choosing the highest-risk trucks from the stream of commerce), user acceptance, and costs.

Objectives. The overall purpose of the Kentucky Commercial Vehicle Safety Applications (CVSA) Evaluation was to provide an independent assessment of the performance, usability, safety benefits, and wider applicability of an advanced system for screening trucks at the roadside. The system, known as ISSES, has been deployed along selected interstate highway routes by the Kentucky Transportation Cabinet, under a grant from the Federal Motor Carrier Safety Administration (FMCSA). ISSES is made up of a radiation monitor, a thermal inspection device, a laser scanner/vehicle detector, a license plate recognition system, and a USDOT number reader. The system has potential applications for both highway safety and nuclear detection/homeland security. The present evaluation is focused on the first deployment, at Laurel County, near London, Kentucky, on I-75 northbound. This Technical Report describes the evaluation objectives, the data collection and data analysis methods, and the evaluation results. Goals of the evaluation were to estimate whether the ISSES will make highways safer and more secure, and to determine how the ISSES makes the commercial vehicle inspection process more efficient and effective. The main aspects of this evaluation were (a) system performance, (b) inspection selection efficiency, and (c) user acceptance/system costs.

Data Collection. For the system performance study, available data were collected from all of the relevant ISSES subsystems, vendor information, state inspections conducted on commercial vehicles during a 2-week field observation, and past inspections at the London site and other comparable sites in Kentucky. Several visits were made to the London site for observations. For the inspection efficiency study, data were collected on the decisions made by inspectors at the London site, compared with data available from the ISSES during the same period, and with data potentially available from external state and national databases. For the user acceptance and cost study, data were collected in a series of interviews and researcher observations at the London site.

Data Analysis. For the system performance study, data were analyzed by comparing actual performance data versus manufacturer and system integrator specifications and user documentation. For the inspection efficiency study, the current methods for selecting trucks to inspect were documented, and the safety characteristics of the general commercial vehicle population at the site were determined. Statistical models were used to project effects of ISSES on the efficiency of selecting the highest-risk trucks for inspection. These results were used to model the potential reductions in truck crashes, based on an improved ability to take these highest-risk trucks out of service (OOS) until they are repaired. The views and attitudes of the inspectors and others working with ISSES at the London site were summarized, to document perceived system usability and ideas for future deployments, and to depict the one-time and recurring dollar costs to deploy and operate the ISSES in the field.

Schedule. Planning for the evaluation began in June 2005, and the full-scale independent evaluation began in October 2006. Field observations and most interviews took place in June 2007.

Results. Overall, despite the fact that commercial vehicle law enforcement staffing levels in Kentucky did not allow for full-time, dedicated use of the ISSES by inspectors at the time of the evaluation, the subsystems that were under evaluation in this task were found to be performing effectively in a stand-alone mode. During the field observation, the radiation monitor generated a relatively large number of gamma alarms for naturally occurring substances, causing inspectors generally to ignore most of the radiation alarms. Also, despite having been installed for two years, the roadside system was not yet integrated with in-state or national databases of historical safety information on carriers or vehicles, so the ISSES was not able to provide instant, "actionable" historical information that the inspectors could apply in their decision-making. Such integration has the potential, if implemented, to afford significant benefits in vehicle screening and safety enforcement, according to the modeling performed in connection with the inspection efficiency study. The ISSES software and components now deployed—though operational—are considered to be in a development mode as of late 2007.

The vendor informed the evaluation team that the company attempted to use commercial, off-the-shelf technologies for the ISSES whenever possible. While this approach provides advantages with respect to reducing first costs and allowing the state to begin using subsystems like the thermal inspection camera and radiation monitor immediately, it also increases the cost and difficulty of integrating disparate commercial systems.

Kentucky's current inspection selection methods were compared with potential applications of ISSES technology across a set of scenarios, used to model improvements in commercial vehicle safety, as measured by changes in the rates of OOS orders issued to commercial vehicles. Applying various combinations of inspection selection strategies and available or envisioned technologies for real-time vehicle identification and safety information exchange at the roadside, in a hypothetical statewide deployment supporting about 44,000 vehicle inspections and 86,000 driver inspections in a year, the ISSES was estimated to contribute to incremental reductions of between 63 and 629 commercial vehicle-related crashes per year, reductions of between 16 and 163 personal injuries, and reductions of up to 7 fatalities.

The overall user acceptance of the system was difficult to measure for two main reasons. First, the KVE inspectors interviewed in 2007 for this evaluation reported having had very little training on the system, which had been in place for two years prior to the evaluation. The vendor reported having held a training session when the system was installed in 2005. Offsite training and onsite exercises for response to radiation alarms were also provided. Secondly, the workload and day-to-day priorities of the inspectors generally cause them to rely more on visual evidence, professional experience, and judgment than on advanced-technology screening devices such as ISSES when they make inspection selection decisions. Thus the ISSES was in place and operating at the inspection station, but was not being used to any effective extent during the period of the evaluation.

The deployment took place in a larger enforcement context that has up to now emphasized and rewarded inspectors for the numbers of inspections they complete per time period, not necessarily for achieving high rates of OOS orders. Thus the purpose of the ISSES (to help inspectors focus on the trucks with the worst safety records, and in effect drive upward the rate of OOS orders) is not directly aligned with the traditional, quota-driven goals of the inspectors in Kentucky. Both approaches, i.e., the productivity of completing a large number of inspections and the efficiency or effectiveness of identifying a high proportion of safety violations per time period, are valid goals of commercial vehicle inspection. This institutional disconnect in Kentucky, however, affected the degree to which the inspectors perceived the ISSES as helping them achieve their personal and organizational job goals. The inspectors who were interviewed tended to regard the ISSES as a technology that could potentially help in their inspection duties, but they had not had the breadth and depth of experience in using it to permit a detailed characterization of the degree of user acceptance.

The system at Laurel County cost $350,000 to install initially. The Kentucky Transportation Center (KTC) at the University of Kentucky, which was involved in ISSES contracting between the state and the vendor, reported that funds from Oak Ridge National Laboratory were also used in the original Laurel County installation and deployment, and that subsequent systems installed in other Kentucky counties have cost the state approximately $500,000 each to procure and install. The state has also paid approximately $109,000 in follow-up costs paid to the system vendor between November 2006 and August 2007 for ongoing maintenance, off-site monitoring of system status, and on-site troubleshooting, such as system calibration, testing, adjustment, technical support, training, and repair at all of the ISSES sites. Not all of these follow-up costs have been directly related to actual ISSES maintenance and repair, however. Some fraction of the costs were for administrative activities, software programming support, and communications protocol development for the nuclear detection subsystem.

Conclusions. The KVE inspectors at Laurel County were not using the ISSES to any great extent during the period of the field study. According to interviews with inspectors and with staff from the KTC, the ISSES hardware was functioning satisfactorily, but the state's current enforcement staffing levels—and an organizational emphasis on the quantity of inspections completed, as opposed to the rate of OOS orders issued—prevent inspectors from having the time or incentives to make effective use of the information being displayed by the ISSES.

Although they were not yet integrated with any state or national data sources, the portions of the ISSES under evaluation in this study appeared to be performing as designed. The system has the potential to reduce commercial vehicle related crashes, injuries, and fatalities substantially if deployed more widely. Such wider deployment would also depend on the ISSES being connected with current and historical sources of safety and inspection data, which would enable inspectors to focus their efforts on the highest-risk carriers, vehicles, and drivers, while allowing the safer, more compliant vehicles to continue traveling past the weigh station. Overall, to the extent that they had been exposed to the ISSES, the users at the Laurel site were positive toward it and appeared to recognize its potential, but within their current organizational environment, they regarded it as more of a developmental test or research device than as a tool that they wanted to use immediately in their day-to-day commercial vehicle inspection and law enforcement duties.

Abbreviations

Abbreviation	Definition
ALPR	Automated license plate recognition
ALTS	Automated Licensing and Taxation System
CDLIS	Commercial Driver License Information System
CMV	Commercial motor vehicle
CV	Commercial vehicle
CVIEW	Commercial Vehicle Information Exchange Window
CVISN	Commercial Vehicle Information Systems and Networks
CVSA	Commercial Vehicle Safety Applications (Kentucky)
DHS	U.S. Department of Homeland Security
DVR	Digital video recorder
EWD	Extended Weight [Coal] Decal
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration (USDOT)
FMCSA	Federal Motor Carrier Safety Administration (USDOT)
FMCSR	Federal Motor Carrier Safety Regulations
HQ	Headquarters
ICC	Interstate Commerce Commission
ID	Identification
IFTA	International Fuel Tax Agreement
IIS	Intelligent Imaging Systems
IR	Infrared
IRP	International Registration Plan
ISS	Inspection Selection System
ISSES	Integrated Safety and Security Enforcement System
ITS	Intelligent transportation systems
JPO	Joint Program Office (U.S. DOT)
KIT	Kentucky Intrastate Tax
KTC	Kentucky Transportation Center (Univ. of Kentucky)
KVE	Kentucky Vehicle Enforcement
KYU	Kentucky Use
L&I	Licensing and Insurance
LTCCS	Large Truck Crash Causation Study
MCMIS	Motor Carrier Management Information System
MCSIP	Motor Carrier Safety Improvement Program
MDI	Model Deployment Initiative
NAFTA	North American Free Trade Agreement
NCIC	National Crime Information Center
NLETS	National Law Enforcement Telecommunication System
OCR	Optical character recognition
OOS	Out of service
ORNL	Oak Ridge National Laboratory
PRISM	Performance and Registration Information Systems Management
RE	Roadside enforcement
RITA	Research and Innovative Technology Administration (USDOT)
SAFER	Safety and Fitness Electronic Record
SM	Safe Miles
SSRS	Single-State Registration System
TFSS	Truck Fleet Safety Survey
USDOT	US Department of Transportation
VMT	Vehicle miles traveled

Abbreviation	Definition
VNTSC	John A. Volpe National Transportation Systems Center (USDOT)
WDT	Weight distance tax
WIM	Weigh in motion

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Kentucky Commercial Vehicle Safety Applications Evaluation

January 31, 2008

1.0 Introduction and Program Background

The London, Kentucky, northbound weigh station on Interstate 75 is the site of an advanced, computer-aided, integrated system intended to help commercial vehicle inspectors with Kentucky Vehicle Enforcement (KVE) improve the effectiveness and efficiency of roadside safety, security, and registration enforcement operations. The system, which was commissioned in June 2005 and formally dedicated by the Governor on August 12, 2005, is now in daily operation (Figures 1-1 and 1-2).

Officials in Kentucky refer to the system as the Integrated Safety and Security Enforcement System (ISSES).[1] The system is also known as part of "Kentucky's Weigh Station of the 21st Century." The station is located at mile marker 33 between Corbin and London in Laurel County. Funded in part by the Kentucky Transportation Cabinet through federal highway funds (Project VII.H.15.C), the system is the first of its kind in the country. Since 2005, two similar systems have been installed in

- Kenton County (I-75 southbound at mile marker 168, 20 miles south of Cincinnati/Covington, commissioned August 2006)

- Simpson County (I-65 northbound at mile marker 4, on the route from Nashville, Tennessee, commissioned October 2006).

A fourth site, in Lyon County (I-24 eastbound in southwestern Kentucky), is also being considered for 2008, pending the outcome of the state's evaluations of the existing systems. Also, a mobile version of the ISSES is scheduled for delivery in 2008.

Partners with the Kentucky Transportation Cabinet in this deployment include KVE, the University of Kentucky Transportation Center (KTC), and the Federal Motor Carrier Safety Administration (FMCSA, an agency of the US Department of Transportation, or USDOT). The KTC is working with Transportation Security Technologies LLC (TransTech, based in Oak Ridge, Tennessee)—which is the vendor leading a consortium of private-sector equipment developers and manufacturers—plus various other component vendors, suppliers, software developers, subcontractors, and system integrators to undertake the Kentucky deployment.

[1] Three of the abbreviations used in this report happen to be similar and may be confusing. "ISSES" stands for the advanced-technology portal screening system deployed in 2005 and being evaluated at Laurel County. "ISS" is the USDOT computer-based Inspection Selection System, introduced in 1995, and available nationally to aid in the commercial vehicle inspection decision process. "IIS" is the corporate abbreviation for Intelligent Imaging Systems, a private company formerly known as Thermal Eye Technologies, which is active as a vendor in the development and deployment of the ISSES.

Figure 1-1. London, Kentucky, northbound I-75 weigh station (Laurel County). ISSES thermal inspection cameras in foreground and portal monitor/automated vehicle identification system in background.

Figure 1-2. London, Kentucky, ISSES deployment. System control cabinet at left; elevated radiation detection panels close to truck lane on either side; visible lighting and identification camera apparatus in foreground.

TransTech is a subsidiary of Intelligent Imaging Systems, formerly known as Thermal Eye Technologies, based in Edmonton, Alberta. In addition, nearby Oak Ridge National Laboratory (ORNL) in Tennessee has been instrumental in providing expertise and funding support for the Kentucky deployment.

The focus of the present evaluation is commercial vehicle safety and enforcement, in particular assessing the capability of the ISSES to provide inspectors with real-time inspection-decision aids. The system also, however, has homeland security applications in terms of detection and prevention of radiological incidents or attacks. These security functions are outside the scope of this FMCSA-sponsored evaluation.

The USDOT sponsored an independent evaluation of the Kentucky deployment, to provide the government with important information on the accuracy, applicability, feasibility, and measurable benefits of selected technologies for use in other jurisdictions that may be considering similar Intelligent Transportation System (ITS) deployments. The independent evaluation, which is described in this report, is known as the Commercial Vehicle Safety Applications (CVSA) Evaluation. An Evaluation Strategy (USDOT 2005a), Evaluation Plan (USDOT 2006c), and Test Plan (USDOT 2007c) were prepared, detailing the research objectives, hypotheses, evaluation measures, and data collection and analysis methods. This evaluation is organized around three related studies:

- System performance
- Inspection efficiency, with a focus on safety improvements
- User acceptance and costs.

2.0 Goals of the ISSES Deployment Project

The overall goal of the roadside deployment at the London northbound station is to enhance the screening of commercial trucks by more readily identifying those trucks that might pose safety hazards and/or unreasonable risks to homeland security. Kentucky seeks to develop a roadside system that gives the inspectors automated tools to work more efficiently, while not burdening the inspectors with added duties and complexity. Notifications from the system should be backed up by valid, accessible, and convenient data at the roadside.

3.0 Technologies Being Deployed

The ISSES technology in Kentucky is intended to give inspectors real-time information about trucks passing by the scale house at a slow ramp speed (nominally less than approximately 15 mph, according to posted signs) through several integrated subsystems:

- A bulk radiation detection monitor
- A front tractor automated license plate recognition (ALPR) system
- A USDOT number reader, using optical character recognition (OCR) technology
- A thermal imaging (infrared, or IR) inspection system

- A vehicle classification system (laser scanner).

The system also includes an overview (color still image) camera mounted near the roof of the scale house and a (visible) color video image system in parallel with the IR camera. The locations of the primary systems relative to the overall weigh station layout in Laurel County are illustrated in Figure 3-1. Further descriptions of traffic flows into and around the Laurel County site, and the prevailing methods of inspection selection, are presented in the Inspection Efficiency section below.

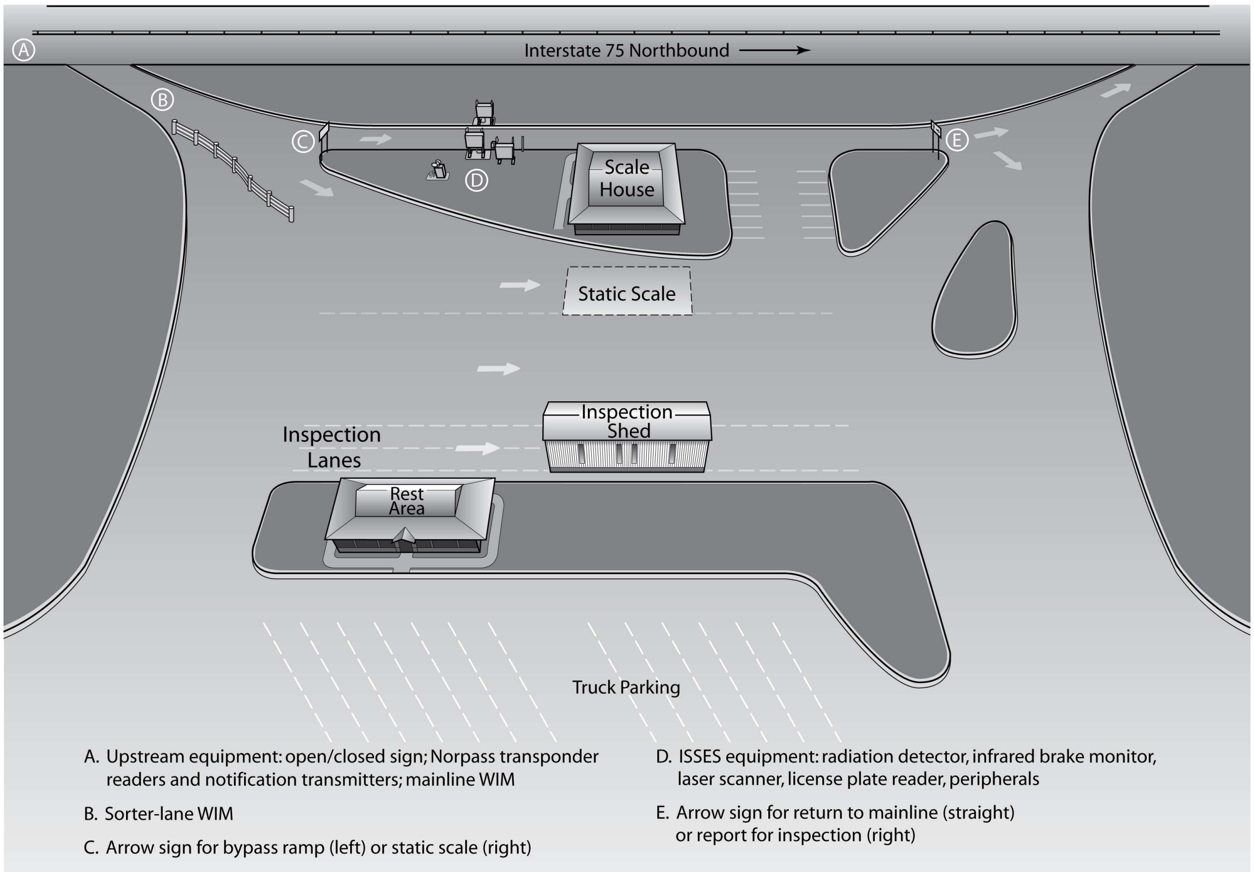


Figure 3-1. Layout of weigh-inspection station and traffic patterns at London, Kentucky (Laurel County) on northbound I-75. Illustration is not to scale.

When the evaluation began in earnest in early 2007, the equipment vendor/integrator reported that the radiation monitor, thermal imager, license plate reader, USDOT number reader, and laser scanner were installed and fully operational in stand-alone mode at the London site. Integration and data transmission software were still in development and testing. Related testing activities at the site by other organizations, outside the scope of this independent evaluation, are detailed in the Evaluation Plan (USDOT 2006c).

The Kentucky deployment of ISSES is unique in that it is attempting to integrate disparate enforcement and security functions. TransTech is currently working with more than 10 jurisdictions (e.g., Florida, New York, Virginia, Quebec, and Ontario) on deploying similar systems, but these typically involve subsets (e.g., ALPR + weigh-in-motion, or WIM, or ALPR + USDOT number reader + WIM), and not the full set of combined functions being attempted in Kentucky.

4.0 Summary of Evaluation Goals, Objectives, and Hypotheses

This independent evaluation conducted on behalf of the USDOT is intended to document the performance and benefits of the ISSES from a national point of view and provide practical information on commercial vehicle safety and efficiency that will be useful to other states considering the deployment of similar equipment. Safety-related results from this independent evaluation are also being incorporated into the national evaluation of the Commercial Vehicle Information Systems and Networks (CVISN) Deployment Program under a separate task order with the USDOT (2006d,e; 2007a).

The goals and objectives of the Kentucky evaluation, summarized below, are described in the Evaluation Strategy (USDOT 2005a), which was prepared based on research, phone contacts, and site visits in July and August 2005. Related measures, data sources, methods, and anticipated deliverables for the independent evaluation were described in an Evaluation Plan (USDOT 2006c).

Two goal areas, with respective objectives and hypotheses, guided the evaluation. Although each objective is numerically related to a particular goal area, most of the objectives were interconnected, and were instrumental in achieving more than one goal.

<u>Goal 1</u> ***To estimate whether the ISSES will make highways measurably safer and more secure.***

<u>Objective 1.1</u> Measure subsystem and integrated system performance characteristics.

Hypotheses: The radiation monitor accurately alerts inspectors to potential radiation hazards, and produces minimal false alarms.

The thermal inspection device enables inspectors to see potential heat-related defective or malfunctioning equipment that might not be readily visible otherwise.

The laser scanner accurately logs the passage of trucks through the ISSES apparatus, and signals other subsystems.

The ISSES performs with a minimum of unscheduled downtime.

Objective 1.2 Use data from the field test to determine the distributions of kinds of vehicles traversing the weigh station under normal conditions. This provides a baseline for reference in assessing the highway safety benefits of the ISSES.

Hypothesis:* *The distribution of commercial vehicles passing the London site, relative to the respective motor carriers' SafeStat score ranges, is similar to that of the national population of commercial vehicles.

Goal 2 ***To determine how the ISSES makes the inspection process more efficient and effective, in turn contributing to improved highway safety.***

Objective 2.1 Determine the degree of user acceptance and the perceived usefulness and usability of the ISSES as deployed, and quantify deployment and operating costs related to the ISSES.

Hypotheses: Inspectors and state transportation managers believe that ISSES enables roadside inspectors to perform their job functions better.

Inspectors believe that ISSES should be deployed more widely.

In deploying similar systems, officials at other sites believe their system enables them to perform their job functions better.

Inspectors found their training and user documentation for ISSES to be helpful to them in their normal course of duties.

In deploying ISSES, Kentucky incurred one-time start-up and recurring costs that were clearly defined and measurable.

Objective 2.2 Measure the ability of the ISSES to improve inspection selection efficiency, and in turn to yield reductions in crashes and breaches of highway security.

Hypothesis: The ISSES can help inspectors focus their efforts on higher-risk trucks.

Objective 2.3 Explore options for integrating the data available from the ISSES with existing safety, enforcement, and administrative data sources, and prepare models or plausible scenarios for Kentucky or other states to apply.

Hypothesis: Data from ISSES can yield important information for commercial vehicle enforcement and administration when combined with data from other state and federal sources.

5.0 System Performance Evaluation

The purpose of the system performance evaluation was to assess how well the ISSES performed in the field, relative to its design and its intended use as described by the system vendor through information such as product literature, specifications, and training materials. The evaluation team attempted to determine the performance of the radiation monitor, the thermal inspection system, and the laser scanner.

As detailed below, the system in Laurel County appears to perform reasonably well in comparison with expectations, and considering that it is the first installation of its kind in the nation. The system displayed real-time visual and digital-format information about the trucks passing through the ISSES portal, permitted users to scan retrospectively through data screens showing visual imagery and digital data on previous passing vehicles, and produced usable data archives from the various subsystems, with some limitations. The user interfaces in the scale house were intuitive and seemed to be easy to learn, given appropriate training.

This assessment was affected by several important factors:

- The local ISSES was not yet integrated with any state or national databases of historical safety, inspection, out of service (OOS), or registration/licensing information, so it was operating in a stand-alone mode.

- The staffing levels at Laurel County were such that no KVE inspectors were assigned to use the ISSES as part of their mainstream job duties. The system was in place and operating during the evaluation period, but as noted in the user acceptance section below, in general no one was attending to the information shown on the ISSES display screens. The inspectors appeared to consider the system to be still something of an experimental or test prototype rather than an integral tool to achieving their day-to-day safety and law enforcement goals.

- Related to the previous factor, the deployment took place in a larger enforcement context that has up to now measured safety improvements (and provided incentives to inspectors) based on the numbers of inspections completed, not based on achieving high rates of OOS orders among a set number of inspections completed. Thus the purpose of the ISSES (to help inspectors focus on the trucks with the worst safety records, and in effect drive upward the rate of OOS orders) is not directly aligned with the current organizational goals of the inspectors in Kentucky. Both approaches, i.e., the productivity of completing a large number of inspections and the efficiency or effectiveness of identifying a high proportion of safety violations per time period, are valid goals of commercial vehicle inspection. This institutional disconnect in Kentucky, however, affected the degree to which the inspectors perceived the ISSES as helping them achieve their personal and organizational job goals.

- At the request of FMCSA, the evaluation team was asked to disregard the performance of the ALPR and USDOT number reader systems. These two subsystems, which if effective could help KVE achieve important safety screening goals, did appear to be operating during the evaluation period. Both the ALPR and the USDOT number reader were capturing and logging visual image and digital-format data on some portion of the commercial vehicles passing through the ISSES portal, but no quantitative evaluation of these subsystems was made. KTC is evaluating the performance of these systems as part of the state's CVISN program.

- Some of the data that were planned to be collected (e.g., electronic screening bypass data for the first week of the field observation and thermal imaging video data from the Laurel County site) were not available, owing to unforeseen hardware problems and communication gaps or misunderstandings between the evaluation team and the system vendor. Also, because no inspectors were using the ISSES thermal imaging system under normal circumstances, the thermal imaging video that was made available to the evaluators was from a special two-day training session, which resulted in the quality of the image data available for analysis being relatively poor and uneven.

5.1 Data Collection

Data were collected on all of the relevant ISSES subsystems from information provided by the system vendor and from site visits to two Kentucky weigh stations. Specifically, training materials and design specifications describing ISSES and its components were provided by the system vendors, Transportation Security Technologies LLC (TransTech), an affiliate of Intelligent Imaging Systems (IIS). Field inspection reports prepared during the ISSES field studies and training exercises in Laurel County and Kenton County were provided to the research team by the Kentucky Justice and Public Safety Cabinet's Department of Vehicle Enforcement (also known as Kentucky Vehicle Enforcement, or KVE). ISSES output generated during the field observation period (June 11 through 22, 2007, at Laurel County) and during a two-day training exercise at Kenton County (July 31 to August 1, 2007) was provided to the research team by TransTech/IIS between June and September of 2007. The research team also visited the Laurel County weigh station in mid-2005 and in June 2007, and visited both Laurel and Kenton in January 2007 to gather feedback from KVE personnel and observe ISSES performance directly.

The following subsections describe the technologies that comprise ISSES, provide examples of output expected to be generated by the system, and summarize the observations made by on-site personnel during the Laurel and Kenton site visits.

5.1.1 System Components, Configurations, and Outputs

ISSES consists of the following component technologies:

- A vehicle detection and classification system, which uses a laser rangefinder to detect commercial motor vehicles (CMVs) and measure their speed, height, width, and length, facilitating the identification of vehicle types based on key characteristics (e.g., number of axles).

- An overhead camera that documents the passing of each CMV by capturing an image of the vehicle (Figure 5-1).

- A radiation detection system, which measures gamma and neutron radiation levels, to help inspectors recognize potentially hazardous material shipments and cargo. Inspectors at the station were also provided with a hand-held radiation detection and identification device, which can be used once a truck has been parked for closer inspection.

- A thermal imaging inspection system, which displays and records IR and visible video of the CMVs as they pass through the sensors, allowing inspectors to detect thermal/visual anomalies.

- An automatic license plate recognition (ALPR) system, which captures and stores wide-angle and narrow-angle digital images of the front of passing CMVs and performs OCR on the tractor front license plate numbers.

- A digital USDOT number recognition system, which captures digital images of the sides of passing CMV tractors and performs OCR on the USDOT number posted on the side of each tractor.

Figure 5-1. Example image recorded by overhead camera at the Laurel site.

Several of the ISSES subsystems have dedicated computer servers located in the scale house at the weigh station. ISSES is designed for installation at CMV weigh stations, where it can be used by weigh station operators to identify potential problems and/or safety concerns with passing CMVs and to compile CMV traffic data and other statistics. The following sections detail the configurations and outputs of individual ISSES components.

Laser Scanner (Vehicle Detection)

The ISSES laser scanner serves two purposes. First, it acts as the main trigger for the system: when a CMV passes through the detection zone, the laser rangefinder signals the overhead camera, ALPR system, and USDOT number reader to begin collecting data. Second, the scanner generates data on the vehicle's length, width, height, speed, and number of axles as the vehicle passes through its two laser beams. These data can used for vehicle classification. At Laurel, as currently configured by the vendor, the data on length, number of axles, speed, and width is collected by the ISSES laser scanner/sensor system, but is not stored. The vendor determined that such information had limited value in terms of inspection operations at the time of deployment. Once the ISSES is connected to external data sources and automated screening rules are programmed, the state may choose to set alarm thresholds for width, length, etc., and store these data for later analysis if desired.

Under normal conditions, laser scanner output consists of five messages for each vehicle that passes through its field of detection. These messages typically are generated in the following order:

1. Vehicle Detection – Beam #1
2. Vehicle Detection – Beam #2
3. End of Vehicle – Beam #1
4. End of Vehicle – Beam #2
5. Vehicle Classification.

The first four messages detect the presence of a vehicle and its position in the lane. The fifth and final message transmits the vehicle's speed and physical characteristics (length, height, width, and number of axles), classifies the vehicle, and provides a degree of confidence for the classification result. For validation purposes, vehicle classification information can be cross-checked against images from the overhead camera (see example in Figure 5-1).

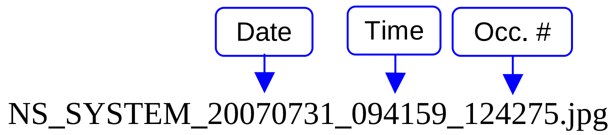
Figure 5-2 shows some of the ISSES components. The laser scanner apparatus is at right center, aimed downward at a slight angle toward the roadway. Four auxiliary photocell (conventional light beam) emitters/receivers are mounted in an "X" pattern on the upstream support poles of the two square, raised radiation portal monitors on either side of the roadway. These detection devices appear as small gray boxes in Figure 5-2. These electronic beams supplement the laser triggering system that detects the beginning and end of each passing vehicle.

Figure 5-2. Laser scanner for triggering and classification (far right) and raised radiation portal monitors (left and center-right).

Radiation Portal Monitor

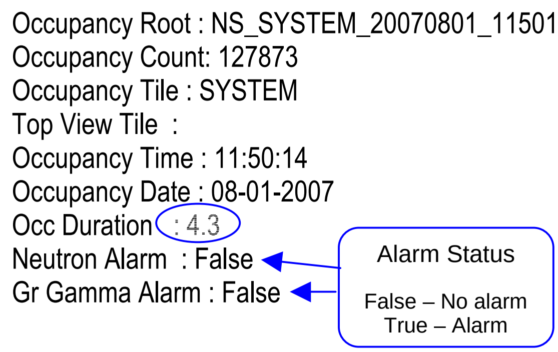
A key role of ISSES is to alert weigh station operators of potentially dangerous vehicles and cargo. The radiation portal monitor (NucSafe Inc.) allows ISSES users to determine whether the bulk levels of gamma and neutron radiation emitted from passing CMVs are above or below a preset threshold. Unlike the Laurel County system, the ISSES deployed at Kenton County has an isotope identification feature in addition to the capability to measure bulk radiation levels against a preset threshold. As shown in Figure 5-2, the portal at Laurel is configured as a pair of sensor panels mounted on opposing towers on either side of the weigh station vehicle lane. The panels face each other and detect the neutron and gamma rays emitted by vehicles that pass between them. If either type of radiation level exceeds a user-defined threshold, the system initiates a neutron or gamma alarm that can be seen and heard by the ISSES user, via the user interface. The gamma alarm sounds different from the neutron alarm, and alarm intensity is governed by the radioactivity of the cargo. For example, items that emit higher levels of gamma or neutron rays produce louder and higher-pitched alarms than items that emit lower levels of radiation. Once an alarm sounds, the user can then decide whether to divert the vehicle that triggered the alarm for inspection. The radiation portal monitor allows weigh station operators to monitor for dangerous cargo without slowing traffic.

A number of output files are generated by the radiation detection system and stored on the radiation (or rad) server. All of these files follow a naming convention that includes the date of "occupancy" (i.e., passage of a single CMV through the portal), the time of occupancy, and the vehicle's sequential occupancy number (i.e., the vehicle's place within the rolling "count" of vehicles that have passed through the portal). An example filename is provided below:



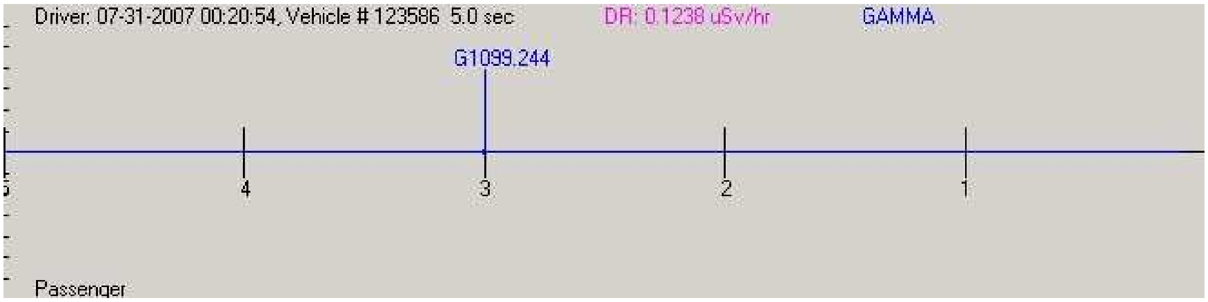
The following file types (extensions) are generated by the radiation monitoring software. In some instances, the sample contents have been edited to protect the vendor's proprietary information, while providing a general idea of the function of each file type.

- OCC – This file type contains details about each CMV as it passes through the ISSES station. Contained within the file are the duration of occupancy in seconds (circled) and the status of both the neutron and gamma alarms for that CMV. Sample contents of an OCC file are provided below:

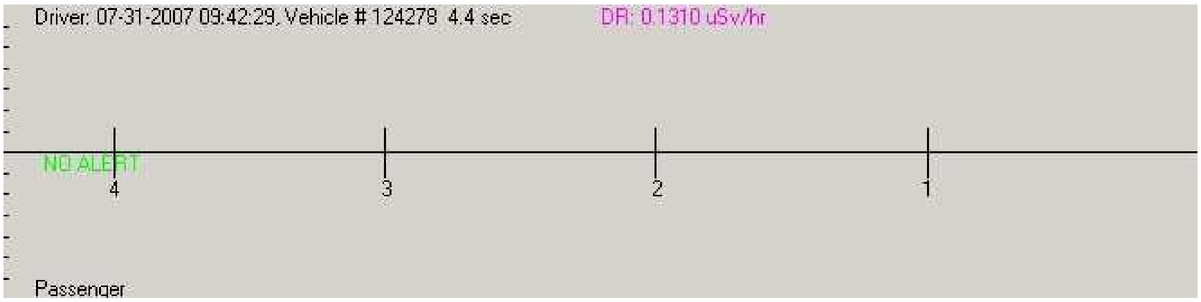


- JPG – These image files save the count rate and alarm profile for a particular occupancy. Sample JPG files from the Kenton and Laurel sites are shown in Figure 5-3 below. While the underlying data are the same, the two JPG images are configured differently. The Kenton images depict a timeline, whereas the Laurel image superimposes a plan view of a generic commercial vehicle. The superimposed vehicle image remains the same no matter the configuration of the actual vehicle. The computer image is drawn as a semi tractor-trailer to reflect the predominant truck configuration passing through the portal. In the case of alarms, both formats provide the inspector or analyst with a visual cue as to the location of the emitting source relative to the geometry of the vehicle. Note the varying time periods of occupancy, ranging from 3.8 seconds at Laurel (c) to 5.0 seconds on the Kenton gamma alarm image (a), reflecting varying travel speeds of the three trucks through the radiation portal monitor.

a. Kenton – Gamma Alarm



b. Kenton – No Alarm



c. Laurel – Gamma and Neutron Alarms

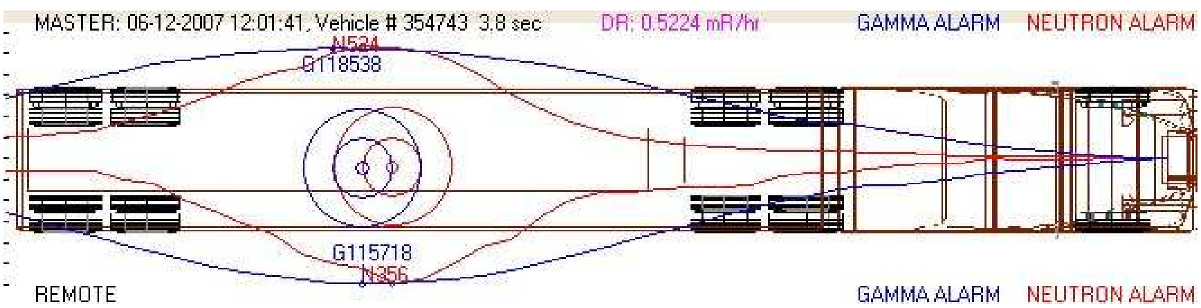


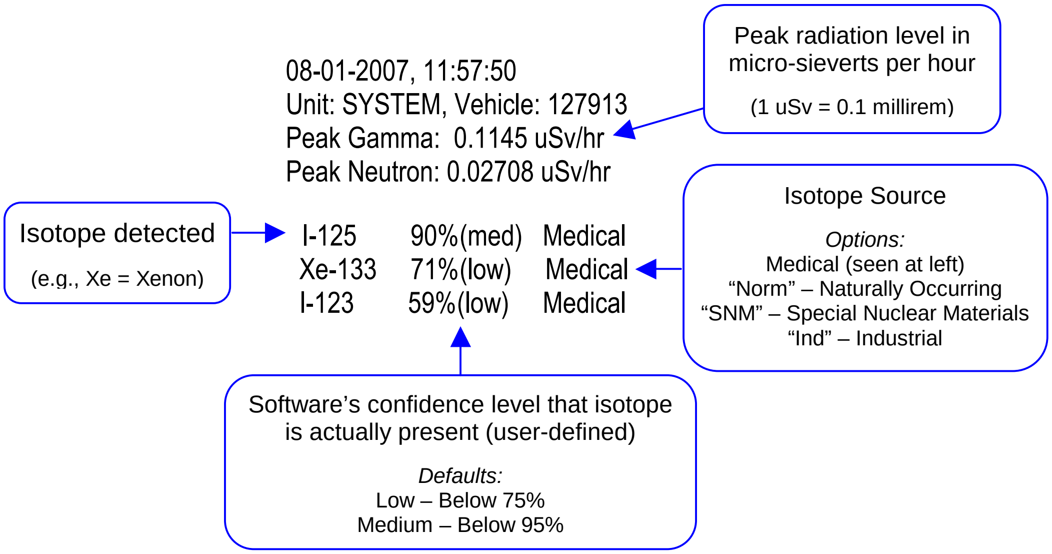
Figure 5-3. Graphic representations of radiation monitor output for CMVs passing through the Kenton and Laurel sites.

- BAL – This NucSafe file type is generated but not normally saved by the system. It is a message file indicating that a radiation alarm has started; the file also records the time at which this has occurred. The following is an example of BAL file contents:

  07:01:45
  Gamma Count Rate Alert

- DATA – This file type, similar to the OCC file, is generated by the ISSES software, not by NucSafe. Thus, DATA files are not associated with the radiation portal monitoring function and are unrelated to safety enforcement.

- ID – This file type, generated only by ISSES when configured with isotope identification (e.g., at Kenton), contains a spectroscopy report. The file is generated only when a radiation alarm is activated and spectroscopy is performed. The contents of a sample ID file are presented below:



- NAF – These NucSafe Alarm Files contain the start and end times of the alarm state for gross counting purposes and for each energy band region of interest. When all alarms clear, the peak dose rate is recorded. Two examples of NAF contents are shown below (one in which no alarm was activated [1] and one in which a gamma alarm was activated [2]):

[1] 13:10:05 No Alarm

[2] 06-12-2007 05:00:08 End Alarm-CPS: 4464 Lvl: 11.12586
06-12-2007 05:00:08 End Alarm-CPS: 4503 Lvl: 14.07915
06-12-2007 05:00:08 End Alarm-CPS: 3284 Lvl: 10.62847
06-12-2007 05:00:08 End Alarm-CPS: 3323 Lvl: 13.57283
06-12-2007 05:00:08 End Alarm MAX Dose Rate: 0.00594 mR/hr

- SPC – This file type contains the spectra stored by the spectroscopy package used to generate the ID report. An excerpt from an SPC file (abbreviated for display purposes) is shown below:

```
Length       : 1024
Realtime     : 1.25
Livetime     : 9.99
Deadtime     :0.999
CalibPoint1  : 9999999
CalibCoeff   : a=0 b=3 c=0 d=0
SpectrumText : Nucsafe 07-31-2007 10:01:42
```

Infrared/Thermal Imaging System

The ISSES infrared (IR)/thermal imaging system uses heat signatures to help weigh station inspectors identify possible heat-related defects or malfunctioning equipment on a CMV that might not be readily visible otherwise. Figure 5-4 shows the thermal image cameras. As described below, one camera captures IR, and the other captures mixed IR/color images. Users of the system are trained to recognize defects or safety concerns characterized by unusually high temperatures (e.g., overheated brakes or tires) or abnormally low temperatures (e.g., brakes that should be generating heat during use but are not engaged), which show up on the video as exceptionally bright or dark spots, respectively. The system can help inspectors identify a variety of problems beyond brake issues, such as overheated wheel bearings, faulty universal joints, leaking (hot) fluids, and flat or damaged tires. The inspector uses the relative differences in brightness and darkness to discriminate between normally operating components (usually wheels and tires) and potentially malfunctioning or unsafe components.

Two video feeds are captured from the thermal inspection device, which houses one full-color video camera and one thermal/IR video camera. Using controls in the scale house, an inspector can "fade" (superimpose or overlay) the screen image from visible/color to IR views, to obtain the optimum image for a given vehicle or ambient lighting condition. A third video, separate from but integrated with the thermal imaging system, is captured by a gable-mounted color overview camera that has pan-tilt-zoom capability, but is normally focused on the ISSES truck portal. The images are archived on a digital video recorder (DVR) for approximately one month or until space is needed. Figure 5-5 provides an example of a still image from the composite video captured at the Kenton site. The three main images show color video from the gable-mounted overview camera (top left); IR (top right); and overlay, or combined color/IR (lower left). In the sample shown in Figure 5-5, the fade control had been set by the user to full IR, so that the two close-up views of the passing truck appear to be identical. This was a user setting and does not represent a hardware fault.

Figure 5-4. Location of thermal imaging video cameras at Laurel site, showing pan-tilt-zoom camera head. The cameras are upstream of the scale house, facing the oncoming lane of traffic at an angle.

Figure 5-5. Images captured by thermal imaging video cameras at Kenton site, as replayed on DVR viewer.

USDOT Number Reader and ALPR System

Although the USDOT number reader and the ALPR subsystems were outside the scope of this evaluation, descriptions of the two subsystems are provided here for reference purposes. ISSES uses OCR systems as the basis for its ALPR system and USDOT number reader. OCR technologies provide digital strings of license plate characters and USDOT numbers—as well as visual imagery—to weigh station inspectors without disrupting the flow of commerce. The ALPR relies on pulsed IR lighting technology, while the USDOT number reader relies on visible lighting, including lights specifically installed for nighttime operation of the USDOT number reader. For the ALPR at Laurel, ISSES uses two cameras to achieve the resolution needed for OCR. Working in tandem, the two cameras provide a greater field of view so that license plate images are captured no matter where they are located on the vehicle, and wherever the vehicle might be in the lane. Figure 5-6 shows the two ALPR cameras, installed with slightly different orientations. One camera is pointed more toward the right side of the vehicle front, and the other camera is pointed more toward the left front. Figure 5-7 shows the configuration of the USDOT number reader camera, located at about the height of the center of the tractor (cab) door. According to the vendor, increases in digital resolution and imaging technology have enabled newer deployments of ISSES to function with a single ALPR camera. Also, a new version of the USDOT number reader using IR lighting is at the testing stage and will be deployed in Kentucky in the future.

Figure 5-6. Two cameras used for ALPR subsystem.

ALPR output consists of JPEG images of the target vehicle’s front license plate. While the cameras capture four images (two wide-angle and two narrow-angle), the data storage system shows the best two images for each vehicle – one narrow-angle/focused image of the plate and one wide-angle image of the front of the vehicle. The file names of ALPR output files include the date and time of the reading, along with a decoded text string representing the OCR reading of the license plate number, and a confidence level associated with the reading. If the digits on the license plate cannot be read by the system, the file names contain the term “no-read” in place of the license plate number. Examples of images generated by the ALPR system are provided in Figure 5-8.

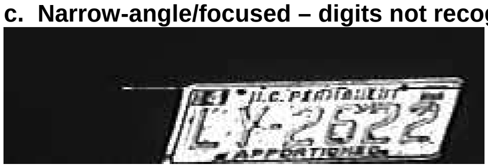
Figure 5-7. Rear view of USDOT number reader camera (at center foreground, on narrow post below two light fixtures). Two ALPR cameras are on larger post at right of USDOT camera.

USDOT number reader output consists of one or two files per CMV, depending on whether the OCR sensor is able to recognize the USDOT number on the side of the vehicle. When the digits can be read, an event file is generated with a file name that includes the date and time of the reading, a decoded text string representing the OCR reading of the USDOT number, and a series of numbers representing the confidence of the reading and status of the record. In such cases (i.e., when the number is legible), a JPEG image of the portion of the vehicle containing the USDOT number is also generated; the date/time stamp in the JPEG file name corresponds with that in the event file name. In these cases only an event file is generated, with the word “Fail” in the file name where the OCR reading would otherwise be. When the digits cannot be read, a JPEG file is created but, based on a decision by the vendor, the file is discarded and is not passed to the storage archive. This decision was driven in part to conserve disk space and to improve operational performance. Another factor at this stage of testing and deployment was that inspectors working under tight time constraints would ordinarily have little time available to review old image files. It would be helpful in future systems to program the system to archive a JPEG file automatically in such cases, so that analysts could attempt to identify trucks retrospectively, even when the OCR system did not read the USDOT number successfully. An example JPEG image generated by the USDOT number reader is shown in Figure 5-9.

a. Wide-angle – digits not recognized (no-read)

b. Wide-angle – digits identified

c. Narrow-angle/focused – digits not recognized (no-read)



d. Narrow-angle/focused – digits identified

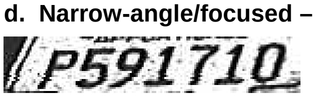


Figure 5-8. Images generated by the ALPR system.

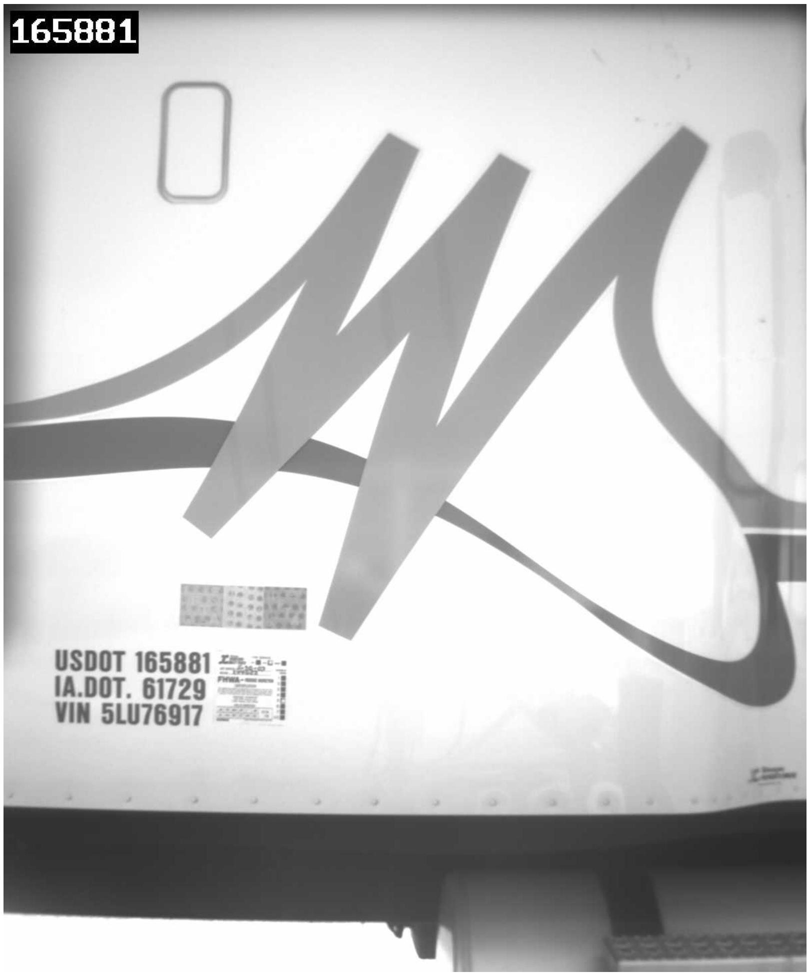


Figure 5-9. Image generated by USDOT number reader. Actual USDOT number is on passenger side of tractor cab (lower left). ISSES-generated OCR text conversion is superimposed at upper left.

5.1.2 Field Data Collection and Direct Observations

ISSES deployments at weigh stations in Laurel County (northbound) and Kenton County (southbound) were included in this evaluation. A description of these sites is provided in Sections 1 through 3 above. The data used to assess system performance were collected during the following time periods:

- Laurel County station – 12:00 AM on June 11, 2007 through 11:59 PM on June 22, 2007 (12 days); and
- Kenton County station – 12:00 AM on July 31, 2007 through 11:59 PM on August 1, 2007 (2 days).

As noted in Section 5.1, the research team visited the Laurel County site several times during the course of the field study. During these visits, members of the research team conferred with KVE CMV inspectors, CMV police officers, and with vendor representatives from TransTech/IIS.

Team members also observed the inspection selection process from inside the weigh station scale house, and they observed and photographed several inspections taking place. Observations made during these visits are reported below.

Research team members who visited the two deployment sites noted several structural or design differences between them, as outlined in Table 5-1.

Table 5-1. Comparison of Laurel and Kenton station configurations.

ISSES Feature	Laurel	Kenton
Lighting fixtures for USDOT number reader	On passenger side, facing toward mainline	On driver side, facing away from mainline
Electrical supply conduits for lighting fixtures	Visible	Hidden
Mainline WIM scale	Yes	No
Sorter-Lane WIM scale	Yes	Yes
ISSES location relative to scale house	Closer to scale house	Further upstream from scale house

The location of the visible lighting fixtures was changed at Kenton to reduce the amount of stray light reaching the mainline of traffic. Also, the lights at Kenton are positioned such that the light source is not visible to the approaching driver. The Kenton ISSES equipment was positioned approximately twice as far upstream from the scale house as the ISSES equipment at Laurel, in principle allowing Kenton inspectors more time to make decisions based on the system's output. One other change at Kenton was the placement of all of the ISSES above-ground portal apparatus, except one of the radiation panels, on the driver's (highway) side of the low-speed bypass lane. This change reduces the amount of equipment interfering with the sight lines between the passing vehicle and the inspector in the scale house, which is on the passenger side of the bypass lane.

The ISSES interface operates as follows. The ISSES main system monitor allows the user to view a summary of the seven to ten most recent trucks to pass through the ISSES portal. Each summary includes a color image of the truck, the license plate reading, the USDOT number reading, and the radiation alarm status (if available). The digital readouts on the monitor are color-coded, such that blue means "no data available," green means "good data available," and red indicates an alarm condition. The user can switch this summary view to show all recent trucks or only those recent trucks that triggered an alarm. Figure 5-10 shows an example of the ISSES continuous monitoring interface.

Once the user has chosen a particular vehicle for further analysis, he or she can select any of a series of individual system views, including the radiation (rad) server, the DVR (digital video recorder) server for the thermal imaging system, the ALPR (plate) server, or the USDOT number server. The user chooses these subsystem server views from the management interface screen (Figure 5-11). The various server detail view options, some of which are not yet activated in ISSES, are listed down the left side of the interface screen. For example, the rad server shows individual data for the master and remote panels on either side of the ISSES portal, and a

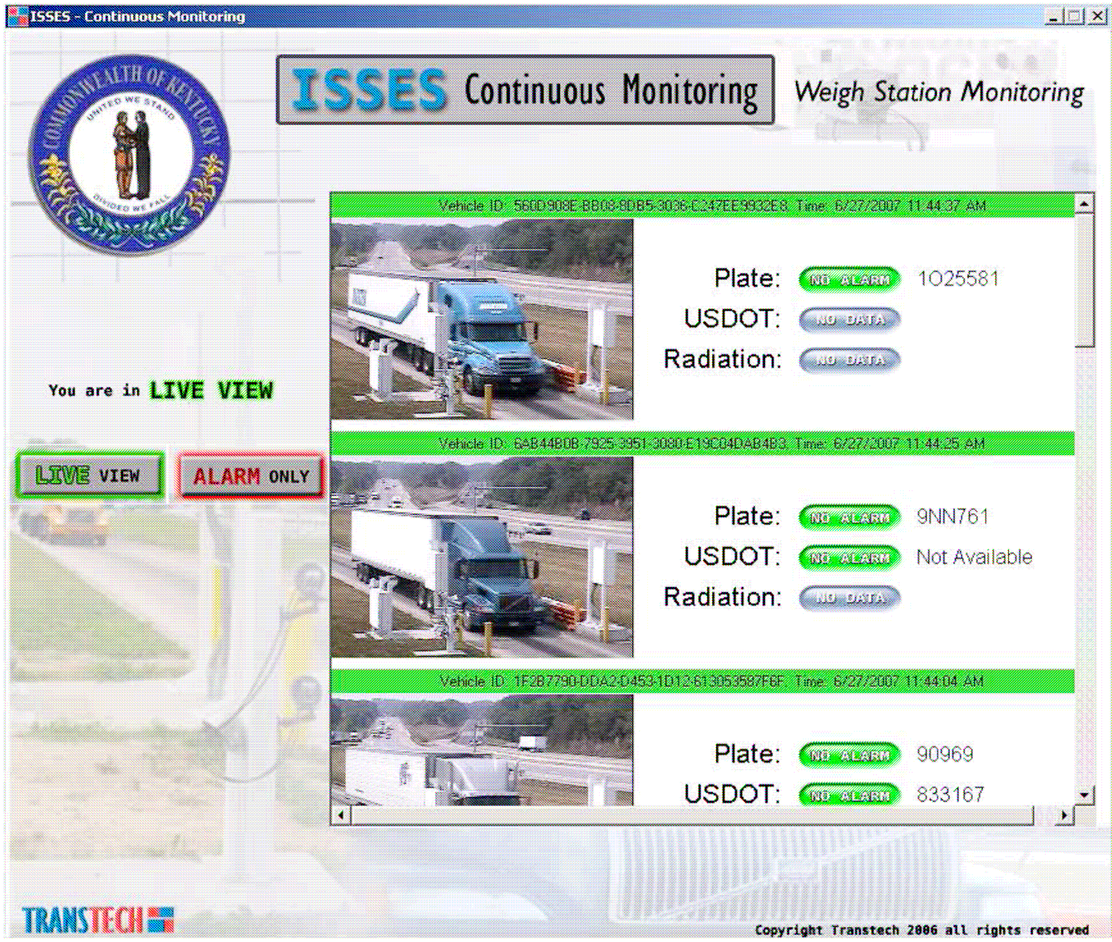


Figure 5-10. ISSES continuous monitoring interface, showing the "live view."

combined or system-level radiation data reading. This view also depicts a generic image of the vehicle's structure (see Figure 5-3 above), showing the relative position of the radiation source and its emission level (indicated by graphic lines that are depicted at various distances from the longitudinal centerline of the vehicle).

The IR/thermal camera server can be adjusted to switch from IR to visible/color output. The USDOT number server shows a large image of the side of the tractor, a date/time stamp, a decoded text string representing the OCR reading of the USDOT number if available, and a series of numbers representing the confidence and status of the record being viewed.

Visitors to the Kenton and Laurel sites made a number of observations about the degree to which ISSES equipment was used by weigh station staff, both in general and with respect to the system's intended usage. On multiple occasions, research team members visiting the Laurel site observed and/or were told by weigh station personnel that ISSES is not used very often. During one site visit, the ISSES monitors were not used at all. As described elsewhere, no one at the Laurel site was assigned to watch the monitors constantly, due partly to manpower and resource constraints, and partly to the enforcement objectives at the site, which emphasize numbers of

Figure 5-11. ISSES management interface, showing the server detail options at left.

inspections rather than OOS rates. This prevented the evaluation team from comparing inspection decisions potentially influenced by ISSES data readings with those decisions based on traditional methods such as obvious visual evidence and inspector knowledge or judgment.

The research team also learned that CMVs are only rarely pulled over when an inspector happens to notice a potential problem on the IR screen. Instead of using ISSES, inspections at the Laurel station were typically based on random selection, visual judgment, and the inspector's knowledge of the carriers.

A representative of the KTC, a research organization based at the University of Kentucky and funded in part by the Kentucky Transportation Cabinet (which owns and maintains the weigh stations on Kentucky highways), provided some additional insight into the apparent under-use of the ISSES equipment during the field observation. The KTC representative noted that the system works as designed, but that KVE staff, because of their workloads and primary duties, as well as an institutional emphasis on achieving a required number of inspections per time period, perceive watching the ISSES monitors to be too time-consuming and not worthwhile, in terms of meeting the quotas that make up part of their departmental management objectives and incentive system. For example, an inspector might watch an IR camera for 30 to 40 minutes before seeing a truck he or she wants to inspect, whereas by standing at the window and observing the line of traffic, he or she will likely see a truck of interest in 10 or 15 minutes. That 15 to 30 minute differential is often considered to be wasted time by inspectors (whether justified or not).

With respect to individual ISSES components, the research team made two key observations when visiting the Kenton and Laurel sites. First, the OCR systems are designed for trucks traveling approximately 15 MPH past the cameras. However, observers noted that at both the Kenton and Laurel stations, trucks routinely travel at speeds up to 20 or 30 MPH (despite the 10 MPH speed limit posted on the ramp), reducing the time available for the automated systems to capture, process, and report on the image and the digital output. The vendor indicated that the optimum vehicle speed for the system as designed represents a tradeoff between the interests of the trucking companies, who want to keep their trucks moving quickly through the station, and the state inspectors, who want the trucks to move slowly enough to allow sufficient time to make inspection decisions, without causing a large volume of truck traffic to "tailback" from the station to the mainline. From a technical viewpoint, the limiting factor on portal speed is the radiation detection system. The imaging systems have few restrictions up to highway speeds, but the ability to accurately identify trace radiation sources diminishes as vehicles travel faster than the design speed of 15 MPH. When trucks do so, the ISSES still collects data, but the higher speeds tend to reduce the level of accuracy.

Second, the team members learned that some users are not satisfied with the performance of the radiation monitors for various reasons. At the Kenton site, a KTC staff member indicated that the radiation detection panels are believed to be less than optimal because they are positioned too close to the ground, effectively missing a majority of a vehicle's cargo area (Figure 5-12). The installation at Kenton was made with the intent of eventually installing a second row of sensors at a higher level. Elevating the existing panels—or adding other panels on top of the existing ones—would require a significant capital expenditure. The system vendor indicates that the Kenton configuration is more than sensitive enough to gather accurate radiation data on the vast majority of radiation loads passing through the portal. According to the vendor, raising the Kenton panels or adding a second level would, for the most part, make no difference to what an operator experiences in the weigh station. A similar lower-profile configuration was also used at the Simpson County site, shown in Figure 5-13. For comparison, the higher-profile panels at Laurel County are shown in Figure 5-7 above.

Inspectors at the Laurel site report that the alarm as currently configured is too sensitive to low levels of radiation. As a result, the alarm activates whenever a CMV carrying harmless but gamma ray-emitting materials (e.g., bricks, porcelain, clay, granite, cat litter, ceramic tile) passes through the station, and staff are prone to ignore the numerous gamma alarms. The gamma detector gives more nuisance alarms than the neutron detector.

The system vendor reported that the ISSES radiation detector subsystem will not be optimized until true "risk matrices" are cross-referenced with USDOT hazardous materials rules and remote data to automate useable transportation safety alarms for inspectors. This "rules manager," which is the final stage in the development of ISSES, will cross-reference sensor data from ISSES with remote data stores to give user-defined alerts to operators. For example, the system is being programmed by the vendor to provide an audible alarm when some kinds of radiation-emitting loads are observed being hauled by a carrier whose USDOT number is not associated with the appropriate certificates, credentials, or permits.

Figure 5-12. Lower configuration of radiation detection panel at Kenton ISSES site.

Figure 5-13. ISSES configuration at Simpson site.

According to a TransTech field support representative familiar with the Laurel County and Kenton County demonstrations, the ISSES system has been generally reliable. However, the system has been subject to downtime due to component hardware/software issues (see Appendix E). TransTech informed the research team that the company attempted to use commercial, off-the-shelf technologies whenever possible. While this approach provides advantages with respect to reducing first costs, it also increases the cost and difficulty of integrating disparate systems. Using off-the-shelf technologies allowed KVE to begin using subsystems like the thermal inspection camera and radiation detection system immediately. However, developing a more integrated solution has been a process characterized by:

- Technical challenges associated with hardware/software integration (as of November 2007, reportedly complete save for minor improvements)

- Operational challenges (e.g., how to design the user interface to work for KVE—the remote and on-site viewers have been redesigned since the original installations).

Several specific problems with ISSES and its components were reported to the research team by weigh station and system maintenance personnel. At the Laurel station, site personnel reported that the DOT camera was inoperable for five days when a fiber optic switch needed to be replaced. In general, the system's cameras have proven to be difficult to calibrate and are sensitive to bumps and jars. Some time was required to obtain consistent readings from them. The TransTech maintenance representative reported that ISSES equipment is particularly sensitive to downtime after power interruptions or other system problems. All systems and network connections need to be manually restarted after power is lost, in the version of ISSES that was installed at the Kenton and Laurel sites.

Regarding the manual restart issue, according to the system vendor, the ISSES software and components now deployed—though operational—are considered to be in development mode as of late 2007. The vendor has been upgrading isotope identification sensors in Kenton and Simpson, debugging small anomalies as they appear, and collecting raw data for client studies. In the near future, the vendor plans to turn to production mode, which will incorporate an auto restart function.

5.2 Data Analysis

5.2.1 Data Analysis Methods

The research team analyzed system performance by comparing actual performance data against manufacturer and system integrator specifications, user documentation, and laboratory test data, where available. In essence, evaluators considered how the component technologies performed relative to how they were *intended* to perform.

Laser Scanner (Vehicle Detection)

The research team considered whether the laser scanner accurately logs the passage of trucks through the ISSES apparatus and signals other subsystems. as part of the inspection efficiency study, the research team manually collected vehicle identifiers during site visits. These counts of identifiers were used to verify the performance of the laser scanner system in recording vehicle events. Although the ALPR and USDOT number reader are not subject to evaluation in this effort, vehicle identification data also were used for quality checking and verification purposes as an independent source to help ensure the completeness of vehicle records at each site.

Radiation Portal Monitor

The research team considered whether the radiation monitor accurately alerts inspectors to potential hazards and minimizes the occurrence of both false positives (alarm is sounded when no significant radiological emission is present from vehicle) and false negatives (alarm is not sounded when there is sufficient radiological emissions present from the vehicle). Graphical representations of the radiological emissions from passing vehicles were archived off of the rad server onto a hard drive and sent to the research team.

Infrared/Thermal Imaging System

The research team evaluated whether the thermal inspection device enables inspectors to see potentially defective or malfunctioning equipment through heat signatures recorded by the device's IR camera. Video feeds captured by the thermal inspection device at the Kenton site were archived off the DVR server onto a hard drive and sent to the research team, which navigated through the video footage to locate specific vehicles and determine whether potential heat-related problems would have been visible to weigh station inspectors. The video footage was also used as a cross-check against Driver/Vehicle Examination Reports prepared by inspectors at the Kenton weigh station to determine if defects noted during the inspection were visible in the IR images.

USDOT Number Reader and Automatic License Plate Reader
These systems were not under evaluation.

5.3 Results

This section presents performance evaluation results for each subsystem, followed by general system performance conclusions.

5.3.1 Laser Scanner (Vehicle Detection)

There was some discrepancy between the number of vehicles counted by the research team staff member during site visits and the number of individual records generated by the software over the same time period. A comparison of records collected over a two-hour period on June 14 uncovered no instances in which the human observer recorded vehicles that were missed by the software. However, the software generated a significant number of records (i.e., distinct rows in the data file output produced by the software, which associates output for each vehicle from the radiation detector, USDOT number reader, overhead camera, and ALPR system in a single line) with "n/a" or "Not Available" values in columns that would normally contain OCR readings, file names, etc., which were not reported by the human observer.

At the Laurel site, for example, 1,769 records were generated by ISSES during a span of approximately 8 hours on June 14. During the same time period, the research team member recorded 1,455 vehicles, a difference of 314 records. While it is possible that the observer missed some vehicles during periods of heavy traffic, the research team attributes much of the inconsistency in observed and detected vehicle counts to the ISSES vehicle detection component, which seems to have produced three distinct types of errors. In some cases ISSES generated two records, or rows, for the same vehicle, as evidenced by the fact that a single overhead camera image is associated with two adjacent records. This occurred 67 times during the 8-hour period on June 14.

In three other instances during the same 8-hour period, a value of “n/a” was generated instead of an overhead camera image, indicating that either the overhead camera was not triggered or that an extraneous record was created. The third type of error occurred when ISSES components (e.g., the overhead camera) were triggered when no vehicle was passing through the portal. This error is evidenced in Figure 5-14, which shows three images recorded in close sequence by the overhead camera. Each of these images is associated with a separate record in the ISSES output file. However, image [2] was taken after the vehicle shown in image [1] had already passed through the portal, but before the vehicle in image [3] reached the sensors. In other words, image [2] should not have been recorded and represents an extraneous record, or row, in the output file. In general, records that contained nothing but “n/a” or “Not Available” values were considered by the research team to be associated with one of these three types of errors.

The vendor acknowledged to the evaluation team that vehicle triggering and ordering the time sequence of actual events in the resulting data files has been a challenge in deployment. It appears that the system generates a certain number of unnecessary records when no vehicle was present. According to the vendor, triggering invariably involves trade-offs between either missing a vehicle or having extra triggers on a single vehicle. Every type of sensor has a chance of either missing a vehicle or having false triggers. In the case of the ISSES, the decision was made to allow a certain number of extra or false triggers, in exchange for having a system that is more likely to collect usable data on any vehicle suspected of posing a radiological threat. The extra ISSES triggers pose a low-consequence nuisance in data analysis. In practice, the vendor contends that these extra triggers should be obvious to operators or analysts, by cross-checking the suspect trigger records against the overview camera image associated with each record. The vendor also indicated that apparent sequencing errors when looking across server time stamps might be caused by fluctuations in computer network traffic volume, and time lags of varying durations required for internal processing and transmitting of signals from ISSES subsystems.

5.3.2 Radiation Portal Monitor

The research team assessed the general output of the radiation portal monitor. During the 2-week field observation, the ISSES recorded nine neutron alarm vehicles and 558 gamma alarm vehicles. Considering the approximate number of vehicles recorded during this period (28,000), the neutron alarm was activated by one out of every 3,111 vehicles, and a gamma alarm was activated by one out of every 50 vehicles. During a standard, 8-hour, daylight shift (8:00 AM to 4:00 PM), the average daily number of gamma alarms activated during the 2-week observation period was 29; and the average daily number of neutron alarms activated was slightly less than 1. The weigh station staff indicated that the gamma alarms sound fairly frequently. The inspectors indicated that staffing levels prevented them from inspecting every truck that tripped a radiation alarm. A tendency for nuisance alarms caused by naturally occurring substances has the effect of making inspectors more likely to ignore all of the bulk gamma radiation monitor alarms, as confirmed in the user acceptance interviews. As indicated in Section 7, the vendor and KTC have confirmed that the Laurel County system was recently modified to greatly reduce the number of nuisance alarms.

[1, first]

[2, middle]

[3, last]

Figure 5-14. Series of images recorded by ISSES overhead camera at Laurel site on June 14, 2007.

The evaluation team intended to make as few changes to the normal operating conditions as possible during the field observation, so no attempt was made to compare the bills of lading or the actual contents of the alarm vehicles with the data recorded by ISSES. No overt or covert field tests of the radiation monitor using known emitters were conducted during the evaluation period. Such tests would have permitted an assessment of false positive or false negative alarms from the radiation detection system. However, as indicated by a number of inspectors at the site, the radiation monitor would benefit from having a mechanism to more finely differentiate potentially dangerous loads from common items such as clay and brick, as evidenced by observations made during field visits. According to KTC, the Laurel County site was adjusted in the fall of 2007, after the time of the field observation, to greatly reduce the frequency of nuisance alarms.

In an attempt to characterize the truck population triggering neutron and gamma alarms during the field observations, USDOT number records and their associated JPG images were extracted from the ISSES records. These USDOT numbers were reviewed against the SAFER database to collect company information. Of the nine neutron alarms recorded by ISSES, only one USDOT number and associated JPG image was available. Of the 558 gamma alarms recorded by ISSES, 151 had valid USDOT number JPG images associated with them. A cursory review of these USDOT numbers showed no clear patterns or trends that would allow the evaluation team to characterize the truck population emitting gamma alarms.

However, it was noted anecdotally that, among the JPG images of the sides of trucks that showed evidence (through graphics or business names painted near the USDOT number) of the type of cargo that might have been carried on trucks triggering gamma alarms, the following commodities were named: marble, building systems, asphalt maintenance, and tile distribution. This unscientific observation would tend to confirm the KVE inspectors' opinions (described in the user acceptance section) that clay and related building products were among the naturally occurring substances that could trigger a gamma alarm.

To assess the internal consistency of the radiation detection data storage system, the final counts of each file type recorded on the RAD server were tabulated. The numbers of each file type are presented in Table 5-2 below for the 2-day Kenton training exercise and the 2-week Laurel field observational studies. As shown in the table, approximately 28,000 vehicles passed through the Laurel site and 4,200 vehicles passed through the Kenton site during the field study periods. While it would be expected that ISSES would generate equal numbers of the main file types for each vehicle (record), represented by the DATA, OCC, and JPG columns, Table 5-2 shows that there is some variability in the numbers when looking across all file types for the periods under study. According to the vendor, as discussed in Section 5.1.1. above, the ID, SPC, NAF, and BAL files would ordinarily be generated and stored only in alarm conditions, so would be expected to be fewer in number. The reasons for this variability are unknown but may be related to the generation of extraneous records by ISSES, as discussed in Section 5.3.1.

Table 5-2. Radiation portal monitor files generated during field studies.

	Number of Files Generated by Type							
Site	*DATA*	*OCC*	*JPG*	*ID*	*SPC*	*NAF*	*BAL*	*None*
Kenton	4,237	4,207	4,204	4,209	4,210	821	829	1,413
Laurel	28,416	28,006	25,794	0	0	28,004	565	4,260

As shown in Table 5-2, no ID or SPC file types were generated at the Laurel station. TransTech reported that first-generation radiation monitoring software was installed at the Laurel site; therefore, spectroscopy was not performed and the associated SPC and ID files were not created. Theoretically, JPG and OCC files should have been created for each vehicle that passed through the portal. However, Table 5-2 shows that no two file types had the same number of records. It is unclear why this occurred. NAF files, which are supposed to be generated only when an alarm is triggered, were created for nearly all the vehicles that passed through the Laurel site. This could be attributable to the use of first-generation software at Laurel.

The vendor indicated that live testing of the ISSES radiation monitor was conducted through the Domestic Nuclear Detection Office of the US Department of Homeland Security (DHS), and that the systems were confirmed to detect passing loads that were emitting radiation. The vendor reports having seen no evidence through testing that the radiation monitor has issued any false alarms (i.e., an alarm sounds when no radiation source is present). As opposed to false alarms, the tendency for nuisance alarms in the scale house when naturally occurring substances pass through the portal is discussed elsewhere.

5.3.3 Infrared/Thermal Imaging System

The research team reviewed video feeds captured by the thermal inspection device at the Kenton site. The objective was to determine whether potential heat-related defects were visible on the video and to track these defects. Originally, the intent was to compare the evaluator's observations with actual inspection reports provided by KVE to see if the defects found by weigh station inspectors were plainly apparent on the video.

The independent review of the two days' worth of Kenton IR video was hampered by several factors. As indicated by the vendor, the IR camera from this period was used in a training exercise, mainly by untrained inspectors learning and using the system for the first time. The camera was not set up properly for the first seven to eight hours of the Kenton field study. Video images were extremely blurry, and it was difficult to discern the general shape of the vehicle, let alone the specific components that were giving off a particular heat signature (see Figure 5-15). The evaluation team was not present during this scheduled KVE training exercise at Kenton, and no reason was given by the vendor for the video being blurry. It is assumed that the beginning of the recording represents a time when the inspectors were working with other ISSES subsystems, because at one point in the video, the camera settings were noticeably adjusted to provide the appropriate level of contrast between dark and light values. This greatly enhanced the image; however, at the same time that the contrast was adjusted, the operator of the IR camera appeared to zoom in and pan the camera manually to move along with (i.e., track) each passing vehicle. This resulted in only a portion of the vehicle appearing in the IR camera viewer at any given time (see Figure 5-16). Also, camera movement was disorienting to an evaluator with minimal

Figure 5-15. Image taken while contrast on the Kenton IR camera was improperly adjusted.

Figure 5-16. Image taken from Kenton IR viewer after contrast adjustment (note the time lag between the IR and color images and the inability to view the entire vehicle in IR mode).

training, trying to focus on possible areas of brightness or darkness. As a result, it was difficult to determine with any certainty that a particular tire, brake, or other component was giving off an unusual heat signature. These difficulties with the video image data appeared to be caused more by operator choices than by any inherent shortcoming with the technology.

The research team also noted a difficulty in correlating the image in the color (gable-mounted overview) camera viewer and the image in the IR camera viewer, on the three-part composite DVR player screen. As a vehicle approached the ISSES portal, it appeared on the IR viewer several seconds earlier than it appeared on the color monitor. This delay—most likely caused by the operator changing the aim of the IR camera while the overview camera remained stationary, or vice versa—was confusing, since the vehicle shown on the top right (IR) screen was often not the same vehicle visible simultaneously on the top left (color overview) screen (see Figure 5-16). The delay or time lag between the images appears to be amenable to correction through more careful operator training and experience. There is a benefit to enabling the user to aim the two camera systems (overview and thermal) independently, but this option carries costs for analysts interested in efficiently matching truck images with data records from the ISSES.

The research team was unable to cross-check video footage against Driver/Vehicle Examination Reports prepared by inspectors at the Kenton weigh station on July 31 and August 1, 2007, due to an inability to accurately identify the inspected vehicles on the IR/color video. USDOT numbers and/or license plate numbers from the inspection reports were used to find the date/time stamp on the USDOT number reader or ALPR output files and identify the time at which the vehicle passed through the ISSES portal. However, a review of the video at the corresponding times failed to identify vehicles with the same physical characteristics as those described in the inspection reports or shown in the still images captured by the ALPR/USDOT number reader. The research team watched video taken several minutes before and after the specified time, but could not conclusively match the images with the paper inspection records. When asked, the vendor indicated that the computer server that synchronizes the system time clocks at the Kenton site was down at the time of the recording, and the DVR clock did not match the ISSES clock. Because of this hardware fault, therefore, a direct, retrospective comparison was not possible, given the state of integration between the thermal imaging subsystem and the other ISSES vehicle identification and triggering subsystems when this sample of image data was stored. Such integration between the truck images shown on the overview color camera and the thermal/IR camera will be critical for enforcement and accurate vehicle identification in future enhancements of the ISSES hardware and software.

5.3.4 USDOT Number Reader and ALPR System

These systems were not under evaluation, so no results are presented.

5.3.5 System Performance Conclusions

The radiation monitor appears to alert inspectors to potential radiation hazards. No attempt was made to simulate radiation-emitting loads to formally test the rates of false positive alarms or false negative (missed detection) alarms. The alarm system produces different kinds of audible signals in the scale house, shows graphic images of the location and strength of the radiation source, and records quantitative information on the alarm conditions for retrospective review. A tendency for nuisance alarms caused by naturally occurring substances, however, has the effect of making inspectors more likely to ignore all of the gamma radiation monitor alarms, which reduces their effectiveness as a tool for identifying true threats. As a rule, the KVE inspectors do attend to neutron alarms, which sound different in the scale house and are much fewer in number than the gamma alarms.

The thermal inspection device enables inspectors to see potential heat-related defective or malfunctioning equipment that might be missed in a visual review. The field of view for the IR image can be manipulated as to direction and width, enabling close-up or wide-angle views of the stream of traffic. The system also records video data (in both IR and color/visible light) for later review. The effectiveness of the thermal inspection system appears to vary depending on the training, experience, and skills of the operator, especially in synchronizing the views of the ground-level IR/color camera and the gable-mounted color overview camera.

The laser scanner appears to log every truck passing through the ISSES apparatus, but its adjustment is such that the system generates a certain number of extra (blank) records or extra trigger events, which is an impediment to later review of traffic data. For the sample of data reviewed for this evaluation, some gaps in the time synchronization were noted.

The ISSES appears to perform with a minimum of unscheduled downtime. Partly owing to the exposed geographic location of the Laurel County weigh station, the hardware has been subject to several outages caused by lightning strikes and other power drops or interruptions. The system has experienced a low rate of hardware failure, other than some events related to the reliability of electrical power to the site. The developmental version of the system software is not equipped with a self-restarting function, which is expected to be included in production versions. Also, the state and the vendor are investigating the installation of an uninterruptible power supply system for the ISSES.

As of mid-2007, the system appeared to be at a late stage in the product development cycle, not completely in full-scale production mode, but well beyond the field test prototype stage. It was not yet integrated with any current or historical state or national databases, which affected its usefulness for real-time enforcement applications, but it appeared to be functioning well in stand-alone mode.

6.0 Inspection Efficiency Evaluation

This section addresses Goal Area 2: ***"Determine how the ISSES makes the inspection process more efficient and effective, in turn contributing to improved highway safety."***

Section 6.1 presents the research objectives and hypotheses that guided this portion of the evaluation along with a high-level description of the analysis. Section 6.2 provides an overview of Kentucky's current approach to selecting vehicles for inspection. Section 6.3 provides detailed information on the techniques used in data collection as well as how these data were used to meet the objectives of the independent evaluation. Understanding the demographics of the motor carrier population and the relative risk associated with truck traffic at the Laurel County station (objective 1.2) is covered in Section 6.4. Objective 2.2 is addressed in Section 6.5, where the inspection efficiency of the Laurel County station is assessed. Section 6.6 covers the safety benefits calculated based on various scenarios if KVE inspectors had instant, real-time (or advance) access to truck and motor carrier historic safety/inspection/driver information via ISSES or other CVISN technologies. Section 6.7 examines the potential effect of other credentialing data sources on safety benefits. Sections 6.6 and 6.7 together address objective 2.3, on the integration of ISSES data with external data sources.

6.1 Objectives and Overall Approach

This chapter will cover the following objectives and hypotheses:

Objective 1.2 Use data from the field test to determine the distributions of kinds of vehicles traversing the weigh station under normal conditions. This provides a baseline for reference in assessing the highway safety benefits of the ISSES.

Hypothesis: The distribution of commercial vehicles passing the London site, relative to the respective motor carriers' SafeStat score ranges, is similar to that of the national population of commercial vehicles.

Objective 2.2 Measure the ability of the ISSES to improve inspection selection efficiency, and in turn to yield reductions in crashes and breaches of highway security.

Hypothesis: The ISSES can help inspectors focus their efforts on higher-risk trucks.

Objective 2.3 Explore options for integrating the data available from the ISSES with existing safety, enforcement, and administrative data sources, and prepare models or plausible scenarios for Kentucky or other states to apply.

Hypothesis: Data from ISSES can yield important information for commercial vehicle enforcement and administration when combined with data from other state and federal sources.

Data to address these objectives and hypotheses were collected through various methods: (1) interviews and site visits with various KTC and KVE personnel; (2) a 2-week field study at the Laurel County inspection site; (3) various federal and state safety data sources; and (4) past federal studies that relate to CMV crashes and safety. Listed below are the main data sources used and the role that each data source played in achieving the goals of the evaluation.

- **Interviews with KVE inspectors and KTC specialists**. Information was compiled to characterize and understand Kentucky's current approach to the roadside screening and inspection process, the data sources used in the process, and how the ISSES fits into the overall inspection selection approach.

- **USDOT numbers for all trucks going through the ISSES portal at the Laurel County station during a 2 week field study (during normal daytime hours).** This collection of USDOT numbers provided a representative sample of carriers that pass through the ISSES at the Laurel County station. The USDOT numbers were used to acquire various kinds of carrier demographic information as well as current and historical safety information from federal and state data sources.

- **NORPASS (electronic screening/preclearance) bypass decisions per truck for one week during field study.** This data was used to determine the number of trucks that utilize the NORPASS system, with screening decision criteria as set by Kentucky, at the Laurel County station as well as provide an idea of the percentage of trucks that are given green and red lights to either bypass or pull into the station. Information on these trucks, when combined with data from the trucks that went through the ISSES, provided a fuller profile of truck traffic that went by the inspection station during the second week of the field study.

- **Electronic copies of inspections performed during 2-week field study.** These inspections provided the evaluation team with insight into the types of vehicles that are selected for inspection at the Laurel County station. The inspection report contained information on the specific types of violations found during the inspection. In addition, USDOT numbers of vehicles inspected were cross-referenced with federal and state data sources to learn more about the safety risk of carriers that are inspected at the Laurel County site.

- **Electronic copies of Kentucky statewide inspections spanning over 2.5 years.** These inspection reports provided a more robust picture of trucks selected for inspection statewide. From these inspections, state OOS rates were calculated for various groups of trucks as defined by their safety risk. The inspections also identified those OOS violations that occur most frequently in the population and allowed the evaluation team to calculate the probability of occurrence for these most commonly occurring OOS violations.

- **SAFER.** A copy of the Safety and Fitness Electronic Record (SAFER) carrier and inspection tables was obtained from the Volpe Center at the time of the field study. SAFER was used to obtain current safety risk measures such as SafeStat (Motor Carrier

Safety Status Measurement System) and Inspection Selection System (ISS) scores. These sources were in addition to other historical safety-related information on trucks observed during the field study as well as those trucks that were inspected statewide over the past 2.5 years. SAFER enabled the evaluation team to place both observed and inspected trucks into safety risk categories defined by their current ISS score.

- **Kentucky Clearinghouse.** A copy of the Kentucky Clearinghouse database was obtained at the time of the field study. This database showed vehicle and driver OOS rate information on carriers that traversed the station. Also, registration and insurance status about each carrier was extracted so that it could be combined with other safety-related information to form a clearer picture of each motor carrier.

- **Infrared Images.** It was planned to obtain IR (thermal) images on a sample of trucks that passed through the ISSES at the Laurel County station during the field study. Unfortunately, only images from a two-day training session at the Kenton site, and none from Laurel, were made available to the evaluation team. Miscommunication between the evaluator and the vendor resulted in the Laurel County thermal imaging data being inadvertently discarded. However, results from a prior research study conducted in 2000 for FMCSA to evaluate a similar IR imaging and video package, known as IRISystem, were used to estimate the increase in OOS orders issued when trucks are screened via IR imaging.[2]

- **Large Truck Crash Causation Study (LTCCS).** Data from the LTCCS were used to identify those OOS violations that present a high relative crash risk. This was important in that a larger number of crashes could be avoided by finding those OOS violations in an inspection that have a higher relative crash risk.

- **2003 National Truck Fleet Safety Survey.** An FMCSA-sponsored survey in which approximately 2,800 trucks were selected at random for inspection in order to estimate the percentages of trucks and drivers that operate with OOS conditions. These OOS rates were used as estimates for the probability of finding an OOS violation when inspectors select trucks for inspection randomly.

- **Large Truck Crash Facts – 2005.** Federal statistics on the number of crashes, injuries, and fatalities in which large CMVs were involved were used to help estimate the safety benefits accruing from various roadside deployment scenarios.

The goal of roadside enforcement is to avoid as many crashes as possible by putting unsafe vehicles OOS before the OOS conditions present on the vehicle contribute to a crash. A means to this end is to improve the inspection selection process in such a way that the greatest benefit can result from a fixed number of inspections. This makes the most efficient use of limited time, human resources, and facilities. The overall approach of this evaluation was to first assess the effectiveness of the current inspection selection methods at selecting high-risk trucks.

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[2] The IRISystem technology was purchased by IIS (the vendor for the ISSES technology under evaluation) in 2003. IIS continues to manufacture IRISystem vans, and the IRISystem designer participates in all of IIS's thermal imaging applications.

In addition, alternative methods for selecting vehicles for inspection were evaluated based on potential availability of information from the above data sources. Several forms of available evidence and inspection selection methods were combined in various ways to develop hypothetical scenarios for the safety analysis:

- Selecting vehicles randomly for inspection, to provide a starting point from which to assess the contribution of the inspectors' knowledge and experience.
- The current vehicle selection process used in Kentucky, which relies primarily on inspector judgment.
- Using electronic screening[3] to eliminate all low- and medium-risk carriers from selection consideration, so that inspectors can focus on high-risk trucks or those with insufficient safety information in federal databases. This approach uses the carrier's ISS score, a rating system promoted by USDOT.
- Using the carrier's vehicle and driver OOS rates, which are the metrics preferred by Kentucky in roadside enforcement.
- Using information on OOS violations with a high relative crash risk
- Using thermal/IR brake images from the ISSES.

Finally, the evaluation measured the success of these new inspection selection methods by simulating what would happen if inspectors used these kinds of information to select high-risk trucks for inspection. The measures used to estimate success were the estimated number of crashes, injuries, and fatalities avoided.

6.2 Kentucky's Approach to Inspection Selection

One of the main objectives of the Inspection Efficiency analysis was to measure the ability of the ISSES to improve inspection selection efficiency. One hypothesis tested was that the ISSES could help inspectors focus their efforts on higher-risk trucks. In order to best address this hypothesis, it was crucial first to understand the current inspection selection philosophies and methods used at the Laurel County site as well as in Kentucky overall. This was accomplished through interviews with KVE inspectors and other personnel from the Laurel, Simpson, and Kenton County stations where the ISSES has been deployed.

Information from these interviews was compiled to characterize Kentucky's approach to the roadside screening and inspection process. Specifically, the ways that Kentucky inspectors utilize aspects of the ISSES or other CVISN screening and safety information exchange technologies to help them make inspection selection decisions were documented. The range of manual and automated inspection selection methods and supporting data systems (e.g., Query Central) that are currently being used were identified as were any state-of-the-art practices.

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[3] The term "electronic screening" is defined, for purposes of this study, as using any computer-based, real-time information source to aid in selecting trucks for inspection, whether the truck carries a transponder or not, and whether the screening occurs at mainline or ramp/sorter-lane speeds. Further details are provided in Section 6.6.2 below.

Specific attention was focused on the degree to which sites are currently integrating various national and state data sources.

6.2.1 Summary of Approach

Kentucky has developed an algorithm for observing and pulling in trucks for inspection. The algorithm is used at inspection stations where an office support assistant is available to capture (by keypad data entry) the USDOT or the Kentucky Use (KYU) numbers and, if possible, the unit number from every truck that enters the station. The algorithm relies heavily on this truck identifying information as well as the Kentucky Clearinghouse, a state database containing carrier-based safety, credentialing, and licensing information that is housed at the Kentucky Transportation Cabinet in Frankfort. As Kentucky does not have sufficient resources to place such an office support assistant at each inspection station, the algorithm is not used at every Kentucky inspection station. This section presents the methodology used to select vehicles for inspection at sites where an office support assistant is available to capture truck identifying information. This is followed by a discussion of inspection selection practices at other sites, including the Laurel County northbound station, where the algorithm is not used, because no office support assistant is assigned to this station.

Table 6-1 describes the data contained in the Kentucky Clearinghouse and how it is used for inspection selection purposes. Most information in the Clearinghouse comes from internal Kentucky data sources supplemented with information obtained through federal safety systems such as SAFER or SafetyNet. Some data values in the Clearinghouse are updated in real time while others are updated hourly or daily from their respective sources.

Table 6-1. Kentucky Clearinghouse database fields as of September 2007.

Field	Description
USDOT Number	The USDOT field is populated from a daily update from SafetyNet.
Census National File Indicator	Indicates whether the USDOT number was pulled from the Motor Carrier Management Information System (MCMIS) Census File meaning the carrier is on file with the USDOT (Y) or if the record was created by Division of Motor Carriers personnel as they were issuing various credentials during that day (N). The Y should replace the N as soon as SafetyNet refreshes with the issuance of the new USDOT number, which should be within a few days.
USDOT Status	The carrier's status with USDOT as seen in SafetyNet.
Driver OOS Rate	The driver OOS rate as posted for the company in SafetyNet.
Vehicle OOS Rate	The vehicle OOS rate as posted for the company in SafetyNet.
OOS Rate	The larger of the Vehicle OOS or three times the Driver OOS Rate is posted in this field, and is subsequently used in all screening calculations. (Because most of Kentucky's screening is focused on carriers whose OOS rates are above the national average, the driver OOS number is multiplied by three so as to better be able to compare the two numbers – this concept is explained further in the discussion following this table).
Number of Observations at Kentucky Facilities	A four digit number representing the number of times any of the company's vehicles had been recorded (data entered) by a state official as they were observed passing through one of Kentucky's scale facilities. This number currently can be between 0 and 500, and resets to zero after the system flags and notifies the scale personnel that an inspection may be warranted.
KY Intrastate Tax License	The status of the carrier's KY Intrastate Tax license as it is currently displaying

Field	Description
Status and Reason	in the Automated Licensing and Taxation System (ALTS). The status for this field is updated in real time.
KY Intrastate Tax Inactive Reason	If a carrier is inactive, this field displays the reason the carrier has been made inactive [(C) for cancelled in good standing, (R) for revoked, or (S) for suspended, which means that the license has only been inactive for less than 30 days].
IFTA Status	The status of the carrier's real-time International Fuel Tax Agreement (IFTA) [(A) for active, (I) for inactive and (N) for no data available] of KY IFTA carriers from the ALTS mainframe system, as well as the IFTA status of any carrier whose base jurisdiction utilizes the IFTA Clearinghouse to forward the status of their carriers. The inactive status for a non-KY carrier can only be posted if the jurisdiction identifies the revoked carrier within the Clearinghouse by their USDOT number.
IFTA Reason	If a carrier is inactive, this field displays the reason the carrier has been made inactive [(C) for cancelled in good standing, (R) for revoked, or (S) for suspended, which means that the license has only been inactive for less than 30 days].
IFTA State	Indicates the IFTA base jurisdiction
SSRS Status	The field flags for-hire motor carriers that have expired liability insurance. This data begins with a daily file extract from SAFER, which goes to the Single State Registration System in Illinois. From there, an extract is passed back to Kentucky, where it populates this field and displays all interstate, for-hire motor carriers' status: (A) for active and (I) for inactive. Private and intrastate carriers are populated with an (N). While the SSRS has been repealed (to be replaced by the UCR program), the data that is obtained for this field is and will continue to be an accurate indicator for insurance and operating authority status.
IRP Status	The status for the carrier's International Registration Plan (IRP) is updated each hour from the Cabinet's Oracle IRP system. Any change in status is warehoused within the IRP system until the top of the hour, when a file is created to move the data from the IRP System to the KY Clearinghouse.
IRP Expiration Date	Any change in the IRP expiration date is passed hourly to the Clearinghouse. The date is the expiration date of the IRP plates issued to this company by Kentucky. When new plates are issued, the expiration date is advanced a year and the system is updated within an hour. If the plates are not renewed in the IRP system by the expiration date, the KY Clearinghouse changes the (A) in the status to an (I) to indicate the plates are expired. Within an hour the update takes place in the Clearinghouse, but can be updated on line immediately.
Extended Weight Coal Decal	The current status of the Extended Weight Coal Decal, which works in an identical fashion as the IRP system. It is also populated from an Oracle based EWD system and the status will set to (I) if the decal is not renewed.
NORPASS enrollment status	Denotes if the carrier is enrolled with Kentucky's NORPASS screening system. This flag (Y/N) is set whenever a company registers its vehicles with NORPASS and the information is loaded into KY's transponder system. The information is refreshed each hour in the same process that provides the transponder system with its master flag setting and the random pull-in percentages.
ICC Exempt Authority	Denotes whether the company has additional ICC exempt operating authority. This information is updated in real time from KY's mainframe systems that handle these authorities.
Kentucky for-hire Authority	Denotes whether the company has additional KY for-hire operating authority. This information is updated in real time from KY's mainframe systems that handle these authorities.
PRISM Status	Comes from the MCSIP field within SafetyNet. This flag is updated daily with the refresh from SafetyNet. If SafetyNet indicates this company is in MCSIP,

Field	Description
	the field displays a (Y), otherwise it displays an (N).
KYU Exempt	Used to override the observation systems requirement for a large truck to have an active KYU number on file. For example, an 80,000 pound farm plated truck would get stopped each time it went through a scale because it did not have a KYU number. A tractor trailer combination licensed for only 55,000 pounds would get pulled in each time as well. When the user places a letter in this field [(F) for farm, or (W) for weight], the system ignores the KYU edit check.
KYU Number	Kentucky Use Number
KYU Status	Denotes the status of the KYU number [(A) for active, (I) for inactive]
KYU Reason	Displays the reason the carrier has been made inactive [(C) for cancelled in good standing, (R) for revoked, or (S) for suspended, which means that the license has only been inactive for less than 30 days].
Exam	A multi-purpose field that could be used to stop vehicles of companies who were active for all criteria in the system, but needed to be stopped for some other reason. (1) means that there were no vehicles listed on KYU vehicle inventory system. (2) is generally used to stop a carrier and obtain a valid address from them. (3) indicates that the scale personnel should contact the radio room for additional instructions on this carrier. (4) is used to override an inactive KYU number (in most cases this was due to a delinquent tax return being present in the state office, but for some reason could not be processed at that time). (5) is used to stop carriers who had not provided a valid USDOT number to cross reference their KYU number.
OOS Grace Date	Used to override the OOS rate data that is feeding into the Clearinghouse. Example: The OOS rate could be altered and a grace date can be populated to establish the length of time the system recognizes the altered information. For example, if a company had been inspected a number of times recently due to a poor OOS rate and had drastically improved their equipment, the OOS could be manually lowered and a grace date could be set for three months out to allow the inspections to make it through the system and update the company's rating. The Clearinghouse would ignore the daily data that was coming from SafetyNet until the grace date passed and then would proceed as usual from that day forward. The process would work the same for SSRS and PRISM.
SSRS Grace Date	Used to override the SSRS status data that is feeding into the Clearinghouse.
PRISM Grace Date	Used to override the PRISM status data that is feeding into the Clearinghouse.

6.2.2 Algorithm for KY Clearinghouse Observation Inspection Pull-Ins

This section describes the algorithm that determines whether a vehicle is targeted by the system to be pulled in for inspection or not, using data from the Kentucky Clearinghouse. Most of the computation is focused on the OOS fields in the Clearinghouse. Random pull-ins for transponder-equipped vehicles on the mainline are also initiated using this algorithm. Although it does not have an official name, the algorithm will be referred to in this report as the Kentucky OOS Rate Inspection Selection Algorithm.

Some Kentucky inspection stations utilize office support assistants to key in the USDOT or KYU numbers from the cabs of vehicles as they slowly pass the scale house during hours when inspectors are on duty. The truck identification information is typed into a computer terminal connected directly to the Kentucky Clearinghouse. Then, information on the carrier is compiled and sent back instantaneously to personnel at the inspection station. An inactive status in such fields related to USDOT number, KYU number, IFTA, IRP, SSRS, Kentucky Intrastate Tax License, and others, causes the system to display the specific problem on the office support assistant's screen and invoke the printer to provide a paper copy listing the issue as well. The office support assistant then makes a decision whether to turn on the "PARK" signal on the variable message sign for the vehicle to pull into the lot to park the vehicle and enter the scale house. The driver would then enter the scale house and work with KVE personnel to resolve the issue.

The decision to have the vehicle pull into the lot is based on the office support assistant's quick evaluation of the information available from the Clearinghouse before the truck has passed under the directional signage. There are instances where the Clearinghouse identifies issues with the carrier but the office support assistant decides to let the vehicle continue back to the mainline. For example, the office support assistant may see that the screen is displaying a name other than the name displayed on the vehicle that was just keyed, leading him or her to believe that the DOT number may have been typed incorrectly. The office support assistant may also make a judgment call that there is not enough personnel available to handle additional vehicles at this time. In addition, the speed of the vehicle or the time involved in the evaluation may be such that the vehicle is past the variable message sign before the office support assistant can act.

Inspection decisions using the Clearinghouse are based on three factors: 1) OOS rates; 2) the carrier's status in the Performance and Registration Information Systems Management (PRISM) Target File; and 3) the number of times the carrier's vehicles have visited a Kentucky station since their last inspection. The carrier's vehicle and driver OOS rates are both pulled down daily from SafetyNet and loaded into the Clearinghouse. In addition, the PRISM Target File [in the form of the Motor Carrier Safety Improvement Program (MCSIP) A, B, & C carriers] is pulled from SafetyNet and loaded as well. A counter system was developed within the Clearinghouse to keep track of how often a carrier's trucks enter Kentucky inspection stations. Using a series of adjustable pull-in rates maintained in the Clearinghouse, the system determines which vehicles should be "kicked out" and displayed on the screen indicating that the office support assistant should consider selecting that vehicle for inspection.

The following is a quick explanation of the counters in the Clearinghouse. There are currently 16 scale facilities in Kentucky, all of which are equipped with a data entry system for screening trucks. When staffed with an office support assistant, each of these facilities utilizes the single Clearinghouse database located in Frankfort. Each time the weigh station personnel enter an observation (keying a USDOT number and unit number) into the database, the master record for that company has a counter that is increased by one. For example, if the counter is set at 278 for a particular carrier, and an observation for that carrier is recorded at Morehead Scales, the counter increases to 279. If three seconds later an observation is recorded at Fulton Scales for a different vehicle operated by the same carrier, then the carrier's counter value increases to 280. This counter increases regardless of whether the observation shows an active or inactive status for the carrier.

The purpose of the counter is to establish how many times the company's vehicles have been "observed" or entered into the system since the last time the system kicked one out to be inspected. As soon as the system designates a company's vehicle for inspection, the counter rolls back to zero and the next observation is recorded as "1." The system knows when to select a vehicle for inspection by using the adjustable pull-in rates shown in Table 6-2. These pull-in rates apply both to sites where an office support assistant is assigned to the scale house and to sites equipped with the NORPASS electronic screening system. The Clearinghouse utilizes both the vehicle and driver OOS rate to determine when a company should have their next vehicle pulled in for inspection. Since the national average for driver OOS is roughly a third of the vehicle OOS, the driver OOS Rate is multiplied by 3 to even the two numbers out so that the higher of the two numbers can be used for screening. (The driver OOS multiplier can be altered in the algorithm to accommodate different inspection selection strategies.) Throughout the remainder of this section, OOS rate refers to the maximum of the vehicle OOS rate and three times the driver OOS rate.

Table 6-2. Carrier and NORPASS pull-in rates for Kentucky OOS rate inspection selection algorithm.

Carrier OOS Rate*	Carrier Pull-In Rate (Truck selected for inspection by Clearinghouse algorithm)	NORPASS Pull-in Rate as Defined by Kentucky
100%	Every 20th Truck	50%
76-99%	Every 5th Truck	40%
50-75%	Every 10th Truck	20%
25-49%	Every 100th Truck	10%
0 – 24%	Every 500th Truck	5%

* Larger of (vehicle OOS rate) and (driver OOS Rate times 3)

Depending on where that OOS rate falls within the ranges provided in the first column of Table 6-2, the carrier pull-in rate in the second column sets the point at which the counter for each particular company initiates a "kick-out," i.e., notifies the weigh station personnel to inspect a vehicle, and automatically reset the counter to zero. For instance, a carrier with an OOS rate of 58 percent has one out of every 10 of its trucks kicked out for inspection, while a carrier with a more favorable safety rating (e.g., one with an OOS rate of 5 percent) sees every 500th truck kicked out. By design, carriers with a 100 percent OOS rate are pulled in less frequently than carriers with OOS rates between 50 and 99 percent. Kentucky has found that a large number of carriers with a 100 percent OOS rate as displayed in the Clearinghouse are actually companies that have had only one inspection, which happened to result in an OOS order. Since there are a significant number of such carriers and to better manage the number of kick-outs at the station, a decision was made to look at these carriers with less frequency than carriers with slightly lower OOS rates.

When a truck is kicked out for inspection, the office support assistant's screen and printer immediately displays information such as the following example:

DOT NO: 1787878
KYU NO: 007878
COMPANY NAME: TO-MARK-IT TRUCKING
INSPECT 066

This would indicate to the office support assistant that the vehicle that he or she just entered had a vehicle OOS of 66 percent or a driver OOS of 22 percent, either of which would be significantly greater than the national average. Because the carrier OOS rate fell between 50 and 75 percent, it would also mean that the vehicle in question was the tenth vehicle to be observed (or entered into the Clearinghouse system) since the last time the system had kicked a vehicle out from that company to be inspected.

In addition to the company counter that every carrier has, the Clearinghouse also maintains an internal counter for every carrier in the PRISM Target File. If the carrier is in the PRISM Target File, a separate and independent counter is created to keep track of vehicle observations for PRISM purposes. When that company's PRISM counter hits 5, the counter reverts to 0 and the office support assistant's screen and printer displays the following:

DOT NO: 1787878
KYU NO: 007878
COMPANY NAME: TO-MARK-IT TRUCKING
PRISM Y

The carrier observation counter and the PRISM counter are completely independent of each other, and as soon as a carrier is taken off the PRISM Target File, its PRISM counter is disengaged. The observation counter is constantly in use and increases regardless of the circumstances of the observation.

All of the data fields described above can be altered to focus inspection kick-outs as KVE sees fit. Currently, KVE uses five levels of pull-in rates, but the system can handle up to 10 levels. Also the settings are such that every 500th vehicle of a company that is at or below the national average for OOS is kicked out for inspection. That can be changed at any time to any arbitrary number if so desired. The driver OOS multiplier is currently set to 3 so that any company with a driver OOS rate above 8 is screened at a much higher level, but that could be increased, for example, to 8 or 9, so that KVE could focus on companies with high driver OOS rates.

At the current levels set by the table, there are more kick-outs than scale personnel can handle. This is done mainly for two reasons. First, it provides the scale personnel with plenty of discretion as to which vehicles they inspect. In addition to the inspection decision produced by the inspection selection algorithm, an inspector may visually spot a problem with a vehicle (flat tire, unsecured load, etc.), or choose to inspect a PRISM-identified carrier, or an overweight vehicle. These obviously needed inspections require the scale personnel to ignore the kick-outs due to lack of time and resources. Secondly, each inspection site has different levels of personnel, and the staff there are to complete their assigned number of inspections. It would be virtually impossible to program the system to kick out the right number of vehicles for the day and have them spaced out appropriately for the inspectors to handle. This would also require drastically decreasing the pull-in rates so that possibly only six or eight kick-outs occur per inspector on any given shift. Potentially, three or four could occur within an hour, and then nothing else might show up for another three or four hours.

As Table 6-2 indicates, the Kentucky Clearinghouse utilizes a built-in pull-in rate that is passed to the NORPASS System for random red light pull-ins from the mainline. As it is with the inspections, the higher a carrier's OOS rate, the fewer green light bypasses allowed. Currently a carrier at or below the national average for OOS would be required to pull into the station 5 percent of the times that its trucks encounter a NORPASS-equipped Kentucky inspection station. Alternatively, carriers with OOS rates between 76 and 99 percent would be required to pull into the station at a rate of 40 percent. These rates can also be altered as needed by KVE. PRISM carriers (i.e., carriers in MCSIP) get red lights 100 percent of the time, when the weigh station is open.

6.2.3 Inspection Selection Methods at Laurel County Inspection Station

At the time of the field observation, there was no regular office support assistant assigned to manually enter USDOT or KYU numbers of trucks passing the scale house at the northbound Laurel County inspection site. Thus, the inspection selection algorithm associated with the Kentucky Clearinghouse was not used at the Laurel County station. Rather, trucks were predominantly selected for inspection based on the inspector's visual observation of the trucks as they entered the station, the inspector's personal knowledge of the carrier and its corresponding safety history, and the inspector's professional judgment and experience. This is important to keep in mind as analyses on inspection efficiency and safety benefits are presented in Sections 6.5 and 6.6, respectively.

6.2.4 Traffic Flow at Laurel County Inspection Station

The Laurel County ISSES site (see Figure 3-1 above) is equipped with transponder-based mainline electronic screening via NORPASS and has a high-speed, mainline weigh-in-motion (WIM) scale linked with the NORPASS system. There is also a low-speed WIM on the sorter lane leading from the mainline to the scale house. All trucks are required to enter the station when it is open, with the exception of those NORPASS participants that are given permission to bypass. The layout for the site is such that there is one exit ramp from the highway that leads to a sorter-lane WIM. Trucks on the ramp with an acceptable WIM reading are directed to a lane on the west (highway) side of the scale house, which is the lane that contains the ISSES equipment. Overwidth trucks are directed to a static scale on the east side of the scale house, because the width of the ISSES portal cannot accommodate overwidth vehicles. Also, any vehicles that lack a valid low-speed WIM weight reading or are suspected of being overweight are directed to the static scale.

For trucks that pass through the ISSES equipment, information from the bulk radiation detection monitor, thermal imaging inspection system, vehicle classification system, USDOT number reader, and license plate recognition system are communicated to officers in the scale house. At the time of the field observation, these systems were not integrated with any legacy Kentucky or federal safety data source. As such, ISSES information was generally not used in the inspection selection decision.

Once trucks have been weighed on the sorter-lane WIM and/or the static scale, inspectors make a decision whether to let the truck continue to go straight back to the mainline if there are no problems or to have the truck pull around to the back of the station into the inspection area or shed for further examination by motor carrier enforcement personnel. This decision is communicated to the driver via lighted arrow signs located on both sides of the scale house.

6.3 Field Observational Study Data Collection

The Kentucky field data collection was conducted from June 11 to June 22, 2007 at the Laurel County northbound weigh station. Prior to the actual field data collection, introductory visits to the site were made by evaluation personnel in July and August, 2005, shortly after the system had been deployed. A preliminary site visit was also made on January 24, 2007, to both the Laurel County northbound I-75 and the Kenton County southbound I-75 ISSES sites. Personnel from the KTC and the system vendor (TransTech/IIS) were the principal contacts. The main goal of this January visit was to observe the operations at the stations and consult with members of the deployment team and inspectors. Of particular interest to the Inspection Efficiency portion of the evaluation was to understand the truck movements through the stations, the information available to inspectors to make decisions on which trucks to inspect, and how inspectors use this information to make inspection decisions. A second goal of the preliminary site visit was to determine how data could be extracted from the ISSES and other IT systems on-site and how best to locate researchers within the scale house at Laurel County to capture vehicle identification information visually. Researchers met with inspectors and officers from KVE as well as information technology personnel to understand the screening and inspection operations and took tours of both inspection stations.

Beginning on June 11, 2007, a researcher from the evaluation team was assigned to the scale house to observe the vehicles entering the weigh station during normal daylight hours while inspectors were present. To the extent possible, each entering vehicle was identified by USDOT number. Periodic time values were also recorded for reference and data matching purposes. This information was recorded via the researcher speaking into a digital voice recorder. The digital voice recorder was the preferred medium for data capture, because it allowed the researcher to capture the USDOT number without having to look away from the vehicle. The audio data were then transcribed to a Microsoft Access database application and quality-checked. Trucks passing by the scale house during daylight hours were no more than 10 feet from the window and, for the most part, were going at a very low speed through the ISSES, thus enabling the research team to capture vehicle identification information for most of the vehicles. Based on feedback from the data collector, it is estimated that no more than 5 percent of the vehicles going through the ISSES were missed. Mainly, truck information was missed when many trucks were too closely spaced and traveling too fast as they passed the scale house window for the data collector to capture all information. It is assumed that the safety ratings and other characteristics for the missed trucks are no different than those for the complete population of trucks traveling on this section of I-75 in Kentucky.

Table 6-3 shows the dates and times that a researcher was on duty during the field study. For the most part, a researcher was collecting USDOT information from passing trucks during normal business hours while at least one inspector was at the station inspecting vehicles. One exception was on Tuesday, June 12, where no data collection occurred due to an unplanned absence. Also, the station was closed after 11 AM on Tuesday, July 19 for a meeting of KVE officials, so data collection on that day was limited to the morning.

Table 6-3. Times when USDOT numbers were captured from truck traffic passing through ISSES equipment.

Date	Time	Comment
Monday, June 11	8:00 AM – 4:00 PM	
Tuesday, June 12	Not applicable	No USDOT number data were collected; researcher unavailable
Wednesday-Friday, June 13-15	8:00 AM – 4:00 PM	
Monday, June 18	8:00 AM – 4:00 PM	
Tuesday, June 19	8:00 AM – 11:00 AM	Station closed at 11:00 AM for staff meeting. It was not reopened until 6:00 PM
Wednesday-Thursday, June 20-21	8:00 AM – 5:00 PM	
Friday, June 22	8:00 AM – 4:00 PM	

It was desirable to characterize all vehicles that traversed the Laurel County station during the time of the field study so that the sample of trucks that can be identified could be considered a representative sample of all trucks that travel this section of the highway. However, in certain cases, vehicles can bypass the station, making it impractical to identify these vehicles visually because of their mainline speeds and the distance from the scale house. Vehicles can legally bypass the station because: 1) they were cleared as a result of NORPASS; or 2) the station was closed temporarily to prevent queuing on the mainline as they approached. Vehicles can also bypass the station illegally by not stopping when the station is open or, in the case of e-screening participants, not entering the station when a red light signal is communicated to the driver. The NORPASS ModelMACS screening equipment provides an audible alarm in the scale house if any transponder-equipped vehicle bypasses the station without receiving a green light.

The Kentucky Transportation Cabinet provided a file of all NORPASS-participating trucks that traversed the highway where the Laurel County inspection station was located for the second week of the two-week study. Information provided in the file for the second week of the field study included:

- Time and date when the vehicle’s transponder was read
- Decision made on truck (bypass or pull in)
- Reason for decision
- Carrier name
- USDOT number
- Vehicle unit number
- State of Registration (IRP state)
- Vehicle license plate number.

The trucks that were given a bypass signal during the hours of data collection at the site were added to the list of trucks that were captured by the on-site data collector to get a more complete list of truck traffic that went by the inspection station during the second week of the field study. E-screening participating trucks that were pulled in and went through the ISSES portal would already have been captured by the data collector. KVE personnel estimated that approximately 8 percent of the trucks that enter the Laurel County weigh station cross the static scale, instead of going through the ISSES portal. These "static scale" trucks, most likely overwidth or flagged as potentially overweight on the low-speed ramp WIM, are not accounted for in this analysis.

An assumption was made that the population of vehicles that bypass the station when it was temporarily closed is not significantly different from the population of trucks that came in when the station was open. Therefore, no identifying information was captured on vehicles that bypassed when the station was closed. The major closure was on Tuesday, June 19. Based on hourly truck counts observed on that day, it is estimated that approximately 1,000 trucks bypassed the weigh station during the late morning/afternoon station closure. There were instances where the station was closed for very short periods of time due to excessive backups on the ramp leading from the mainline to the weigh station. The number of trucks that bypassed the station during these brief closures was minimal. Also, it is unknown what proportion of vehicles bypass the station illegally, although it is assumed to be a low percentage of the truck traffic for purposes of this study.

Electronic copies of reports from all inspections conducted at the Laurel County station during the two-week field study were obtained from KVE at the conclusion of the study. This provided evaluators with a list of specific vehicles that were chosen for inspection from the truck traffic that traversed the station during the field study. These inspection reports detailed the level of inspection, results of the inspection, and any violations or OOS orders. KVE also provided a database of all inspections performed at all fixed and mobile sites in Kentucky for the 32.5-month period from January 2005 through mid-September 2007. Information from these inspection reports provided analysts with accurate information as to OOS rates for Kentucky inspections for different classes of vehicles.

The Kentucky Department of Motor Vehicles also provided a copy of the Kentucky Clearinghouse Database. The data in the Clearinghouse changes daily, so it not possible to know the exact contents of the Clearinghouse for each day of the field study. Rather, an attempt was made to get a copy of the database as close to the time of the field study as possible. Due to a delay in making the file available to researchers, a snapshot of the database was obtained by researchers in August 2007, reflective of information as of July 17, 2007, roughly one month after the field study. It is unknown to what degree the contents of the Clearinghouse changed between the end of the field study and July 17. However, for purposes of this study it is assumed that any changes to a carrier's profile would be minimal. Registration and insurance status about each carrier was extracted so that it could be combined with other safety-related information to form a more complete picture of each motor carrier. More information on the Kentucky Clearinghouse and the specific fields in the database is presented in Section 6.2.

Unfortunately, video images from the IR/thermal imaging camera during the field study at the Laurel site were not available to the evaluation team. However, video data from the thermal imaging system were provided to the independent evaluator on vehicles that passed through the

Kenton County inspection station during a two-day training session on July 31 and August 1, 2007. Although these video images were not useful to the Inspection Efficiency portion of the evaluation, because they did not correspond to the truck traffic observed during the two-week field study, they were reviewed in connection with the system performance study, covered in Section 5.0.

6.4 Characteristics of Truck Traffic at Laurel County Station

A quantitative, statistically rigorous baseline picture of the commercial traffic using I-75 northbound through southern Kentucky is important in preparing strategies for helping vehicle inspectors to focus on higher-risk carriers and vehicles. First, summary demographic information on truck traffic that traversed the Laurel County inspection station during the field study was collected. A second key factor in this effort was describing and understanding the relative safety risk of these trucks. Information on the trucks observed entering the site or legally bypassing the site via NORPASS during the field study were used.

The purpose of this section is to describe the truck traffic near the Laurel County inspection station and to compare characteristics of this population to the national population of motor carriers. Table 6-4 provides an overview of the numbers of trucks that were observed.

Table 6-4. Truck traffic volume observed during field study.

	June 11 – June 15		**June 18 – June 22**		**Complete Field Study**	
	Number of Trucks	**Percent**	**Number of Trucks**	**Percent**	**Number of Trucks**	**Percent**
Entered Station and Captured by Data Collector	5,588	100.0	6,738	93.1	12,326	96.1
Bypassed Station via NORPASS	NA*	NA	498	6.9	498	3.9
Total	**5,588**	**100.0**	**7,236**	**100.0**	**12,824**	**100.0**

* NORPASS bypass information was available for only the second week of the field study.

Overall, USDOT numbers were captured for 12,326 CMVs entering the Laurel County station during the two-week field study. Information on an additional 498 vehicles that legally bypassed the station during the second week of the study was captured via NORPASS. Because of a software or hardware archiving failure associated with the ModelMACS screening system in Kentucky, bypass information for the first week of the study could not be used because key pieces of information were missing from the NORPASS file that reports truck bypass and pull-in information. The 498 trucks that bypassed in the second week were added to the 12,326 captured by the on-site researcher for a total of 12,824 vehicles used in the analysis. A total of 57 trucks were inspected during the first week of the field test, while 36 trucks were inspected the second week.

Table 6-4 describes only those trucks that were observed either by the data collector or NORPASS. As noted previously, identifying information was not captured on a small subset of vehicles. For example, trucks that did not pass through the ISSES but were instead directed automatically or manually to the static scale were not captured by the data collector. Due to the rate at which trucks passed by the scale house window after going through the ISSES and the distance between the ISSES equipment and the static scale on the opposite side of the building, it was not possible for the data collector to capture USDOT numbers from both sets of vehicles. In consultation with KVE, the KTC estimates that, when the station is open, approximately 8 percent of the daily truck volume passes over the static scale as opposed to going through the ISSES. In addition, it is estimated that the researcher was unable to obtain identifying information on about 5 percent of the vehicles traveling through the ISSES, mostly because consecutive trucks were at times traveling too fast past the scale house window to capture all information. While such unidentified trucks are excluded from this analysis, it is assumed that the safety ratings and other characteristics for the small set of missed trucks are identical to those trucks from which identifying information was captured.

Figure 6-1 summarizes the number of trucks observed each day of the field study. Since the number of hours of data collection varied by day, the number of trucks per hour is also provided to be able to better compare truck volumes by day. The average number of trucks observed traversing the station per day over the two weeks of data collection was about 1,370. This equates to about 179 trucks per hour. Truck volume was greatest on Thursdays and generally higher toward the end of the week. Monday was the slowest day in terms of truck traffic. Data were not collected on weekends. Also, no data collector was present on July 12, and raw truck counts are lower on July 19 due to the station being closed in the late morning and entire afternoon.

Figure 6-2 shows the total number of trucks and the number of trucks per hour that bypassed the station via NORPASS and hence were captured by the NORPASS system during the second week of the field study. An average of 13.5 trucks per hour bypassed the station via NORPASS during the 37 hours of data collection in the second week. The largest number of bypasses occurred Wednesday through Friday.

Figure 6-3 illustrates the number of inspections conducted per day at the station. The number of inspections per day varied throughout the course of the two-week study and was driven by the number of inspectors on duty on a given day. During the field study, Laurel County had two new KVE inspectors working for the first time. This was not believed to have a significant effect on the evaluation, nor on the number of inspections achieved per day. The prevailing attitude among inspectors at the time of the study was that the two new inspectors, once trained, might enable the KVE staff at the site to make better use of the ISSES data. The new inspectors were not observed to be using the ISSES equipment any more than the experienced inspectors assigned to the Laurel site. Since no data collector from the evaluation team was present on the weekends, no inspection data was collected on weekends either.

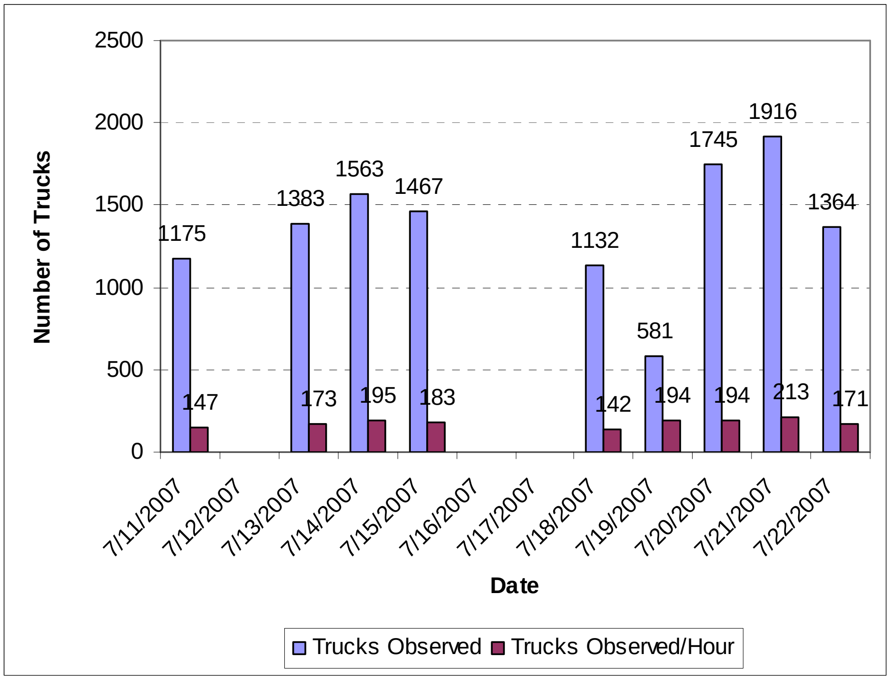

Figure 6-1. Total number of trucks and trucks per hour observed by data collector during each day of field study.

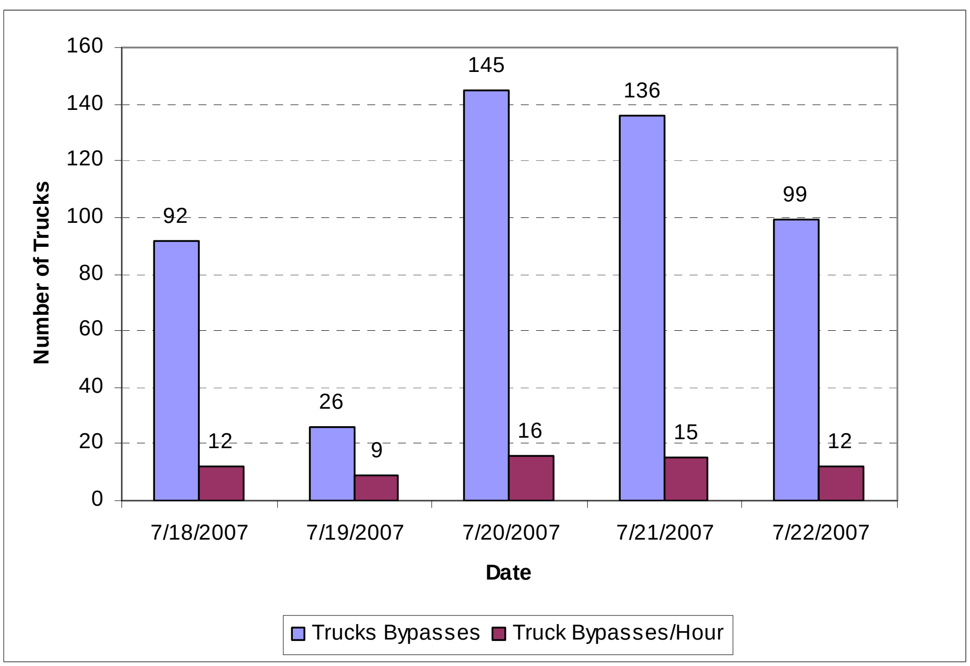

Figure 6-2. Daily number of total truck bypasses and bypasses per hour for second week of field study.

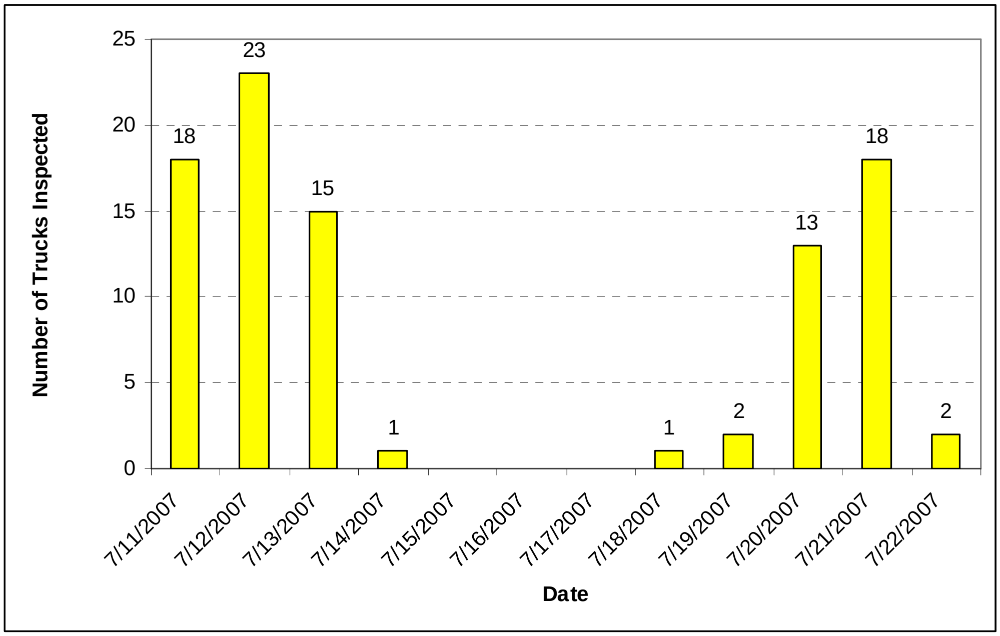

Figure 6-3. Daily number of inspections during field study.

6.4.1 Carrier Demographics

The USDOT number for every truck observed during the field study was cross-referenced with the Motor Carrier Management Information System (MCMIS) Census File to obtain selected demographic information. A large percentage of the truck traffic, 95 percent, was interstate carriers, while the remaining 5 percent operated within the state of Kentucky. The large percentage of interstate carriers is not surprising, given that the station lies along I-75, a main corridor for north/south traffic in that part of the country, and is located just 30 miles north of the Tennessee border.

Table 6-5 shows a breakdown of the trucks' home states. Since license plate information was not captured on all trucks, the home state for each truck is defined as the base state of the truck's carrier as listed in the MCMIS Census File. Roughly 11 percent of the truck traffic was based in Kentucky. Another 25 percent of the trucks had carriers based in three of the states bordering Kentucky (Tennessee, Ohio, and Indiana). A large portion of the truck traffic hailed from the midwest and south with a small percentage based in western states.

Table 6-5. Distribution of carrier base state for observed field study trucks.

State	Number	Percent
Kentucky	1,387	10.82
Tennessee	1,301	10.15
Ohio	1,144	8.92
Indiana	773	6.03
Michigan	707	5.51
Arkansas	685	5.34
Wisconsin	593	4.62
Florida	564	4.40
Illinois	531	4.14
Ontario, Canada	477	3.72
Georgia	445	3.47
North Carolina	409	3.19
Pennsylvania	333	2.60
Nebraska	288	2.25
Iowa	283	2.21
Alabama	263	2.05
Arizona	243	1.89
Missouri	235	1.83
Texas	221	1.72
Minnesota	194	1.51
South Carolina	183	1.43
Virginia	175	1.36
New Jersey	107	0.83
All Other States	1,283	10.00
TOTAL	**12,824**	**100.00**

6.4.2 Carrier Electronic Screening

Of the 12,824 observed trucks that traversed the Laurel County inspection station during the times of field study data collection, 639 (or 5 percent) contained a transponder enrolled in NORPASS. Seventy-eight percent of the 639 e-screening participating trucks were allowed to bypass the station while the remaining 22 percent were instructed to pull into the station. This observed pull-in percentage is consistent with what would be expected given the NORPASS pull-in rates provided in Table 6-2. Figure 6-4 illustrates the percentage of trucks that bypassed and pulled into the station each day for the second week of the study. The percentages are fairly consistent across the five days, with a slightly higher pull-in rate on Thursday and Friday.

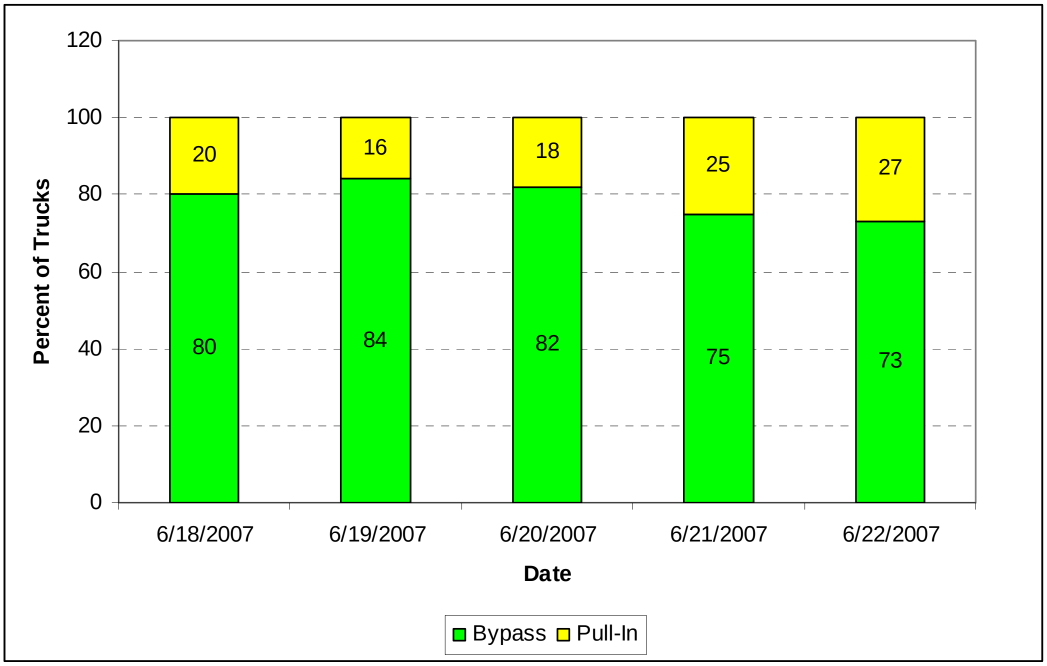

Figure 6-4. Percentage of e-screening participating field study truck traffic that bypassed and pulled into inspection station.

Table 6-6 displays the percentage of trucks that pulled into the station at the direction of NORPASS broken down by the reasons they were pulled in. Over half of the trucks were pulled in because of no weight data available from the mainline WIM. KTC officials commented that weight data may not be available in cases where a truck is straddling the WIM or there is a significant cargo shift while crossing the WIM. This also could indicate a technical problem with the WIMs. Eighteen percent were selected randomly for pull-in, while 13 percent had problems with their credentials or they were identified as a PRISM carrier. About 11 percent were brought in for a weight violation.

Table 6-6. Distribution of reasons e-screening participating trucks were required to pull-in to inspection station during field study.

Reason for Pull-In	Percentage of Trucks
Credentials related or PRISM Carrier	12.6%
No weight data	58.2%
Random Selection	17.9%
Weight Violation	11.4%

6.4.3 Carrier Risk

The carriers' ISS scores were used to assess their safety risk. ISS is a decision aid for CMV roadside driver/vehicle safety inspections, which guides safety inspectors in selecting vehicles for inspection. The underlying inspection value is based on data analysis of the motor carrier's safety performance record using information from FMCSA's MCMIS. It is primarily based on SafeStat with an additional carrier-driver-conviction measure. SafeStat ranks all carriers by their safety performance in areas of crash history, inspection history, driver history, and safety management experience (UGPTI 2004). The system provides FMCSA with the capability to continuously quantify and track the safety status of motor carriers, especially unsafe carriers. This allows FMCSA enforcement and education programs to effectively allocate resources to carriers that pose a high risk of involvement in crashes. The ISS provides a three-tiered recommendation, as shown in Table 6-7.

Table 6-7. ISS values and recommendations.

Recommendation	ISS Inspection Value	Risk Category
Inspect (inspection warranted)	75 - 100	High
Optional (may be worth a look)	50-74	Medium
Pass (inspection not warranted)	1-49	Low

The USDOT numbers for the 12,824 trucks observed at the inspection site were compared with a copy of the SAFER database obtained at the time of the field study to obtain the ISS score for each carrier that could be identified. Trucks were then placed into risk categories based on Table 6-7. Carriers were placed into an "insufficient data" risk category if there was not enough information to generate an ISS score. Carriers with USDOT numbers that could not be found in SAFER were labeled as unknown. The distribution of safety ratings was also generated for all active carriers in the SAFER database at the time of the field study so that a comparison could be made between the relative safety risk for the population of Kentucky traffic around the Laurel County station and the population of CMVs nationally.

Figure 6-5 shows the percent of Kentucky field study truck traffic that fell into each risk category based on each carrier's ISS score, compared with the risk breakdown of all active trucks in SAFER at the time of the field study. A large proportion of the carriers in SAFER, however, about 81 percent, do not have sufficient information to generate an ISS score based on safety information (as opposed to less than 8 percent of the field study truck traffic). This skewed the risk distribution for the national truck population toward the Insufficient Data risk category. To better compare the Kentucky carriers with the national carriers, only carriers with sufficient information from SAFER were used. Also, unknown carriers (ones where USDOT numbers could not be matched to SAFER) were removed from this particular comparison.

About 33 percent of the Kentucky field study truck traffic is considered high-risk based on ISS while 21 percent and 46 percent are considered medium- and low-risk, respectively. The percentage of national high-risk carriers is lower than in Kentucky. As mentioned previously, there were a large number of carriers in SAFER with insufficient information to place them in a risk class—much more so than in the truck traffic for Kentucky. Furthermore, an examination of historical inspection reports from Kentucky has indicated that carriers with insufficient data to generate an ISS score have OOS rates comparable to those trucks in the high-risk category. Consequently, the exclusion of all carriers from SAFER with insufficient data may be artificially lowering the percentage of high-risk carriers from a national perspective. Regardless, the risk distribution of Kentucky truck traffic does not differ dramatically from that of the national risk breakdown. Furthermore, the percentages of trucks by risk are relatively consistent with results obtained from three other field studies conducted in Colorado, New York, and Ohio as part of the separate Evaluation of the National CVISN Deployment Program (not shown here). As a result, it is reasonable to assume that the traffic near the Laurel County station is comparable to the national population of carriers from a risk standpoint.

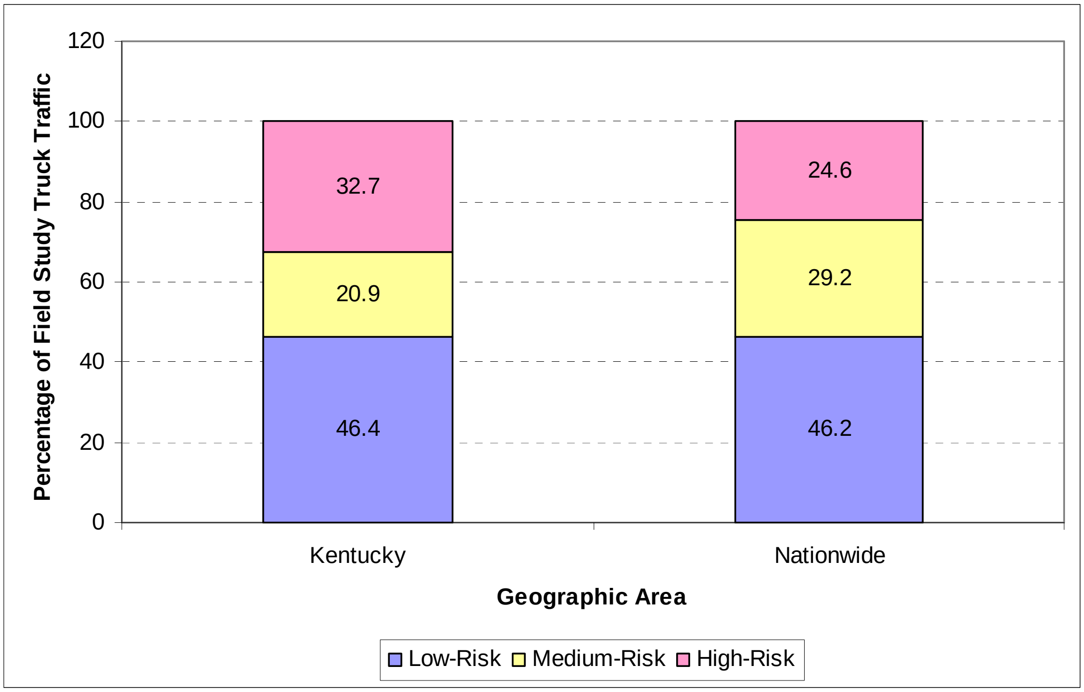

Figure 6-5. ISS risk distribution for Kentucky field study truck traffic as well as national risk distribution from SAFER.

Notes: 1. Kentucky truck traffic based on 11,515 observed trucks during June 11 – June 22, 2007 with sufficient information to calculate ISS score.

2. National data based on approximately 219,000 carriers in SAFER Carrier Table with sufficient information to calculate ISS score.

In addition to assessing the safety risk distribution for Kentucky truck traffic versus the national carrier population, risk classification was also used to compare different segments of the Kentucky truck traffic observed during the field study. Table 6-8 examines the risk distribution (based on ISS scores) of Kentucky field study trucks with and without transponders.

Table 6-8. Comparison of ISS risk distribution for e-screening and non-e-screening Kentucky field study trucks.

ISS Risk Classification	# of KY Field Study Trucks Screened with Transponder	%	# of KY Field Study Trucks Screened without Transponder	%
High	83	13.0	3,677	30.2
Medium	91	14.2	2,315	19.0
Low	459	71.9	4,890	40.1
Insufficient Data	4	0.6	996	8.2
Unknown	2	0.3	307	2.5
Total	639	100.0	12,185	100.0

Of all trucks participating in e-screening, about 72 percent are classified as low-risk compared to only 40 percent of non e-screening participating carriers. Thirteen percent of e-screening carriers are in the highest risk class as opposed to more than 30 percent of trucks without transponders. This is not surprising, because carriers with better safety records are more likely to enroll in e-screening than carriers with poorer safety records.

Table 6-9 examines the risk distribution of all e-screening participating carriers who were given a green light to bypass the station as well as those instructed to pull into the station. Based on the objectives of e-screening, one would expect a larger percentage of high-risk trucks to be pulled in versus allowed to bypass. The data support this expectation as the set of bypassed trucks have a lower percentage of high-risk trucks (about 11 percent) compared to the trucks instructed to pull in (about 21 percent). Again this is not surprising given that the rate in which trucks are pulled into stations is higher for those trucks with higher carrier's vehicle and driver OOS rates. Lower risk trucks are pulled in less frequently.

Table 6-9. Comparison of ISS risk distribution for trucks bypassing station and trucks pulling into station using Kentucky screening criteria.

ISS Risk Classification	# of KY Field Study Trucks that Bypassed Station	%	# of KY Field Study Trucks that Pulled In	%
High	53	10.6	30	21.3
Medium	78	15.7	13	9.2
Low	361	72.5	98	69.5[a]
Insufficient Data	4	0.8	0	0.0
Unknown	2	0.4	0	0.0
Total	498	100.0	141	100.0

a. As shown in Table 6-6 above, 58 percent of the pulled-in, transponder-equipped trucks received red lights because of a lack of weight (WIM) data.

6.5 Inspection Efficiency

For purposes of this evaluation, inspection efficiency is defined by the degree to which inspectors choose high-risk trucks for inspection. A high-risk truck is one where there is a high likelihood that the truck is operating with a serious OOS condition. There are multiple ways to define the risk associated with a truck. Two methods explored in this section are: (1) the carrier's ISS score, a rating system promoted by USDOT; and (2) a carrier's vehicle and driver OOS rates, which are the metrics currently preferred by Kentucky in roadside enforcement.

6.5.1 Risk Categories Using Carrier ISS Score

The data that were needed to assess the efficiency of the current inspection practices included the following:

- ISS Risk classifications for trucks in the population at the inspection site (based on observed truck traffic during field study);

- ISS Risk classifications for trucks that were inspected (based on approximately 2.5 years of state inspections in Kentucky); and

- OOS rates by ISS risk classification, historically, and during the field observational studies.

As discussed in Section 6.4.1, trucks observed at the inspection site were placed into one of five risk categories based on the carrier's ISS score. Using the same methodology, risk classifications based on the ISS score were also obtained for trucks inspected at both the Laurel County north- and southbound stations from January 2005 through mid-September 2007. In order to obtain OOS rates by risk category, the historical inspection records were used to determine whether each inspection over the 32.5 month timeframe resulted in an OOS order being issued. OOS rates were expressed as the number of OOS orders given per 100 inspections for each risk category.

For trucks inspected anywhere in Kentucky from January 2005 through mid-September 2007, the carrier's risk category at the time the inspection took place is not known. The risk category used in the present analysis is based on a copy of SAFER obtained during the field study. The assumption here is that a carrier's current risk rating is the same as when the carrier's vehicle was inspected. A carrier's rating could, of course, have changed over the 2.5-year period. However, based on the availability of SAFER datasets, the rating was assumed to remain constant.

6.5.2 Risk Categories Using Carrier's Vehicle and Driver OOS Rates

Kentucky's use of OOS rates to select vehicles for inspection was described in Section 6.2. For purposes of this discussion, driver OOS rates are multiplied by 3 to make the vehicle and driver OOS rates more comparable numerically. Also, high-risk vehicles are defined as those operated by a carrier with a vehicle or driver OOS rate of at least 25 percent. Medium-risk vehicles are those with a vehicle or driver OOS rate between 10 and 25 percent. Low-risk carriers have OOS rates of at most 10 percent.

OOS rate risk classifications were obtained for the observed truck traffic during the field study as well as vehicles inspected at the north- and southbound Laurel County sites over the previous 2.5 years by cross-referencing each vehicle's USDOT number with the Kentucky Clearinghouse. Then, because there is a wide range of OOS rates for each risk category (e.g., 76 to 99), the average OOS rate for all carriers in each OOS risk category was calculated using historical state inspections. This average number of OOS orders was used in the safety benefits analysis.

6.5.3 Using Carrier ISS Score to Define Truck Risk

Table 6-10 summarizes the inspection efficiency at the Laurel County inspection station in terms of the probability of selecting high-risk trucks. Actual vehicle inspection totals by risk category in the first row are based on more than 17,000 inspections performed at the Laurel County north- and southbound stations between January 1, 2005, and September 13, 2007. Since only 93 trucks were inspected at the northbound ISSES site during the two-week field study,[4] the use of the historical inspections provided a more robust risk distribution of inspections. Also for this reason, inspections from the southbound Laurel County station were included. The southbound station is located on the other side of the highway and is similar in layout to the northbound station, with the exceptions that the southbound station does not have an ISSES, and the southbound station has both the low-speed bypass lane and the static scale lane on the east (highway) side of the scale house. The truck traffic vehicle totals in the second row are based on the total number of trucks observed traversing the station during the field study. The vehicles selected for inspection as well as those in the truck traffic population were divided into high-, medium-, and low-risk, insufficient data, and unknown risk based on the ISS scores of the carrier and are shown in columns 2 through 5 of Table 6-10.

For the inspected and truck traffic vehicles, the probability of a truck being high-risk is shown. The probability of a truck being in the high-risk category is calculated as the number of high-risk trucks divided by the total number of trucks. About 29 percent of the truck traffic at Laurel County was considered high-risk, while 34 percent of the vehicles inspected at the Laurel County station were high-risk. The ratio of the proportion of high-risk vehicles inspected to the proportion in the truck traffic population is 1.16 (33.94 percent divided by 29.32 percent). This ratio is statistically significantly greater than 1 (the value expected if there was no difference between random inspections and current practices). Thus, current inspection practices such as inspector judgment, visual observation of vehicles, and use of NORPASS for transpondered

[4] Although not broken out separately for analysis in this evaluation, as a point of reference, the following is a description of the population of 93 trucks chosen for inspection during the two-week field study at Laurel northbound station. About 46 percent of the trucks were classified as high-risk. This is higher than the 34 percent of all trucks inspected during the 32.5-month period, as shown in Table 6-10 below. Although the exact reason for the difference is unknown, possible explanations include variations in inspector skills and methods, time of day, and changing weather conditions between the longer and shorter time periods of analysis. Factors such as these could have an impact on the truck population or the inspection efficiency of a particular site. By contrast, of these 93 trucks inspected, five had an OOS violation (four were driver-related and one was vehicle-related). This OOS rate of 5.4 percent was, incidentally, lower than the 13.6 percent statewide historical OOS rate.

Table 6-10. Inspection selection efficiency at Laurel County station.

Vehicle Data	Number of Trucks by Risk Classification					Percent of High-Risk Carriers
	High	Med/ Low	Insuff. Data	Unknown	Total	
Inspected[1]	5,929	10,502	987	53	17,471	33.94%
Truck Traffic[2]	3,760	7,755	1,000	309	12,824	29.32%
Inspected vs. Truck Traffic						1.16

1. Vehicle inspection totals based on more than 17,000 inspections performed at the Laurel County northbound and southbound stations between January 1, 2005 and September 13, 2007
2. Truck Traffic totals based on more than 12,800 trucks observed during two-week field study at Laurel County Station

vehicles yield slightly more high-risk trucks than if inspectors would simply choose trucks randomly.

The analysis comparing OOS rates for different inspection selection strategies requires estimates of OOS rates across risk categories. Table 6-11 shows statewide OOS rates by risk categories, which were calculated using all inspections in Kentucky between January 1, 2005, and September 13, 2007. OOS rates were 7.2 per 100 inspections for low-risk trucks and 17.2 per 100 inspections for high-risk trucks. OOS rates for trucks with insufficient data and for an unknown risk class were higher than those for high-risk trucks. The overall OOS violation rate was 13.6% over the 32.5-month span.

Table 6-11. Statewide OOS violation rates by risk category for inspections performed January 1, 2005, through September 13, 2007.

Risk Class (Based on ISS Score)	Number of Inspections	Number of Inspections with an OOS Violation	OOS Rate (No. per 100 Inspections)
High-Risk	70,803	12,183	17.2
Medium-Risk	40,818	5,597	13.7
Low-Risk	80,225	5,763	7.2
Insufficient Data	26,384	5,072	19.2
Unknown	4,222	1,561	37.0
Total	222,452	30,176	13.6

Kentucky's historic OOS rates were found to be significantly below the national average. Nationally, 24 percent of vehicles inspected were put OOS for vehicle violations and 7 percent of drivers inspected were put OOS for driver violations in 2005 (USDOT 2005b). Based on Kentucky inspections performed from January 1, 2005, through September 13, 2007, Kentucky's vehicle and driver OOS rates for 2005 were 9.5 percent and 4.7 percent, respectively. Representatives of the KTC acknowledged that Kentucky's OOS rates are below the national average and that FMCSA and the Commissioner of KVE have identified the raising of OOS rates as a priority. The KTC has been performing a detailed analysis of Kentucky's OOS rates in an attempt to better understand the difference in OOS rates between Kentucky and the rest of the nation. At the time of this evaluation, no results or conclusions from this analysis were available. More discussion on the relatively low Kentucky OOS rates is provided in Section 6.6.

Table 6-12 presents the results of the analysis of OOS rates. The expected number of OOS orders was calculated for two scenarios: if trucks were selected randomly for inspection, and if trucks were selected according to current practices. The expected number of OOS orders per 100 inspections under each of these scenarios was calculated by multiplying the proportion of trucks in each risk category by the OOS rate for that category. That is, the number of OOS orders per 100 inspections was equal to the proportion of those 100 inspections that would be expected to be in the risk category multiplied by the OOS rate for the risk category. For example, the table illustrates that about 29 percent of trucks observed during the field study were classified as high-risk compared to roughly 34 percent of the inspections conducted at the Laurel County station. The state OOS rate for the high-risk category is 17.2. Thus, the expected number of OOS orders per 100 random inspections of high-risk trucks would be 5.04 (29.32*0.172). Using current inspection practices, the expected number of OOS orders per 100 inspections for high-risk trucks is 5.84 (33.94*0.172). Within each inspection selection scenario, the sum of the corresponding numbers over all five risk categories gave the total number of OOS orders expected per 100 inspections.

Table 6-12. Comparison of expected number of OOS orders per 100 inspections for Laurel County inspection station using ISS scores to define risk categories—random selection versus current inspection practices.

ISS Risk Category	Percentage of Commercial Vehicles		State OOS Rate	No. OOS Orders per 100 Inspections	
	Random Selection(1)	Inspected(2)		Random Selection	Inspected
High	29.32	33.94	17.2	5.04	5.84
Medium	18.76	18.43	13.7	2.57	2.52
Low	41.71	41.68	7.2	3.00	3.00
Insufficient Data	7.80	5.65	19.2	1.50	1.08
Unknown	2.41	0.30	37.0	0.89	0.11
Total Expected OOS Orders per 100 Inspections				**13.00**	**12.55**

(1) Random selection percentages were determined from ISS Scores of more than 12,000 vehicles that were observed at the Laurel County northbound inspection site during the field study.
(2) Actual selection percentages are based on more than 17,000 inspections performed at the Laurel County northbound and southbound stations between January 1, 2005 and September 13, 2007.

Overall, if trucks were selected for inspection at random, one would expect about 13 OOS orders per 100 inspections. Using the current inspection selection procedure, the number of OOS orders per 100 inspections would be expected to drop 0.45 OOS orders per 100 inspections. Although the number of OOS orders for high-risk trucks increases, the slight overall drop in OOS orders is due mainly to the lower percentage of insufficient data carriers that are inspected compared to the percentage of carriers with insufficient data in the truck traffic population. This is a consequence of Kentucky focusing on OOS rates as a measure to select high-risk trucks—if any historical safety data were used at all—and not using ISS scores to select vehicles for inspection. Moreover, the state OOS rate for insufficient data carriers is quite high at 19.2 OOS orders per 100 inspections. Thus, current inspection selection practices do not yield an improvement in the number of OOS orders over selecting trucks randomly.

Table 6-13 illustrates the impact on the number of OOS orders per 100 inspections where an inspection selection strategy is adopted that incorporates the use of full electronic screening. Under this hypothetical scenario, all CMVs classified as low- and medium-risk enroll in NORPASS, are equipped with transponders, and are allowed to bypass inspection sites. Inspectors then use current practices to select vehicles for inspection from the remaining trucks in the high-risk and insufficient data categories. The second column again shows the risk distribution of trucks that would be expected if trucks were selected randomly for inspection. The third column shows the proportion that would be inspected if all low- and medium-risk trucks were allowed to bypass the site and if the numbers for the remaining risk categories were increased proportionally. For example, the percentage of high-risk trucks expected to be inspected under this strategy would be 74.17 percent {74.17% = 29.32% / [1-(0.1876+0.4171)]}, while no medium- or low-risk trucks would be inspected. As in the preceding table, the expected number of OOS orders per 100 inspections under each of these two scenarios was calculated by multiplying the proportion of trucks in each risk category by the OOS rate for that category. Within each inspection selection scenario, the sum of the corresponding numbers over all five risk categories gave the total number of OOS orders expected per 100 inspections.

Table 6-13. Comparisons of expected number of OOS orders per 100 inspections for Laurel County inspection station using ISS scores to define risk categories—random selection versus electronic screening where medium- and low-risk carriers are allowed to bypass station.

ISS Risk Category	Percentage of Commercial Vehicles		State OOS Rate	No. OOS Orders per 100 Inspections	
	Random Selection(1)	Full ES(2)		Random Selection	Full ES
High	29.32	74.17	17.2	5.04	12.76
Medium	18.76	0.00	13.7	2.57	0.00
Low	41.71	0.00	7.2	3.00	0.00
Insufficient Data	7.80	19.73	19.2	1.50	3.79
Unknown	2.41	6.10	37.0	0.89	2.26
Total Expected OOS Orders per 100 Inspections				**13.00**	**18.81**

(1) Random selection percentages were determined from ISS Scores of more than 12,000 vehicles that were observed at the Laurel County northbound inspection site during the field study.
(2) Distribution was derived from random selection percentages and the assumption that electronic screening eliminates low and medium-risk carriers from the selection process (e.g., for high-risk category 74.17% = 29.32% / (1-(0.1876+0.4171))).

Again, if trucks were selected for inspection at random, one would expect about 13 OOS orders per 100 inspections. If electronic screening were implemented to the point that all low- and medium-risk trucks would be allowed to bypass the site, the number of OOS orders per 100 inspections would be expected to rise to about 19. This last scenario represents an increase of OOS orders per 100 inspections of about 45 percent from the scenario where trucks are randomly selected for inspection from the population of traversing trucks. It also represents an increase of OOS orders per 100 inspections of about 50 percent compared to current inspection practices.

6.5.4 Using Carrier OOS Rates to Define Truck Risk

Rather than ISS scores, Kentucky uses a carrier's driver and vehicle OOS rate to determine those trucks that should be selected for inspection at stations where an office support assistant is assigned. Trucks observed during the field test were placed into risk categories based on their vehicle OOS rate or their driver OOS rate (multiplied by three), whichever is higher. Carriers with higher vehicle or driver OOS rates are placed into higher risk categories. In turn, the higher the risk category that a truck belongs to, the higher the probability that the truck would be kicked out for inspection.

The USDOT numbers of all trucks observed during the field study were cross-referenced with a copy of the Kentucky Clearinghouse database near the time of the field study to obtain both the vehicle and driver OOS rate for each carrier. Based on the higher of the vehicle and driver (multiplied by three) OOS rates, carriers were placed into one of seven risk categories.

The first three columns in Table 6-14 show the risk categories as well as the risk distribution for the Kentucky field study truck traffic. Carriers are defined as having insufficient data if no inspection information was available for that carrier in SAFER. Unknown trucks are operated by carriers whose USDOT number could not be found in SAFER. About 63 percent of the truck traffic have carriers in the 0-24 risk class. Five percent of the truck traffic had OOS scores above 50.

To evaluate the inspection selection efficiency associated with the Kentucky inspection selection algorithm, the next set of columns summarizes information used to simulate what would happen if inspectors followed the algorithm explicitly. The percentage of trucks that would be kicked out for inspection based on the distribution of truck traffic observed during the field study is provided as well as the kick-out rates for each risk category. The inspection kick-out rates are defined as the number of trucks that the algorithm identifies for inspection and are the standard rates used by KVE personnel as of June, 2007. These rates could be altered by KVE as needed to change the focus of their inspections. However, for this illustration the standard rates are used. Also, the rates for unknown and insufficient data are set at 1 in 500 trucks, the same as the lowest risk category. The number of observed trucks in each risk category is multiplied by the kick-out rate to identify the number and percentage of observed trucks that would be identified by the algorithm for possible inspection.

Table 6-14. Risk distribution of field study truck traffic and trucks kicked out from inspection selection OOS rate algorithm.

Risk Category (Based on OOS Score)	Truck Traffic		Kicked Out Trucks		
	# Trucks	Percent	Inspection Kick-out Rate	# Trucks	Percent
100	41	0.32	1/20	2	1.61
76-99	155	1.21	1/5	31	25.00
50-75	442	3.45	1/10	44	35.48
25-49	2,808	21.89	1/100	28	22.58
0-24	8,071	62.94	1/500	16	12.90
Insuff Data	1,000	7.80	1/500	2	1.61
Unknown	307	2.39	1/500	1	0.81
Total	**12,824**	**100.00**		**124**	**100.00**

Approximately 124 trucks would have been kicked out by the Kentucky OOS rate inspection selection algorithm over the 8.5 days of data collection (or about 14.6 trucks per day). The number of kicked out trucks was arrived at based on the time a researcher was present to capture truck identification information—roughly an 8-hour inspector work day. As designed by the algorithm, the kicked out trucks were spread throughout all risk categories with more emphasis on the higher OOS rate categories. About 25 percent of kicked out trucks had OOS rates in the 76 to 99 range while 35 percent had OOS rates in the 50 to 75 range. Examination of the risk distribution of truck traffic at the station during the field study, as shown in the second and third columns of Table 6-14, shows that the risk distribution of truck traffic is significantly lower—only about 1.5 percent of trucks had an OOS rate in the 76 to 100 range and 3 percent in the 50 to 75 range. Roughly 63 percent of trucks had OOS rates in the 0 to 24 range.

Table 6-15 summarizes the inspection selection efficiency that would be obtained if the algorithm was used explicitly. For both the truck traffic and kicked out vehicles, the probability of a truck being of high risk is shown where high-risk is defined as trucks having an OOS score in the 25 to 100 range. For example, the probability of selecting a high-risk truck if the selection process was purely random is about 27 percent. However, the percent of high-risk trucks kicked out for inspection using the OOS rate algorithm is much higher, at almost 85 percent.

The proportion of high-risk vehicles kicked out for inspection divided by the proportion in the truck traffic population is 3.16. This ratio is also statistically significantly greater than 1. Thus, the inspection selection process where inspectors focused only on trucks that were kicked out for inspection based on the OOS rate algorithm would result in more than three times as many high-risk carriers than would be inspected if the selection were purely random.

Table 6-15. Kentucky inspection selection efficiency using OOS rates to define risk.

Vehicle Data	Percent of High-risk Carriers (OOS >24)
Truck Traffic	26.87%
Kicked Out Trucks	84.90%
Kicked Out vs. Truck Traffic Population	3.16

To further examine the inspection efficiency of the Kentucky inspection selection algorithm, an analysis was performed to compare the number of OOS orders issued under the various scenarios. The analysis comparing OOS rates requires estimates of OOS rates across risk categories. Table 6-16 shows statewide OOS rates by risk categories, which were calculated using all inspections in Kentucky between January 1, 2005, and September 13, 2007. The total number of inspections during this time frame, 222,452, represents all inspections at fixed and mobile sites conducted throughout the state. OOS rates ranged from 7.9 per 100 inspections for trucks with OOS rates between 0 and 24 to 39.6 per 100 inspections for trucks with a 100 percent OOS rate. The overall OOS violation rate was 13.6 percent over the 32.5-month span.

The OOS rate presented in the last column is the main driver for determining the OOS rate risk category (column 1) to which a carrier belongs. Because of this, carriers in riskier categories have higher OOS rates. Because there is a wide range of OOS rates for each risk category, the purpose of Table 6-16 is to get the average OOS rate for all carriers in each OOS risk category. This average OOS rate for each risk category was used in the subsequent analysis of OOS orders per 100 inspections.

Table 6-17 presents the results of the analysis of OOS rates. The expected number of OOS orders was calculated for two scenarios: if trucks were selected randomly for inspection, and if trucks were selected using the Kentucky OOS rate algorithm. The expected number of OOS orders per 100 inspections under each of these scenarios was calculated by multiplying the proportion of trucks in each risk category by the OOS rate for that category. That is, the number of OOS orders per 100 inspections was equal to the proportion of those 100 inspections that would be expected to be in the risk category multiplied by the OOS rate for the risk category. For example, the table illustrates that about 1.21 percent of trucks observed during the field study had an OOS rate in the 76 to 99 range compared to roughly 25 percent of the kicked out vehicles. The state OOS rate for this risk category is 29.9 percent. Thus, the expected number of OOS orders per 100 random inspections of trucks having an OOS rate in the 76 to 99 range would be 0.36 (0.0121*29.9). Using the Kentucky OOS Rate Algorithm, the expected number of OOS orders per 100 inspections is 7.46 (0.2496*29.9). Within each inspection selection scenario, the sum of the corresponding numbers over all seven risk categories provides the total number of OOS orders expected per 100 inspections.

Table 6-16. Statewide OOS violation rates by OOS rate risk category for inspections performed January 1, 2005, through September 13, 2007.

OOS Rate Risk Category	Number of Inspections	Number of Inspections with an OOS Violation	OOS Rate (No. per 100 Inspections)
100	2,068	818	39.6
76-99	4,726	1,413	29.9
50-75	15,890	3,786	23.8
25-49	54,464	8,484	15.6
0-24	114,756	9,052	7.9
Insuff Data	26,384	5,072	19.2
Unknown	4,164	1,551	37.2
Total	222,452	30,176	13.6

Table 6-17. Comparisons of expected number of OOS orders per 100 inspections for Laurel County inspection station using OOS rates to define risk categories.

OOS Rate Risk Category	Percentage of Commercial Vehicles		State OOS Rate	No. OOS Orders per 100 Inspections	
	Random Selection(1)	Kicked Out(2)		Random (based on population)	Random (based on kick-outs)
100	0.32	1.61	39.6	0.13	0.64
76-99	1.21	25.00	29.9	0.36	7.48
50-75	3.45	35.48	23.8	0.82	8.44
25-49	21.89	22.58	15.6	3.41	3.52
0-24	62.94	12.90	7.9	4.97	1.02
Insufficient Data	7.80	1.61	19.2	1.50	0.31
Unknown	2.39	0.81	37.2	0.89	0.30
Total Expected OOS Orders per 100 Inspections				**12.08**	**21.71**

(1) Random selection percentages were determined from Carrier's vehicle and driver OOS rates of more than 12,000 vehicles that were observed at the Laurel County northbound inspection site during the field study.
(2) Kick-out rate distribution was derived using the risk distribution of the more than 12,000 vehicles that were observed at the Laurel County northbound inspection site during the field study and the corresponding kick-out rate for each risk category.

Overall, if trucks were selected for inspection at random, one would expect about 12 OOS orders per 100 inspections. Using the Kentucky OOS rate algorithm to select trucks, the number of OOS orders per 100 inspections would be expected to rise to almost 22. This represents an increase of OOS orders per 100 inspections of about 80 percent from the scenario where trucks are randomly selected for inspection from the population of traversing trucks. Moreover, this inspection selection strategy yields 15 percent more OOS orders than the scenario where electronic screening is performed based on ISS scores and allows all low-and medium-risk carriers to bypass. This is to be expected since the Kentucky algorithm focuses solely on OOS rates for screening while ISS scores are comprised of a number of different safety measures.

In summary, the inspection selection efficiency at the Laurel County station is very similar to the efficiency that would be obtained if trucks were selected randomly from the population of traversing trucks. The percent of high-risk trucks selected for inspection under current roadside enforcement measures is slightly higher than the percentage that would be obtained through a purely random selection. However, the number of OOS orders issued under these two scenarios is not significantly different. These results are based on data collected from a site that does not as yet have a fully operational and integrated ISSES system, nor does the system employ a significant amount of inspection selection criteria beyond visual inspection, inspector experience, or inspector judgment.

As Table 6-17 illustrates, inspection efficiency could be significantly improved if the Kentucky OOS rate algorithm were consistently used to identify vehicles for inspection. The use of this algorithm requires two things: 1) every truck that traverses the inspection station needs to be instantly identified (e.g., USDOT number, KYU number, license plate number); and 2) this identifying information needs to be linked to federal or state databases such as the Kentucky Clearinghouse to obtain the necessary historical safety information needed to identify trucks for inspection in real time. A fully operational and integrated ISSES would provide the necessary means for inspectors to use this algorithm to improve inspection selection efficiency. The USDOT and license plate cameras would record the truck identification information while integration with data sources such as SAFER or the Kentucky Clearinghouse would provide inspectors the instantaneous, real-time access to carrier and truck information needed to make better inspection decisions.

6.6 Safety Benefits

Table 6-18 presents a summary of large trucks involved in crashes in 2005[5] both nationally and within Kentucky.

Table 6-18. 2005 crash statistics for Kentucky and nation

	Kentucky	**Nation**
Large Trucks involved in Crashes	2,853	441,000
Fatalities	124	5,212
Injuries	1,858	114,000

Source: FMCSA 2005 Large Truck Crash Facts (Nation) (USDOT 2007b).
Fatality Analysis Reporting System (FARS), MCMIS.

[5] Although more current crash statistics are available, the safety benefits analysis is performed using a baseline year of 2005 because that was the last year for which complete data were available from all of the relevant sources.

The most important benefit expected from the deployment of the ISSES and other CVISN technologies, especially electronic screening and safety information exchange, is a reduction in CMV-related crashes through improved enforcement of the Federal Motor Carrier Safety Regulations (FMCSRs). The principal hypothesis to be tested is that the ISSES and CVISN technologies will help enforcement staff focus inspection resources on high-risk carriers. This will result in more OOS orders for the same number of inspections—thereby removing from service additional trucks and drivers that would have caused crashes because of vehicle defects and driver violations of safety regulations.

6.6.1 Technical Approach

The following sections describe (1) the sources of data obtained from the literature and the field study conducted at the Laurel County station used to estimate the impacts of ISSES and CVISN on roadside safety enforcement, (2) the crash avoidance model used to estimate safety benefits, and (3) various roadside enforcement (RE) scenarios used to illustrate the safety benefits.

Data Sources

Table 6-19 lists some key safety statistics obtained from the published literature. Most of these data are used in the crash avoidance analysis; others are provided for reference. According to FMCSA, 8.5 million large trucks (>10,000 pounds gross vehicle weight) in 2005 traveled approximately 233 billion miles in the U.S. Also in 2005, the last year for which complete statistics are available, 441,000 trucks were involved in crashes, resulting in approximately 114,000 injuries and 5,212 deaths. The corresponding rates per vehicle mile traveled are derived from these values. Other relevant statistics provided in Table 6-19 include the number of national and Kentucky CMV inspections performed in 2005 and the actual percentages of OOS orders issued. In 2003, FMCSA sponsored the National Truck Fleet Safety Survey (TFSS), in which approximately 2,800 trucks were selected at random for inspection in order to estimate the percentages of trucks and drivers that operate with OOS conditions (i.e., violation rates). These estimates differ from the actual OOS rates because inspectors choose vehicles for inspection based on vehicle appearance and apply their knowledge and experience. The estimated OOS rates reported by the TFSS were 28 percent for vehicles and 5 percent for drivers (FMCSA 2006b).

In order to determine the impact of removing OOS violators from the roadway on the number of crashes, it is necessary to estimate certain probabilities associated with crash causation. One important component to the statistical crash reduction model is being able to estimate the relative risk of driver and vehicle OOS violations in truck crashes. Specifically, we would like to know the probability that an OOS condition exists on a truck given a crash has occurred involving that truck. Before the FMCSA-sponsored Large Truck Crash Causation Study (LTCCS), there were not reliable estimates of this probability for either vehicle or driver OOS violations as there had not been sufficient data to support calculation of reliable estimates. By focusing on the pre-crash condition of the truck, the LTCCS provides the right type of data for this analysis. The LTCCS data was used to calculate various probabilities that were used as inputs to the crash avoidance model (USDOT 2006a). These data are discussed more fully in the next section along with the explanation of the crash avoidance model.

Table 6-19. Relevant national safety and safety enforcement statistics on large trucks.

Statistic Description	Value	Source [1]
Number of large trucks	8.5 million	Large Truck Crash Facts 2005 (USDOT 2007b)
Large truck annual vehicle miles traveled (VMT)	233 billion	Large Truck Crash Facts 2005 (USDOT 2007b)
Large trucks involved in crashes (2005) Injuries from large truck crashes (2005) Fatalities from large truck crashes (2005)	441,000 114,000 5,212	Large Truck Crash Facts 2005 (USDOT 2007b)
Large trucks involved in property damage-only crashes Large trucks involved in injury-only crashes Large trucks involved in fatal crashes	354,000 82,000 4,932	Large Truck Crash Facts 2005 (USDOT 2007b)
Large truck crash rate (truck crashes/100 million VMT) = 441,000 truck crashes/233 billion VMT	189.3	Derived
Commercial vehicle (non-bus) vehicle inspections performed (2005) Commercial vehicle (non-bus) driver inspections (2005) Total CV (non-bus) inspections (driver or vehicle) (2005) Kentucky annual commercial vehicle (non-bus) vehicle inspections performed (2005) Kentucky annual commercial vehicle (non-bus) driver inspections performed (2005) Kentucky annual commercial vehicle (non-bus) (driver or vehicle) inspections performed (2005)	1,949,375 2,669,679 2,708,856 44,142 86,028 86,077	Annual Summary of Roadside Inspections – NAFTA Safety Stats (A&I website) Kentucky Historical Inspection Data
Percent of vehicles placed OOS (2005) Percent of drivers placed OOS (2005) Kentucky percent of vehicles placed OOS (2005-Sept 2007) Kentucky percent of drivers placed OOS (2005 – Sept 2007) Kentucky percent of vehicles or drivers placed OOS (2005 – Sept 2007)	24.0% 7.0% 9.5% 4.7% 13.6%	Annual Summary of Roadside Inspections – NAFTA Safety Stats (A&I website) Kentucky Inspection Data (2005 – Sept 2007)
Percent of VMT with vehicle OOS conditions (2003) Percent of VMT with driver OOS conditions (2003) Percent of inspections that found at least one OOS vehicle violation given a OOS driver violation was found Percent of VMT with brake-related OOS conditions	28% 5% 49% 14%	2003 National Truck Fleet Safety Survey (TFSS) (USDOT 2006b) 1996 National Survey (Star 1997)
Percent of large CMV crashes with vehicle OOS condition present	32.4%	Derived from LTCCS
Percent of large CMV crashes with driver OOS condition present	17.2%	Derived from LTCCS

1 Full reference citations are presented in Section 9.

While these data provide much of the necessary information needed to estimate safety benefits, additional data from the inspection efficiency field study conducted at the Laurel County inspection station were needed to supplement the data in Table 6-19. Specifically, information on the rate at which OOS orders were issued at the Laurel County station were used as well as the calculated increase in the OOS order rate under different roadside enforcement scenarios.

Crash Avoidance Model

Ultimately, safety benefits will be realized only to the extent that targeted inspections and improved compliance translate into reductions in numbers of crashes. The premise of targeted inspections is that, for the same number of inspections performed, additional drivers and vehicles operating with OOS conditions will be removed from the roadway. Furthermore, all of the conditions leading to the OOS order will be fixed and "stay fixed" for a period of time after the inspection. Therefore, crashes that would have occurred during this period are prevented because the OOS conditions that would have caused the crashes were eliminated. The safety benefit of ISSES and CVISN technologies is determined by comparing the number of crashes avoided under a baseline scenario (i.e., with pre-ISSES or CVISN roadside enforcement strategies and technology) with the number of crashes avoided under a number of deployment scenarios involving the ISSES and CVISN. It is assumed under each scenario that the corresponding number of injuries and fatalities avoided are proportional to the number of crashes avoided.

The basic principle of the crash avoidance model, as well as certain assumptions about how roadside enforcement affects crash rates, were motivated by research on the Safe-Miles model developed for FMCSA to estimate the benefits of MCSAP, the Motor Carrier Safety Assistance Program (VNTSC 1999). Although the model used in the Kentucky safety benefits analysis is different from the one used in Safe-Miles, certain model parameters such as the number of "safe miles" a truck travels following an OOS order, are used in this analysis. The approach to safety benefits estimation in the Kentucky evaluation was adapted from the approach documented in Chapter 5 of the CVISN Model Deployment Initiative (MDI) Evaluation (USDOT 2002).

In simplest terms, the number of crashes avoided can be written as

$$\#\,Crashes\ Avoided = \#\,inspections * P(V\,|\,inspection) * [P(C\,|\,V) - P(C\,|\,\overline{V})] \qquad (1)$$

where

- $P(V|inspection)$ is the probability that a truck has an OOS violation given that it was inspected
- $P(C|V)$ is the probability of a crash given that a vehicle has an OOS violation
- $P(C\,|\,\overline{V})$ is the probability of a crash given that a vehicle does not have an OOS violation.

While the number of inspections and the probability of a violation given an inspection are easily obtained, the probability of a crash given that a vehicle has an OOS condition as well as the probability of a crash given that a vehicle does not have an OOS condition are more complicated. Using Bayes Theorem, we rewrite $P(C|V)$ and $P(C\,|\,\overline{V})$ as

$$P(C \mid V) = \frac{P(V \mid C) * P(C)}{P(V)} \quad (2)$$

$$P(C \mid \overline{V}) = \frac{P(\overline{V} \mid C) * P(C)}{P(\overline{V})} \quad (3)$$

where

- $P(V|C)$ is the probability that a vehicle has an OOS violation given it is in a crash
- $P(C)$ is the probability of a crash
- $P(V)$ is the probability that a vehicle has an OOS condition
- $P(\overline{V} \mid C)$ is the probability that a vehicle does not have an OOS violation given it is in a crash
- $P(\overline{V})$ is the probability that a vehicle does not have an OOS condition.

Substituting the new expressions for $P(C|V)$ and $P(C \mid \overline{V})$ presented in Equations (2) and (3) into Equation (1) and performing some algebraic manipulation yields the following model for crashes avoided:

$$\#\,Crashes\ Avoided = \frac{\#\,inspections * P(V \mid inspection) * P(C)}{P(V)} * \frac{P(V \mid C) - P(V)}{1 - P(V)} \quad (4)$$

In this analysis, we are only concerned with crashes that are avoided because they would have been caused by a vehicle defect or driver violation that resulted in an OOS order. Also, it is generally assumed that the probability of a crash is proportional to the number of vehicle miles traveled (VMT). Therefore, the probability of a crash (among vehicles that would have been operating with defects or driver violations) is estimated by the national crash rate for large trucks (denoted by λ) multiplied by the number of safe miles (SM) traveled as a result of "fixing" an OOS condition. This is the approach used in the Safe-Miles program. The values of SM used in the Safe-Miles program are 15,000 miles for vehicle OOS orders and 10,000 miles for driver OOS orders.

Thus, the final model for crashes avoided is the following:

$$\#\,Crashes\ Avoided = \frac{\#\,inspections * P(V \mid inspection) * SM * \lambda}{P(V)} * \frac{P(V \mid C) - P(V)}{1 - P(V)} \quad (5)$$

Equation (5) is used to estimate the safety benefits associated with various ISSES and CVISN deployment scenarios presented in the next section. The national crash rate for trucks, λ, is 441,000 truck crashes divided by 233 billion VMT, or 1.89 crashes per million miles traveled.

Additional data needed for this model include $P(V|inspection)$, the probability of an OOS violation given the truck was inspected, $P(V)$, the probability that a vehicle has an OOS violation, and $P(V|C)$, the probability that a vehicle has an OOS violation given it is in a crash.

These values depend on the particular roadside deployment scenario or enforcement strategy under consideration. The LTCCS was used to estimate *P(V|C)* for various OOS violations and groups of violations. For example, given a crash, the probability of a specific OOS violation (such as brakes) or a group of violations (e.g., vehicle or driver) present on the truck was estimated from the LTCCS data.

6.6.2 Deployment Scenarios

Truck traffic at most inspection sites is very heavy, and inspectors cannot inspect every CMV that passes by. Thus, there needs to be a sound methodology for narrowing down the pool of trucks from which inspectors have to choose. Seven overall scenarios are presented in this section, a few of which have been divided into sub-scenarios. The seven deployment scenarios present different methods for selecting vehicles for inspection with the goal being to select trucks that yield the most OOS orders. Using the crash avoidance model given in Equation (5), these scenarios illustrate the estimated safety benefits of the ISSES and other CVISN technologies.

In the CMV law enforcement community, the term "electronic screening" signifies a transponder-based mainline preclearance system, such as NORPASS, HELP/PrePass, Oregon Green Light, or equivalent. Such systems provide roadside enforcement personnel the ability to detect and identify and (optionally) weigh CMVs at mainline speeds. For purposes of this report, Scenarios RE-3 through RE-6 expand the definition of "electronic screening" to include other means of achieving a similar goal, namely to use computers and telecommunication technology to identify and prescreen vehicles in real time. In Scenarios RE-3 through RE-6, ISSES or an equivalent system is used for identifying trucks moving slowly through a weigh station. The basic function is the same as transponder-based preclearance, the only difference being the truck's speed at the point of decision (red light, pull-in, green-light, bypass). In these four scenarios, it is assumed that some trucks carry transponder tags and some do not. Furthermore, it is assumed that all trucks approaching the station are subject to electronic or computer-based, real-time prescreening—at high or low speeds—as an aid to the inspector's decision process. These four scenarios also diverge from the usual definition of "electronic screening" in that, for purposes of modeling and analysis, they introduce screening decision criteria that are different from the criteria believed to be used in the prevailing mainline e-screening programs or partnerships (NORPASS, PrePass, and Oregon Green Light).

Table 6-20 provides a high-level summary of the seven scenarios presented in this section. A more thorough description of each scenario follows the table.

Table 6-20. High-level overview of roadside enforcement scenarios.

Scenario Number	Screening Criteria Used in Scenario						
	Random Only	Inspector Experience and Judgment	Electronic Screening with Snapshots	KY OOS Rate Algorithm	Vehicle and Driver OOS Rates Using Threshold	Brake and Driver OOS Rates	Infrared Images and Driver OOS Rate
RE-0	X						
RE-1		X					
RE-2		X	X				
RE-3		X	X	X			
RE-4		X	X		X		
RE-5		X	X			X	
RE-6		X	X				X

RE-0: Random Selection. Enforcement officers (inspectors) select CMVs for inspection in a random manner without using personal experience, judgment, or any ISSES or CVISN technologies. This is not one of the roadside enforcement strategies being considered, nor is it a realistic strategy to employ. However, the calculation of safety benefits under this scenario is useful for determining the contribution of the inspectors' knowledge and experience during the vehicle selection process.

RE-1: Baseline—Pre-ISSES/CVISN. Inspectors select CMVs for inspection using personal experience and judgment, but without the aid of ISSES or most CVISN technologies. Electronic screening is assumed to be used at its current level as of June 2007. This baseline scenario is analyzed twice. First, safety benefits are calculated based on Kentucky vehicle and driver OOS rates, which are significantly lower than the national average. Then, the analysis is performed assuming that Kentucky's vehicle and driver OOS rates were on par with national estimates – referred to as RE-1a.

RE-2: Mainline Electronic Screening based on ISS Score. State deploys electronic screening with safety snapshots at all major inspection sites. Motor carriers that are classified as low- and medium-risk based on ISS scores (comprising approximately 60 percent of trucks on the road) enroll in the electronic screening program, are equipped with transponders, and are allowed to bypass inspection sites. Inspectors use current practices to select vehicles for inspections from the remaining 40 percent of trucks in the high-risk and insufficient data categories.

RE-3: Electronic Screening based on Kentucky OOS Rate Inspection Selection Algorithm. State utilizes Kentucky OOS rate inspection selection algorithm at all inspection sites that utilize electronic screening. Every vehicle that enters the inspection station is identified accurately by the ISSES' ALPR and USDOT readers. Safety information for each carrier is obtained from the Kentucky Clearinghouse. Based on the safety information, the algorithm identifies trucks for inspection as described in Section 6.2. Inspectors select vehicles for inspection from this pool of identified trucks, while non-identified trucks continue to the mainline. Trucks with transponders are subject to the same algorithm already built into NORPASS.

RE-4: Electronic Screening based on high vehicle and/or driver OOS rates. State utilizes the ISSES and/or electronic screening at all major inspection sites. This scenario is similar to RE-3 in that each truck is screened via the ISSES based on the vehicle and driver OOS rate of the carrier. However, RE-4 differs in that a threshold OOS rate is established for both vehicles and drivers such that all trucks with OOS rates exceeding the corresponding thresholds are brought into the inspection station for inspection, while all others are allowed to bypass inspection sites. The threshold rates are chosen such that only trucks with the highest OOS rates are candidates for inspection. The threshold values can vary depending on both the truck traffic and the rate at which inspections can be performed at the site. As part of RE-4, three specific threshold values are considered.

RE-5: Electronic screening based on high driver OOS or brake violation rates. State utilizes the ISSES and/or electronic screening at all major inspection sites. Each truck is screened via the ISSES based on its OOS or violation rate for violations that have a high relative risk for crash. In this scenario, vehicles are screened based on their brake violation and overall driver OOS rates as they appear in SAFER. A distinction is made here between violation and OOS rates. SAFER contains a <u>*violation*</u> rate for brakes but not a brake <u>*OOS*</u> rate. Thus, violation rates are used as a safety index for brake issues, while the driver OOS rate is used to screen for driver issues. Both brakes and driver OOS violations have been found to have a high relative risk for crashes. This scenario differs from RE-4 in that vehicles are screened on their brake violation rate as opposed to their overall vehicle violation rate in an attempt to catch those vehicles that have a violation that has a higher relative risk for crash. Similar to RE-4, all trucks with violation rates exceeding the threshold are candidates for inspection, while all others are allowed to bypass inspection sites. Moreover, the threshold rates are chosen such that only trucks with the highest rates are selected for inspection and the thresholds can vary depending on the amount of inspection personnel available at a given station. As part of RE-5, three specific threshold values are considered.

RE-6: Electronic screening based on infrared screening and high driver OOS violation rate. State utilizes the ISSES at all major inspection sites. Each truck is screened via two criteria: the thermal (IR) imaging system on the ISSES and the driver OOS rate of the carrier. In this scenario, vehicles are screened based on the presence of a brake violation through the IR image produced by the ISSES and the driver OOS rate as it appears in SAFER. This scenario is similar to RE-5 in that both brake and driver OOS violations are used as screening criteria. RE-6 differs from RE-5 in that vehicles are screened for brake violations via IR imaging as opposed to brake violation rates obtained from SAFER. All trucks with a potential brake violation as detected from the IR image or trucks with driver OOS rates exceeding various thresholds are candidates for inspection, while all others are allowed to bypass inspection sites.

RE-0 is the most basic selection process of selecting vehicles randomly and is presented mainly to assess the contribution of the inspectors' knowledge and experience during the vehicle selection process, which is represented in the baseline scenario RE-1. The remaining five scenarios all make use of progressively more involved selection criteria. Electronic screening is employed in RE-2 to eliminate all low- and medium-risk carriers from selection consideration. Although this scenario helps improve inspection selection efficiency by allowing inspectors to focus only on high-risk vehicles or those with insufficient data, there are still too many vehicles remaining in these categories for roadside enforcement officials to inspect them all. As a result, scenarios RE-3 through RE-6 provide various methods to further narrow down the number of vehicles that inspectors have to choose from. RE-3 is based on the Kentucky OOS rate inspection selection algorithm, which selects vehicles for inspection at different rates depending on their OOS rates. RE-4 and RE-5 take a slightly different approach in selecting only those vehicles with the highest probability of having particular kinds of OOS violations as measured by some safety index. RE-6 examines the benefits when IR imaging is used to screen for brake violations.

The calculation of safety benefits for scenarios RE-0 through RE-3 are presented in Section 6.6.2. They are straightforward, based on Equation (5), specific inputs contained in Table 6-19, as well as results from the inspection efficiency analysis of the Laurel County site. Scenarios RE-4, RE-5, and RE-6 are more complicated and hence more information is provided in this section in advance of the results presentation in Section 6.6.2.

RE-4 and RE-5: Methodology for Selecting Vehicles for Inspection Based on Safety Index

The inspection selection strategy described in this section is based on the notion of selecting trucks for inspection based on the value of some safety index associated with the carrier. Any truck with a safety index above a given threshold would be pulled in for inspection while all other trucks would be allowed to bypass the station. The two main issues considered in this section are: 1) Determining the most appropriate safety index; and 2) Determining the threshold value for this index that should be used to decide which vehicles to inspect.

Choice of Safety Index. From an inspection efficiency standpoint, the best choice for a safety index is one that correlates well with the probability of finding an OOS violation on a vehicle chosen for inspection. Further, from a crash prevention standpoint, the OOS violations found should be for violations that pose a high relative risk for crashes. Both viewpoints were used in choosing safety indices. The first set of indices considered in this analysis was the carrier's vehicle and driver OOS rate. Results from the inspection efficiency analysis in Section 6.5 suggest that screening vehicles using carrier OOS rates as opposed to ISS may provide a larger percentage of trucks being placed OOS. As a result, scenario RE-4 focuses on using the carrier's driver and vehicle OOS rate to select vehicles for inspection.

Finding OOS violations during an inspection is crucial to keeping unsafe trucks off the road so that crashes can be prevented. Moreover, a larger number of crashes could be avoided by finding those OOS violations that have a higher relative crash risk. While taking trucks OOS for violations that do not pose a high crash risk serves a benefit, more benefits from a crash reduction and life saving perspective can be realized by focusing on violations related to crash risk. Data from the LTCCS were used to identify those OOS violations that present a high relative crash risk. Every truck involved in a crash within the LTCCS was subject to a full Level I inspection as part of the investigation of each crash. For every truck in the LTCCS that was assigned the critical reason for the crash, inspection reports contained in the LTCCS data were analyzed to record the presence of each type of OOS violation. From this information, the probability of a specific type of OOS violation being present on a truck given that the truck crashed could be calculated by dividing the number of trucks having the violation present by the total number of trucks in a crash. Survey weights associated with the LTCCS were used in these calculations to ensure nationally representative probability estimates.

It is also important to identify OOS violations that occur frequently in the population. A violation that has a high relative risk for crash but that does not appear all that often is not of much use to inspectors because trucks with that violation are too difficult to find. Historical Kentucky inspection data were analyzed to identify the most common OOS violations. For each inspection record, the presence of specific OOS violations was recorded. The probability of a truck having each specific OOS violation was calculated by dividing the number of inspections where the OOS violation was present divided by the total number of inspections.

Table 6-21 presents the probability calculations for both the crash data and the historical Kentucky inspection data for vehicle and driver OOS violations overall as well as six specific types of OOS violations. These six violations were chosen as they were the most frequently occurring violations in both the LTCCS crash data as well as the historical state inspections. The second column presents the probability that a truck has a specific violation given the truck was in a crash. The third column contains the probability that a truck has a specific violation in the population based on the Kentucky historical inspection reports. The assumption here is that past inspections have been random. Now, past inspections are not truly random. However, inspection reports provide the best means of knowing the incidence of OOS violations in the population. Moreover, Table 6-12 showed that the number of OOS orders issued under current Kentucky inspection selection practices was essentially the same if trucks were selected randomly. Thus, the assumption is appropriate for this analysis.

Table 6-21. Probabilities of certain OOS violations occurring among vehicles involved in a crash and among the general population of trucks.

OOS Violation Categories	Probability of Violation Occurring	
	In a Crash (LTCCS)	**In KY (Past Inspection Data)**
All Vehicle	**32.4%**	**9.5%**
Brake Violation	21.7%	4.4%
Lighting	3.6%	2.3%
Tires	2.9%	1.5%
Load Securement	4.0%	1.5%
All Driver	**17.2%**	**4.7%**
Log Book	12.3%	2.3%
Hours of Service	1.6%	1.3%
All Violations	**38.72%**	**13.6%**

An examination of vehicle violations shows that roughly 22 percent of trucks involved in crashes have a brake violation as compared to only 4 percent in the Kentucky truck population. Lighting, tires, and load securement all occur slightly more frequently in crashes than in the general Kentucky truck traffic population. However, the differences are not as large as brake violations. Driver OOS violations in general had a high relative risk for crash. About 17 percent of trucks involved in crashes have some sort of driver OOS violation as compared to about 5 percent in the Kentucky truck population. Also, analysis of crash data from the LTCCS found that driver related factors were important reasons leading to causes of crashes in a large majority of the cases (USDOT 2006a). As a result, vehicles are selected for inspection in scenario RE-5 based on their likelihood of having a brake violation or general driver OOS violation. Although violations involving the log book have the highest relative risk among driver OOS violations, it was decided to use the more general driver OOS violation rate as opposed to the log book violation rate as an index since the relative crash risks for both measures were similar and since this would better reflect the LTCCS findings regarding general driver-related factors and crash risk. The carrier's driver OOS rates were obtained from the Kentucky Clearinghouse.

The SAFER carrier table does not include a brake OOS rate for each carrier. Rather, a brake violation rate can be calculated from information contained in the table. The brake violation rate is defined as the number of brake violations in the past 30 months divided by the number of vehicle inspections in the past 30 months. Not all brake violations result in an OOS order. Thus, the brake violation rate for each carrier is associated with a probability of a brake OOS rate in the next section. In summary, the brake violation rate and driver OOS violation rate are used as indices in selecting vehicles for inspection in RE-5. The driver OOS violation rate is also used as an index in scenario RE-6, described in greater detail later in this section.

Choice of Index Threshold for Pulling Vehicles in for Inspection. For each safety index used in scenarios RE-4 and RE-5, the next step was to determine a threshold by which any vehicle with a safety index at or above the threshold are brought in for inspection while all vehicles with a safety index below the threshold are allowed to continue on the mainline. The value of the threshold can neither be so high that very few trucks on the road are brought in for inspection nor can it be too low, which would result in more trucks being flagged for inspection than roadside enforcement resources can handle. Moreover, the appropriate value for the index threshold should be dependent on the number of inspectors available at a given inspection site. Consequently, scenarios RE-4 and RE-5 consider three different threshold values for each index, corresponding to the number of trucks that an inspection station could realistically inspect in a given day given its roadside enforcement resources.

Historical Kentucky state inspections were used to determine the specific threshold values for a given index. The various indices (driver OOS rate, vehicle OOS rate, and brake violation rate) for each truck inspected from January 2005 through September 2007 were recorded. For each index, the values of the index were sorted from low to high and the resulting distribution of values was examined so that the 95th, 90th, and 75th percentiles of the distribution were obtained. The 95th percentile of the index distribution is the value where 5% of the trucks meet or exceed that value of the threshold. Since the index values are sorted from low to high, this index value represents the cutoff point for the 5% of trucks with the highest index value. For example, an inspection station with truck traffic of 2,000 trucks per day during normal inspection hours would expect to have about 100 trucks available for inspection if the 95th percentile of the index distribution was used. Using the 90th percentile would result in about 200 trucks available for inspection.

To use Equation (5) to estimate the number of crashes that would be prevented under these scenarios, it is essential to know the probability of a violation given that an inspection occurred for vehicles at or above the index threshold, [i.e., P(V|inspection)]. In order to obtain this probability, it is necessary to understand the relationship between the safety index of the truck and the presence of the specific OOS violation on the truck given an inspection. Each safety index relates to a specific type of OOS order. For instance, a carrier's brake violation rate should be a good predictor that a truck belonging to that carrier has an OOS brake violation. Similarly a carrier's vehicle and driver OOS rate was used to predict the presence of a vehicle or driver OOS violation, respectively.

To gain a better understanding of the relationship between each index and its corresponding OOS violation, a probit regression model was used to model the probability of an inspection having a specific OOS violation against the safety index. Probit analysis is a standard statistical approach to modeling a probability as a function of some continuous explanatory variable. The probit model has the form:

$$probit(p_i) = \phi^{-1}(p_i) = \beta_0 + \beta_1(x_i) \quad (6)$$

where

i =	1, 2, 3, … corresponding to the total number of distinct values of the index
p_i	is the ratio of the number of historical Kentucky inspections that resulted in a specific OOS violation to the number of inspections within each index value i
ϕ^{-1}	is the inverse of the standard Gaussian distribution function
β_0	is the intercept parameter of the probit regression line
β_1	is the slope parameter of the probit regression line
x_i	is the safety index.

Figure 6-6 shows the general form of a probit regression relationship. Given a threshold value x_i, the corresponding probability of an OOS violation at that threshold value can be calculated from the probit regression model.

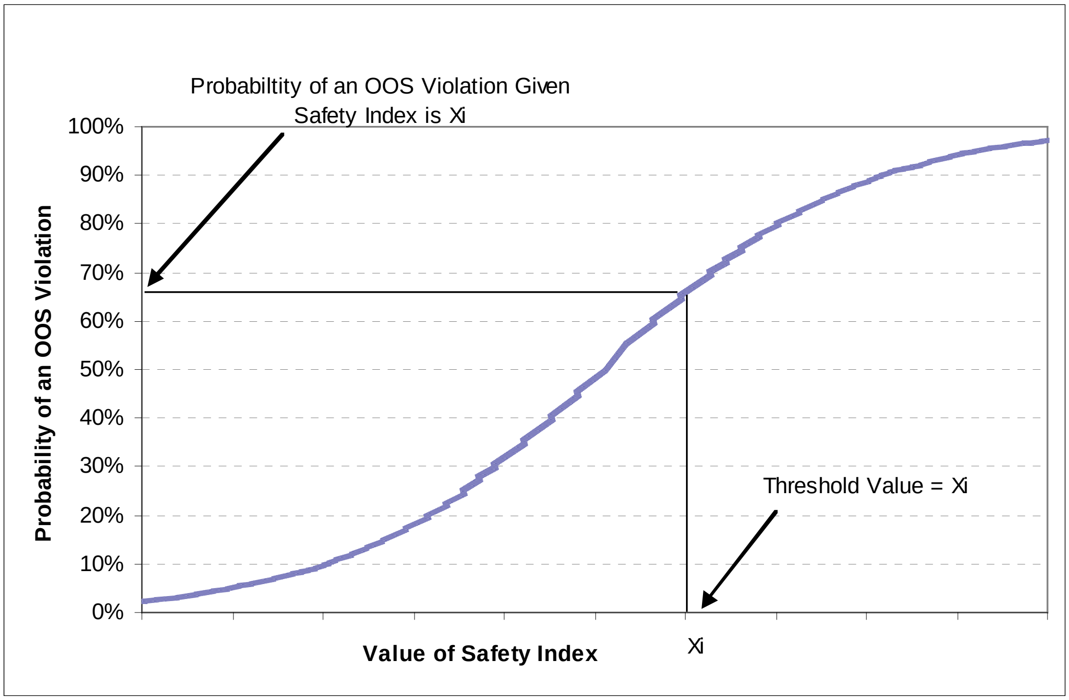

Figure 6-6. Probit relationship between safety index and the probability of an OOS violation.

Historical Kentucky inspection data was modeled separately for each of the three indices using the probit model in Equation (6). The probit model for each index was then used to estimate the probability of a corresponding OOS violation given an inspection for each of the three threshold safety index values corresponding to the top 5 percent, 10 percent, or 25 percent of the distribution of the safety index. These probabilities were then used in Equation (5) to capture safety benefits for scenarios RE-4 and RE-5.

RE-6: Methodology for Selecting Vehicles based on Infrared Imaging

Roadside scenario RE-6 is similar to RE-5 in that it focuses on identifying vehicles that have brake and/or driver OOS violations (violations with high relative crash risk). As in RE-5, the driver OOS rate associated with the truck's carrier is used to identify those trucks with a high probability of a driver OOS violation. Threshold values for the driver OOS rate are again used to select an appropriate number of vehicles to bring into the station for inspection. Where RE-6 differs from RE-5 is the manner in which trucks are selected for inspection based on their chances of having a brake violation. Brake problems are difficult to detect with the human eye alone. As a result, alternative techniques need to be adopted to identify trucks with faulty or inoperative brakes. Scenario RE-5 utilizes historical brake safety information on each carrier to identify trucks that were the most likely to have brake problems. There are limitations to this approach. For example, the presence of a high carrier brake violation rate does not guarantee that the specific truck operated by that carrier and now entering the station has a brake violation, just that this truck is more likely to have such a condition, based on the carrier's history.

Thermal (IR) imaging systems provide inspectors with a tool to more accurately identify trucks with brake violations. This coupled with the fact that there is a high relative risk of a crash associated with brake violations, makes the prescreening of vehicles using IR technology a powerful tool that may provide significant benefits in crash reduction. Unfortunately, because of the lack of IR video imaging data from the field study at Laurel County, the benefit of the ISSES thermal imaging system in terms of inspection efficiency and safety benefits cannot be fully assessed for this particular site. However, prior research was conducted in 2000 for FMCSA on evaluating a similar, portable IR imaging and video package, IRISystem (USDOT 2000). Results from the 2000 study are used to estimate the number of crashes, injuries, and fatalities that could be avoided if IR technology were used to screen vehicles.

The objective of the FMCSA 2000 study was to evaluate the effectiveness of the IRISystem for use as a screening tool on CMVs for detecting bad brakes and unsafe vehicles due to braking. A high-level summary of the research and findings, including the increase in OOS rates due to screening vehicles with IR technology, is presented in Appendix D to provide an understanding of the quantifiable benefits that can be realized through use of this technology. However, the key result from this analysis that pertains to scenario RE-6 is that the percentage of vehicles placed OOS due to brake violations after IRISystem screening was 47.2%. This figure is used as an estimate for the probability of a brake violation given that an inspection occurred, [P(V|Inspection)], in Equation (5).

Although they are manufactured by the same company, the IRISystem and ISSES are two different systems. Furthermore, inspection practices and OOS rates vary across states with Kentucky's OOS rate being much lower as described earlier. As such, the estimates of the number of crashes, injuries, and fatalities generated from this exercise provide a general idea of the safety benefits that could be realized using IR technology to screen trucks for brake and tire-related violations and not necessarily the ISSES itself.

6.6.3 Results

In this section the calculations of the numbers of truck crashes, injuries, and fatalities avoided under each of the roadside enforcement scenarios described in Section 6.6.1 are presented. These calculations, based on Equation (5), utilize inputs contained in Table 6-19 as well as specific assumptions defined by the scenarios. Results from special studies are presented as needed to justify some of the parameter estimates used in these models. The safety benefits are expressed in terms of avoided (reduced numbers of) crashes, injuries, and fatalities per year per state, for a state similar to Kentucky in terms of the numbers of commercial vehicle inspections performed per year.

Scenario RE-0: Random Selection

In 2005, the most recent year for which complete data across all sources are available, Kentucky conducted 44,142 vehicle inspections and 86,028 driver inspections. Under random inspections, the proportions of inspected vehicles and drivers that are given OOS orders are equal to corresponding Federal Motor Carrier Safety Regulation (FMCSR) violation rates. Thus, by applying the results from the National Truck Fleet Safety Survey, 28 percent of the 44,142 vehicle inspections would result in vehicle OOS orders (USDOT 2006b). From Equation (5), the number of crashes that are avoided due to vehicle OOS orders when random inspections are performed is equal to

$$\frac{44{,}142 * (0.28) * 15{,}000 * (1.89/1{,}000{,}000)}{0.28} * \frac{0.3238 - 0.28}{(1 - 0.28)} = 76 \qquad (7)$$

Similarly, 5 percent of the 86,028 driver inspections would have resulted in driver OOS order leading to

$$\frac{86{,}028 * (0.05) * 10{,}000 * (1.89/1{,}000{,}000)}{0.05} * \frac{0.1724 - 0.05}{(1 - 0.05)} = 209 \qquad (8)$$

crashes avoided. Note that these two numbers cannot be added to get the total number of crashes avoided because there is some overlap in vehicle and driver OOS orders. To get an estimate of the total number of crashes avoided, the TFSS found that 49 percent of the inspections that found at least one driver OOS violation also found at least one vehicle OOS violation (FMCSA 2006b). Because the impact of vehicle OOS orders is greater than the impact of driver OOS orders, the number of crashes avoided combined over vehicle and driver OOS orders can be determined by adding (a) the number of crashes avoided due to vehicle OOS orders and (b) 51 percent of the crashes avoided due to driver OOS orders. Thus, the total number of crashes avoided would be 76 + (0.51*209) = 183.

Using the injury and fatality data in Table 6-19, there are on average 5,212/441,000 = 0.012 fatalities per crash and 114,000/441,000 = 0.259 injuries per crash. Therefore, if 183 crashes were avoided, it would be expected that 183*0.259 = 47 injuries would be avoided and 183*0.012 = 2 fatalities would be avoided. This relationship between the numbers of crashes, injuries, and fatalities is assumed to hold for all scenarios.

Scenario RE-1: Baseline—Pre-ISSES/CVISN Using Kentucky OOS Rates

The calculation of crashes avoided in the baseline scenario is very similar to the calculation with random selection of vehicles, except instead of applying the results from the TFSS, the actual numbers of OOS orders for vehicles and drivers in Kentucky are used. From January 2005 through mid-September, 2007, 9.5 percent of the vehicle inspections in Kentucky resulted in a vehicle OOS order, and 4.7 percent of the driver inspections in Kentucky resulted in a driver OOS order. In this scenario (and all that follow), the probability of a vehicle and driver OOS violation in a crash as well as in the general population are based on national estimates. This is because: (1) crash probabilities were not available on a state basis from the LTCCS; and (2) reliable estimates of the probability of a violation in the truck population were not possible from Kentucky data due to their significantly lower OOS rates.

Following the approach used with random selection, 9.5 percent of the 44,142 inspections would result in vehicle OOS orders. From Equation (5), the predicted number of crashes avoided due to vehicle OOS orders is equal to

$$\frac{44{,}142 * (0.095) * 15{,}000 * (1.89/1{,}000{,}000)}{0.28} * \frac{0.3238 - 0.28}{(1 - 0.28)} = 26 \quad (9)$$

Similarly, 4.7 percent of 86,028 driver inspections would result in a driver OOS order leading to

$$\frac{86{,}028 * (0.047) * 10{,}000 * (1.89/1{,}000{,}000)}{0.05} * \frac{0.1724 - 0.05}{(1 - 0.05)} = 197 \quad (10)$$

crashes avoided.

Applying the 51 percent adjustment factor used under random selection, the estimated number of crashes avoided is 26 + 0.51*197 = 126. The corresponding numbers of injuries and fatalities avoided are 33 and 2, respectively.

Note that the number of crashes avoided due to OOS orders under this scenario is less than the number avoided under the random selection scenario (183 versus 126). This is because the Kentucky vehicle OOS rate used in the calculation (9.5 percent) is significantly lower than the violation rate under the random selection scenario (28 percent) estimated in the TFSS. Overall, Figure 6-7 illustrates that Kentucky's vehicle and driver OOS rates are both lower than their respective national averages as well as being lower than the rates for each of the three states where similar field studies were conducted as part of the National Evaluation of the CVISN Deployment Program. Although there are differences in both vehicle and driver OOS rates, the difference in vehicle OOS rates is more pronounced. The Kentucky driver OOS rate of 4.7 percent is only slightly lower than both the 5 percent rate from the TFSS and the 7 percent rate estimated from the 2005 NAFTA summary (USDOT 2005b). All state OOS rates were calculated based on data received on past inspections from the respective states. A cross-reference of these rates was performed with the annual OOS rates published by NAFTA on the FMCSA's A&I website to ensure accuracy. OOS rates from this website were consistent with rates calculated from the state past inspection data.

This lower vehicle OOS rate for Kentucky could be due to many factors. First, trucks traveling in Kentucky may be safer compared to those traveling in other states due to Kentucky laws and regulations. However, Figure 6-5 presented in Section 6.4.2 illustrated that—based on data collected from the Kentucky observational field study and SAFER—Kentucky's safety risk, as defined by ISS score, was similar to that of the national truck population.

A second explanation could be that there may be different inspection selection priorities or differences in truck traffic during scheduled versus randomly selected times. As noted above, a representative of the KTC acknowledged that Kentucky's OOS rates are below the national average and that FMCSA and the Commissioner of KVE have identified this as a priority. Another representative of the KTC commented that state budgets and manpower levels currently do not allow for an office support assistant at each inspection station to prescreen vehicles using the Kentucky OOS rate inspection selection algorithm. Anecdotally, Kentucky has performed internal studies that showed a significant increase in the rate of OOS orders issued when office support assistants prescreen vehicles as opposed to situations where inspectors select trucks on their own.

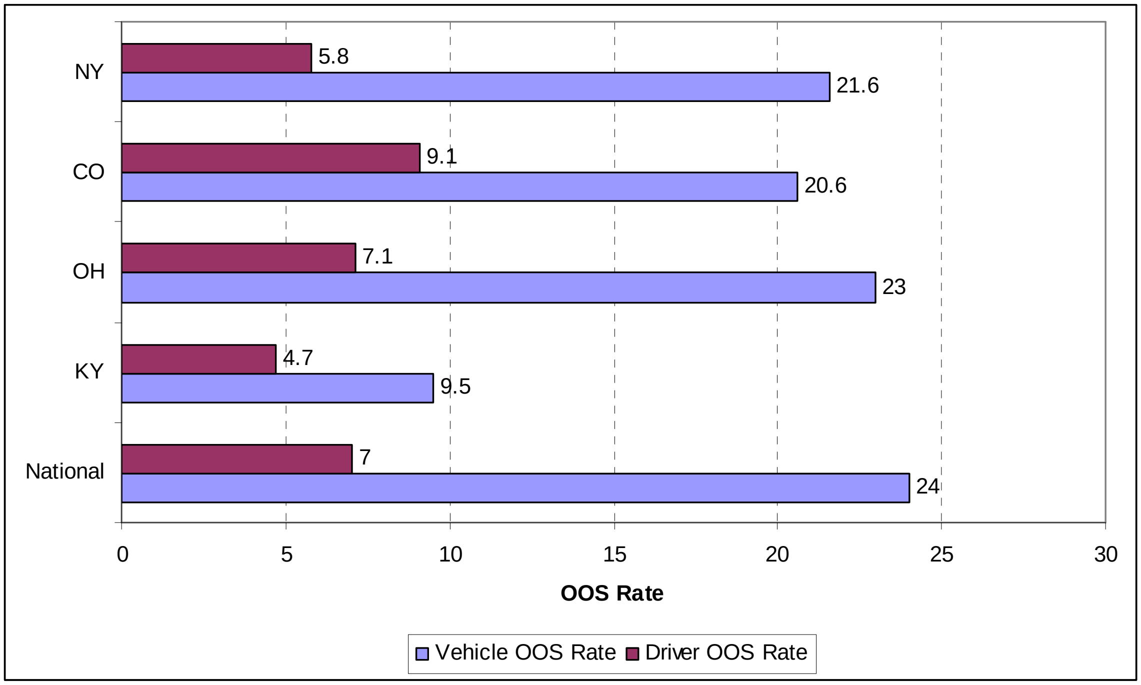

Figure 6-7. Vehicle and driver OOS rates for the nation and various states participating in Kentucky CVSA and national CVISN deployment evaluations

Scenario RE-1a examines the number of crashes avoided if Kentucky's vehicle and driver OOS rates were on par with national estimates. It is presented here to illustrate the increase in the number of crashes, injuries, and fatalities avoided if OOS rates in Kentucky were higher. However, for purposes of this crash avoidance analysis, scenario RE-1 (using Kentucky's current OOS rates) serves as the baseline when comparing results across scenarios.

Scenario RE-1a: Pre-ISSES/CVISN Using National OOS Rates

The calculation of crashes avoided in this scenario is very similar to the previous calculation, except that national OOS rates for vehicle and drivers based on actual inspections are used.

Using national OOS estimates from 2005, 24 percent of the 44,142 vehicle inspections would result in OOS orders. From Equation (5), the predicted number of crashes avoided due to vehicle OOS orders is equal to

$$\frac{44{,}142*(0.24)*15{,}000*(1.89/1{,}000{,}000)}{0.28}*\frac{0.3238-0.28}{(1-0.28)}=65 \qquad (11)$$

Similarly, 7 percent of 86,028 driver inspections would result in an OOS order leading to

$$\frac{86{,}028*(0.07)*10{,}000*(1.89/1{,}000{,}000)}{0.05}*\frac{0.1724-0.05}{(1-0.05)}=293 \qquad (12)$$

crashes avoided.

Applying the 51 percent adjustment factor used under random selection, the estimated number of crashes avoided is 65 + 0.51*293 = 214. The corresponding numbers of injuries and fatalities avoided are 55 and 3, respectively.

As expected, the number of crashes, injuries, and fatalities prevented would be larger under this scenario, which brings Kentucky's OOS rates more in line with national averages. Also, the estimated number of crashes avoided under normal (pre-ISSES/CVISN) inspection practices is about 17 percent higher (214 versus 183) than the number that would be avoided under random selection of vehicles.

Scenario RE-2: Mainline Electronic Screening Based on ISS Score

Currently, 32 states use some form of mainline electronic screening as part of their roadside enforcement. However, even in these states, carrier enrollment in electronic screening is not sufficient to demonstrate any significant impacts on the inspection selection process. Therefore, to illustrate what could happen, the impact of using electronic screening was simulated using results from the field study at the Laurel County station. An analysis was performed under the scenario that: (1) Kentucky deploys electronic screening at all major inspection sites; and (2) all of the motor carriers with ISS ratings in the low- or medium-risk categories (representing approximately 60 percent of all trucks) choose to enroll in the electronic screening program.

Under this scenario, enforcement officials could choose to let the low- and medium-risk vehicles bypass the inspection site and focus all of their efforts on inspecting high-risk carriers and carriers with insufficient safety data. It is assumed that current inspection methods involving manual pre-screening (i.e., visual inspection and inspector experience/judgment) are used, as in scenario RE-1, on the 40 percent of trucks that are not allowed to bypass the inspection site. Section 6.5.2 presented an analysis demonstrating that, under this scenario, the number of OOS orders would increase by 50 percent compared to the average number that would be achieved under current inspection practices. It is assumed that the 50-percent increase in OOS orders would apply equally to vehicle OOS orders and driver OOS orders, therefore translating into a 50-percent increase in the number of crashes avoided.

From here, the calculation of the numbers of crashes, injuries, and fatalities avoided under scenario RE-2 is straightforward. With a 50 percent increase in OOS orders, the number of crashes that can be avoided under RE-2 is 1.50 * 126=189. This represents an increase of 63 crashes avoided compared to the baseline scenario. The corresponding number of injuries avoided is 49 (a difference of 16), and the number of deaths avoided is 2 (no change from RE-1).

Scenario RE-3: Electronic Screening based on Kentucky OOS Rate Inspection Selection Algorithm

To illustrate what could happen if the Kentucky OOS Rate Inspection Selection Algorithm were utilized at all Kentucky inspection sites, an analysis was performed under the scenario that: (1) the ISSES is able to accurately identify each truck that traversed the station; (2) the ISSES is linked with the Kentucky Clearinghouse so that the carrier's vehicle and driver OOS rates could be obtained; and (3) the algorithm is applied to identify trucks for possible inspection. In this scenario, those trucks with transponders are subject to the same algorithm already built into NORPASS as it is programmed to function in Kentucky.

Under this scenario, enforcement officials would only be concerned with trucks that were selected for possible inspection while other trucks were allowed to continue back to the mainline. In most cases, the number of trucks identified by the algorithm are too large for all of them to be inspected. As a result, enforcement officials would select vehicles to inspect from this pool of kicked out trucks.

Table 6-17 in Section 6.5.2 presented an analysis demonstrating that, under this scenario, the number of OOS orders would increase by 80 percent compared to the average number that would be achieved under scenario RE-1. It is assumed that the 80-percent increase in OOS orders would apply equally to vehicle OOS orders and driver OOS orders, therefore translating into an 80-percent increase in the number of crashes avoided. With an 80-percent increase in OOS orders, the number of crashes that can be avoided under RE-3 is 1.80 * 126=227. This represents an increase of 101 crashes avoided compared to the baseline scenario. The corresponding number of injuries avoided is 59 (a difference of 26), and the number of deaths avoided is 3 (a difference of 1).

Scenario RE-4: Electronic Screening based on high vehicle and/or driver OOS rates

In this scenario, the state utilizes the ISSES and/or electronic screening to screen all vehicles based on the vehicle and driver OOS rates of the carrier. This scenario is based on the premise that only trucks with the highest OOS rates are candidates for inspection while other vehicles are allowed to continue on the mainline.

Table 6-22 shows the three levels of threshold values for both the vehicle and driver OOS rate safety index. These trucks inspected during this 32.5-month timeframe were used as a proxy for the truck traffic population in Kentucky. The high threshold for the vehicle OOS rate index is 50%. This means that roughly 5% of the truck traffic has a vehicle OOS rate at or above 50%. The high threshold level would be used to pull in only the top 5% of vehicles in situations where a smaller number of inspectors were on duty. If more inspectors are available, a lower threshold can be used to pull more trucks into the station. The medium and low threshold values for the vehicle OOS rate safety index are 38.1% and 25.0%, respectively. The high, medium, and low thresholds for driver OOS rates are 22.2%, 16.7%, and 10.7%, respectively.

Table 6-22. Vehicle and driver OOS rate threshold values calculated from Kentucky inspections from January 2005 through mid-September 2007.

Percent Selected for Inspection	Safety Index Threshold	
	Carrier's Vehicle OOS Rate	Carrier's Driver OOS Rate
5%	50.0%	22.2%
10%	38.1%	16.7%
25%	25.0%	10.7%

To use Equation (5) to estimate the number of crashes that would be prevented, a probit regression model was used to estimate the probability of an OOS violation among vehicles at or above each value of the index threshold. This probability represents the term P(V|Inspection) in Equation (5), namely the probability of finding an OOS violation given the truck was inspected with an index value above the threshold. By plugging the three threshold rates into the equation and solving for *p*, the probability of a violation given an inspection can be calculated for each level of the safety index. These probabilities are provided in Table 6-23 alongside the threshold values.

Table 6-23. Vehicle and driver OOS rate threshold values along with corresponding probabilities of an OOS violation calculated from Kentucky inspections from January 2005 through mid-September 2007.

Percent Selected for Inspection	Carrier Vehicle OOS Rate		Carrier Driver OOS Rate	
	Threshold	P(V|Inspection)	Threshold	P(V|Inspection)
5%	50.0%	0.26	22.2%	0.11
10%	38.1%	0.17	16.7%	0.08
25%	25.0%	0.10	10.7%	0.05

From Equation (5), the number of crashes that are avoided due to vehicle OOS orders when the highest 5 percent of trucks in terms of vehicle OOS rate are brought into the station for inspection is equal to

$$\frac{44{,}142 * (0.26) * 15{,}000 * (1.89/1{,}000{,}000)}{0.28} * \frac{0.3238 - 0.28}{(1 - 0.28)} = 71 \qquad (13)$$

Similarly, 11 percent of the 86,028 driver inspections would result in an OOS order leading to

$$\frac{86{,}028 * (0.11) * 10{,}000 * (1.89/1{,}000{,}000)}{0.05} * \frac{0.1724 - 0.05}{(1 - 0.05)} = 461 \qquad (14)$$

crashes avoided.

Applying the 51 percent adjustment factor used under the other scenarios, the estimated number of crashes avoided is 71 + 0.51*461 = 306. The corresponding numbers of injuries and fatalities avoided are 79 and 4, respectively.

The calculation for the number of crashes avoided using the medium (top 10 percent) and low (top 25 percent) threshold values is similar and not shown. Rather, the number of crashes, injuries and fatalities avoided under all three threshold levels is presented in Table 6-24.

Table 6-24. Number of crashes, injuries, and fatalities avoided under scenario RE-4.

Percent Selected for Inspection	Number of Safety Events		
	Crashes	Injuries	Fatalities
5%	306	79	4
10%	217	56	3
25%	134	35	2

As expected, the results for scenario RE-4 (above) and for scenarios RE-5 and RE-6 (presented below) indicate that the higher the threshold value for the safety index (i.e., with fewer but higher-risk trucks chosen for inspection), the more crashes, injuries, and fatalities can be avoided as a result of inspecting the same number of trucks. If a state has a low volume of truck traffic or extra inspectors available at a given site, however, officials might choose a lower threshold (e.g., top 10 percent or top 25 percent) to increase the total number of trucks available for inspection. The lower thresholds (10 percent and 25 percent) are shown partly to illustrate the effects of a state choosing to calibrate its threshold to better match the volume of truck traffic and the available inspection resources at a given site. For example, suppose an inspection site sees 2,000 trucks per day traverse the station during normal inspection hours. If the highest threshold value (5 percent) is used, about 100 trucks would be pulled out for inspection per day. Assume for purposes of illustration that 100 trucks is a normal volume of daily inspections at that station. If the state were to assign extra inspectors to that station, they might be underutilized if only 100 trucks were pulled in for inspection. In this case, it might be advantageous for the state to use a lower threshold level in an effort to inspect more than 100 trucks per day. More total inspections would be performed, compared to the number using the 5 percent threshold value. As noted, the figures in Table 6-24 show the safety benefits achieved based on a constant number of inspections (i.e., those performed statewide in Kentucky in 2005). If a state has the resources to inspect more trucks, even under a lower threshold level, the relative safety benefits would be expected to rise. Such benefits, however, were not quantified in this analysis.

The high threshold level represents an increase of 180 crashes avoided compared to the baseline scenario (RE-1). Also, about 46 more injuries and 2 more fatalities are avoided under this scenario.

Scenario RE-5: Electronic screening based on high driver or brake violation rate

This scenario is similar to RE-4 in that the state utilizes the ISSES and/or electronic screening to screen all vehicles at all major inspection sites based on a safety index. This scenario differs from RE-4 in that vehicles are screened on their brake violation rate as opposed to their overall vehicle OOS rate in an attempt to catch those vehicles that have a violation that has a higher relative risk for crash. Brake violation rates are defined as the number of brake violations for the carrier in the past 30 months divided by the number of vehicle inspections in the past 30 months.

Table 6-25 shows the three levels of threshold values for both the brake violation rate and driver OOS rate safety index. The high threshold for the brake violation rate index is 1.07. This means that roughly 5 percent of the truck traffic has a brake violation rate at or above 1.07. The high threshold level would be used to pull in only the top 5 percent of vehicles in situations where a smaller number of inspectors were on duty. If more inspectors are available, a lower threshold can be used to pull more trucks into the station. The medium and low threshold values for the brake violation rate safety index are 0.81 and 0.50, respectively. Note that the thresholds for the driver OOS rate are the same as in RE-4.

Table 6-25. Brake violation and driver OOS rate threshold values calculated from Kentucky inspections from January 2005 through mid-September 2007.

Percent Selected for Inspection	Safety Index Threshold	
	Brake Violation Rate	Driver OOS Rate
5%	1.07	22.2%
10%	0.81	16.7%
25%	0.50	10.7%

To use Equation (5) to estimate the number of crashes that would be prevented, a probit regression model was used to estimate the probability of an OOS violation among vehicles at or above each value of the index threshold. This probability represents the term P(V|Inspection) in Equation (5). By plugging the three threshold rates into the equation and solving for *p*, the probability of a brake-related OOS violation given an inspection can be calculated for each level of brake violation rate. These brake-related probabilities are provided in Table 6-26 along with the probabilities associated with the driver OOS rate index originally presented in RE-4.

Table 6-26. Brake violation and driver OOS rate threshold values along with corresponding probabilities of a brake-related or driver OOS violation calculated from Kentucky inspections from January 2005 through mid-September 2007.

Percent Selected for Inspection	Brake Violation Rate		Driver OOS Rate	
	Threshold	P(V|Inspection)	Threshold	P(V|Inspection)
5%	1.07	0.14	22.2%	0.11
10%	0.81	0.11	16.7%	0.08
25%	0.50	0.07	10.7%	0.05

From Equation (5), the number of crashes that are avoided due to brake-related OOS orders when the highest 5 percent of trucks in terms of brake violation rate are brought into the station for inspection is equal to

$$\frac{44{,}142 * (0.14) * 15{,}000 * (1.89/1{,}000{,}000)}{0.14} * \frac{0.2172 - 0.14}{(1 - 0.14)} = 112 \qquad (15)$$

This estimated number of crashes avoided is conservative. The calculation is based in part on the probability of finding a brake-related OOS condition in the population. According to the National Fleet Safety Study (NFSS) performed in 1996, 14 percent of VMT are with brake-related OOS conditions (Star 1997). In reality, an inspector is going to place a truck OOS if any vehicle OOS violation is found, not just a brake-related one. Thus, the numbers of crashes, injuries, and fatalities reported under scenario RE-5 are conservative.

Eleven percent of the 86,028 driver inspections would result in a driver OOS order leading to

$$\frac{86{,}028*(0.11)*10{,}000*(1.89/1{,}000{,}000)}{0.05}*\frac{0.1724-0.05}{(1-0.05)}=461 \qquad (16)$$

crashes avoided.

Note that these two numbers cannot be added to get the total number of crashes avoided because there is some overlap in brake and driver OOS orders. As reported in RE-0, the TFSS found that 49 percent of the inspections that found at least one driver OOS violation also found at least one vehicle OOS violation (USDOT 2006b). Furthermore, the study found that brake OOS violations represent 42 percent of all vehicle OOS violations. As a result, about 21 percent (0.49*0.42) of the inspections that found at least one driver OOS violation also found at least one brake OOS violation. Because the impact of brake OOS orders is greater than the impact of driver OOS orders, the number of crashes avoided combined over brake-related and driver OOS orders can be determined by adding (a) the number of crashes avoided due to brake-related OOS orders and (b) 79 percent of the crashes avoided due to driver OOS orders. Thus, the total number of crashes avoided annually in Kentucky would be 112 + (0.79*461) = 476. The corresponding numbers of injuries and fatalities avoided are 123 and 6, respectively.

The calculation for the number of crashes avoided using the medium (top 10 percent) and low (top 25 percent) threshold values is similar and not shown. Rather, the number of crashes, injuries and fatalities avoided under all three threshold levels is presented in Table 6-27.

Table 6-27. Number of crashes, injuries, and fatalities avoided under scenario RE-5

Percent Selected for Inspection	Number of Safety Events Avoided		
	Crashes	Injuries	Fatalities
5%	476	123	6
10%	353	91	4
25%	221	57	3

As described above for RE-4, the results for RE-5 indicate that the higher the threshold value for the safety index, the more crashes, injuries, and fatalities can be avoided as a result of inspecting the same number of trucks with higher violation or OOS rates.

The high threshold level represents an increase of 350 crashes avoided compared to the baseline scenario. Also, about 90 more injuries and 4 more fatalities are avoided under this scenario.

RE-6: Electronic screening based on infrared screening and high driver OOS Violation Rate

Roadside scenario RE-6 is similar to RE-5 in that it focuses on identifying vehicles that have brake and/or driver OOS violations (violations with high relative crash risk). Where RE-6 differs from RE-5 is that brake violations are screened via IR technology rather than the carrier's brake violation rate. Prior research conducted in 2000 for FMCSA on evaluating an IR imaging and video package, IRISystem, found that the percentage of vehicles placed OOS due to brake violations after IRISystem screening was 47.2%. This figure is used as an estimate for the probability of a brake violation given that an inspection occurred, [P(V|Inspection)].

From Equation (5), the number of crashes that are avoided due to brake OOS violations when the thermal imaging system is used to select vehicles for inspection is equal to

$$\frac{44{,}142 * (0.472) * 15{,}000 * (1.89/1{,}000{,}000)}{0.14} * \frac{0.2172 - 0.14}{(1 - 0.14)} = 379 \qquad (17)$$

This estimated number of crashes avoided is conservative. The calculation is based in part on the probability of finding a brake-related OOS condition in the population. In reality, an inspector is going to place a truck OOS if any vehicle OOS violation is found, not just a brake-related one. Thus, the numbers of crashes, injuries, and fatalities reported under scenario RE-6 are conservative.

The number of crashes that are avoided due to driver OOS violations when the highest 5 percent of trucks in terms of driver OOS rate are brought into the station for inspection is equal to

$$\frac{86{,}028 * (0.11) * 10{,}000 * (1.89/1{,}000{,}000)}{0.05} * \frac{0.1724 - 0.05}{(1 - 0.05)} = 476 \qquad (18)$$

Applying the 79 percent adjustment factor used in RE-5, the estimated number of crashes avoided is 379 + 0.79*476 = 755. The corresponding numbers of injuries and fatalities avoided are 196 and 9, respectively.

The calculation for the number of crashes avoided using the medium (top 10 percent) and low (top 25 percent) threshold values for the driver OOS rate index is similar and not shown. Rather, the number of crashes, injuries, and fatalities avoided under all three threshold levels is presented in Table 6-28. While the driver OOS rate threshold change for each of the high, medium, and low, levels, the brake OOS rate of 47.2% when using IR technology remains unchanged.

Table 6-28. Number of crashes, injuries, and fatalities avoided under scenario RE-6.

Threshold Level for Driver OOS Rate	Number of Safety Events Avoided		
	Crashes	Injuries	Fatalities
High (Top 5%)	755	196	9
Medium (Top 10%)	644	167	8
Low (Top 25%)	544	141	7

Using the high threshold level for driver OOS rate represents an increase of 629 crashes avoided compared to the baseline scenario. Also, about 163 more injuries and 7 more fatalities are avoided under this scenario.

As discussed above for RE-4, the results for RE-6 indicate that the higher the threshold value for the safety index, the more crashes, injuries, and fatalities can be avoided as a result of inspecting the same number of trucks with higher values of the safety index.

6.6.4 Summary of Results

Table 6-29 summarizes the major results of this safety benefits analysis. According to the model, current roadside enforcement strategies (RE-1) are responsible for avoiding 126 truck-related crashes, which represents about 4.4 percent of the 2,853 crashes in Kentucky that occur annually, based on 2005 crash statistics. Furthermore, it is estimated that current roadside enforcement activities are responsible for preventing 33 injuries and 2 deaths. The safety benefits realized increases with each scenario RE-2 through RE-6. The maximum benefit is achieved with RE-6, where 755 crashes are avoided if the top 5 percent of vehicles in terms of driver OOS violations are inspected in conjunction with IR screening. This implies that about 26 percent of Kentucky's 2,853 annual truck-related crashes could be avoided under RE-6. In reality, this figure is an overestimate, because national crash rates were used in the safety benefit calculations, because reliable crash rates for Kentucky were not available.

To put the crash avoidance numbers into context, consider that the number of large trucks involved in crashes in Kentucky (2,853) is low relative to the 441,000 large trucks involved in crashes nationally, representing only 0.6 percent of national crashes. Also, the percent of Kentucky crashes relative to the number of inspections performed in Kentucky is about 3.3 percent. Comparatively, the national rate of crashes relative to the number of inspections is about 16 percent. Therefore, relative to the number of inspections, Kentucky's crash rate is smaller than the national crash rate. The exact reason for this is unknown, but possible explanations include a lower volume of traffic in Kentucky, less congested highways, or a smaller number of large cities.

Recalculating the safety benefits achieved when the national number of vehicle and driver inspections in 2005 is used instead of Kentucky inspection figures in Equation (5) finds that implementing RE-6 avoids about 6.5 percent of all national crashes. This figure makes more sense in the context of the number of total crashes.

It is not possible to know the exact percentage of crashes caused by driver or brake OOS violations. However, as discussed earlier, there is a 12.2 percent increase in relative crash risk for driver OOS violations, a 4.4 percent increase in crash risk for vehicle violations, and a 7.7 percent increase in crash risk for brake OOS violations. Since a vehicle could have more than one type of violation, the three crash risk figures cannot be added to obtain the total increase in crash risk. However, these figures suggest that if there were no driver or brake OOS violations present in the population, no more than about 20 percent of crashes could be avoided. This is the maximum possible benefit if all OOS violations were removed from trucks traveling on the road. This fact helps to put the Kentucky results into context and to provide an upper bound on the crash avoidance numbers for Kentucky.

Table 6-29. Estimated safety benefits of the ISSES and CVISN under selected deployment scenarios and assumptions.

Scenario	Description		Numbers of Safety Events Avoided[1]			Additional[2] Safety Events Avoided (ISSES/CVISN Benefit)		
			Crashes	Injuries	Fatalities	Crashes	Injuries	Fatalities
RE-0	Random Selection		183	47	2			
RE-1	Baseline – Pre ISSES/CVISN Using Kentucky OOS Rates		126	33	2			
RE-1a	Pre ISSES/CVISN Using National OOS Rates		214	55	3			
RE-2	Mainline Electronic Screening Based on ISS Score		189	49	2	63	16	0
RE-3	Electronic Screening based on Kentucky OOS Rate Inspection Selection Algorithm		227	59	3	101	26	1
RE-4	Electronic Screening based on high vehicle and/or driver OOS rates[3]	5%	306	79	4	180	46	2
		10%	217	56	3	91	23	1
		25%	134	35	2	8	2	0
RE-5	Electronic screening based on high driver or brake violation rates[3]	5%	476	123	6	350	90	4
		10%	353	91	4	227	58	2
		25%	221	57	3	95	24	1
RE-6	Electronic screening based on infrared screening and high driver OOS violation rate[3]	5%	755	196	9	629	163	7
		10%	644	167	8	518	134	6
		25%	544	141	7	418	108	5

1 The estimated number of crashes avoided is based on the assumption that crashes are avoided when vehicles and drivers with safety violations are placed OOS.
2 Compared to baseline scenario (RE-1).
3 Safety Benefits shown for strategies RE-4, RE-5, and RE-6 are dependent on the percentage of the truck population selected for inspection (top 5%, 10%, or 25% in terms of risk).

6.7 Credentialing Data

This section covers one additional data source that could potentially be used to help inspectors in their roadside enforcement decisions. This section assesses the usefulness of a carrier's credentialing status relative to their safety information in identifying high-risk trucks. To this point, most of the focus on data related to vehicles and carriers presented in this report has been related to safety. The goal was to determine if there exists a strong link between a carrier's credentialing status and their safety risk. Some credentialing information is available in federal and state databases. The ISSES, when integrated with these data sources, will allow inspectors real-time, instant access to credentialing data.

Although some credentialing data is present in the Kentucky Clearinghouse database, it is limited in terms of the number of carriers that have information as well as the number of credentials where information is available. This is a direct result of the Clearinghouse not being fully linked to any federal data source such as SAFER. Because of these limitations, credentialing data were left out of the scenarios presented in Section 6.6 and instead are presented separately in this section. Table 6-30 lists the most common credentials needed to operate in Kentucky for which information is available in the Clearinghouse.

Table 6-30. Credentialing information in the Kentucky Clearinghouse.

Credential	Explanation
International Fuel Tax Agreement (IFTA)	Fuel tax agreement for carriers engaged in interstate operations
International Registration Plan (IRP)	Registration for carriers engaged in interstate operations
Weight Distance Tax (WDT)	Mileage tax for carriers operating within Kentucky
Kentucky Intrastate Tax (KIT)	Fuel tax for intrastate carriers
Extended Weight [Coal] Decal (EWD)	Permit for companies hauling coal on state maintained highways
Kentucky Highway Use (KYU) License	Used to report mileage tax

One example of the limited Clearinghouse credentialing data is that while IFTA information is available for all Kentucky based carriers where IFTA is applicable, information from other states is scarce. Kentucky does interface with the IFTA Clearinghouse to capture IFTA revocation data from carriers in other states; however the IFTA information from other states needs to include the USDOT number in order to be processed by Kentucky because the Kentucky Clearinghouse is a carrier-based system. Since a large amount of information from other states is not processed in the IFTA Clearinghouse by USDOT number, the Kentucky Clearinghouse gets limited IFTA information from other states. Over 31% of all carriers with available IFTA information in the Kentucky Clearinghouse are based in Kentucky.

Also, IRP information is strictly limited to Kentucky-based carriers in the Kentucky Clearinghouse. According to representatives of the KTC, the IRP Clearinghouse is currently geared more toward proper recording of registration fund transfers and does not have a strong real-time revocation system. Thus, the Kentucky Clearinghouse does not have IRP information for non-Kentucky carriers.

All carriers traveling in Kentucky are subject to the weight distance tax (WDT) as well as the Kentucky Highway Use License displayed via the Kentucky Use (KYU) number on trucks that operate in the state. Since information for these taxes is housed in a Kentucky state database, the Kentucky Clearinghouse contains WDT and KYU status on a larger number of carriers (both based within and outside of Kentucky). The Extended Weight Decal (EWD) Permit is not used as much as some other credentials and, as such, not a lot of carriers in the Clearinghouse have EWD information. The Kentucky Intrastate Tax is for intrastate carriers only and is obtained from another Kentucky database.

One objective of the inspection efficiency portion of the evaluation was to determine if having access to a carrier's credentialing status would provide new information beyond safety information, such as ISS scores and OOS rates, to an inspector to help him or her select high-risk trucks for inspection. Unfortunately, due to the limits in the amount of data available in the Kentucky Clearinghouse, a complete analysis could not be conducted. However, a few simple analyses were performed to show the relationship between a carrier's risk rating as defined by their ISS score and their credentialing status using IFTA and WDT as examples.

Table 6-31 illustrates the results using a carrier's IFTA status. For each carrier in the Kentucky Clearinghouse where information on IFTA was available, information was captured to determine if the carrier was in good standing with regard to IFTA. In addition, the USDOT number for each of these carriers was cross referenced with SAFER to obtain the carrier's ISS score. The ISS score was used to assign the carrier to one of five risk categories: high-risk, medium-risk, low-risk, insufficient data, or unknown. The carrier risk ratings are the same as presented in Section 6.4. Carriers having insufficient or unknown data were excluded from this analysis. Of the 2,558 carriers in good IFTA standing, 25 percent were considered high-risk as compared to 32 percent of the 1,510 carriers not in good standing that were high-risk. The percentage of medium-risk carriers not in good IFTA standing was also higher (33 percent) than those carriers in good standing (26 percent).

Table 6-31. Comparison of IFTA credentialing status with ISS risk category.

	Credentials in Good Standing		**Credentials NOT in Good Standing**	
Risk Level	**Number of Carriers**	**Percent**	**Number of Carriers**	**Percent**
High	632	25%	1,510	32%
Medium	664	26%	1,546	33%
Low	1,262	49%	1,612	35%
Total	2,558	100%	4,668	100%

Table 6-32 shows similar results when carrier risk rating is compared to WDT status. Thirty-eight percent of carriers not in good WDT standing were considered high-risk versus 24 percent of carriers in good WDT standing. The percentage of medium-risk carriers with not in good WDT standing was slightly higher (31 percent) than those carriers in good standing (29 percent).

Table 6-32. Comparison of Weight/Distance Tax credentialing status with ISS risk category.

Risk Level	Credentials in Good Standing		Credentials NOT in Good Standing	
	Number of Carriers	Percent	Number of Carriers	Percent
High	50,481	24%	3,844	38%
Medium	61,137	29%	3,222	31%
Low	98,458	47%	3,166	31%
Total	210,076	100%	10,232	100%

Both Tables 6-31 and 6-32 illustrate that there appears to be a loose correlation with a carrier's credentialing status and the company's safety risk rating. However, due to the data limitations in the Kentucky Clearinghouse, a more thorough and complete analysis is needed to fully understand and assess the relationship between a carrier's safety and credentialing information.

Also, Kentucky is currently in the process of implementing their Commercial Vehicle Information Exchange Window (CVIEW). Testing was being finalized in October and November of 2007. This CVIEW, unlike the Kentucky Clearinghouse, will be directly linked to federal and state databases such as SAFER, License and Insurance (L&I), and MCMIS. As such, inspectors at the roadside will have access to timelier and larger quantities of data, including credentialing, for use in roadside enforcement.

7.0 User Acceptance and System Cost Evaluation

7.1 Introduction

The purpose of this section is to document specific data collection and analysis methods as well as to report the findings for the remaining objective of Goal Area 2 of the evaluation: ***"Determine how the ISSES makes the inspection process more efficient and effective, in turn contributing to improved highway safety."*** (Section 6.0 discussed the other two objectives of Goal Area 2.) Specifically, this section covers the following objective and hypotheses:

Objective 2.1 Determine the degree of user acceptance and the perceived usefulness and usability of the ISSES as deployed, and quantify deployment and operating costs related to the ISSES.

Hypotheses: Inspectors and state transportation managers believe that ISSES enables roadside inspectors to perform their job functions better.

Inspectors believe that ISSES should be deployed more widely.

In deploying similar systems, officials at other sites believe their system enables them to perform their job functions better.

Inspectors found their training and user documentation for ISSES to be helpful to them in their normal course of duties.

In deploying ISSES, Kentucky incurred one-time start-up and recurring costs that were clearly defined and measurable.

This objective was also intended to identify ways that the state and the deployment team can improve the performance and usability of the ISSES as perceived by the inspectors, which should lead to increased benefits as advanced inspection systems are deployed more broadly. In addition, this objective attempted to assess the costs to deploy, operate, and maintain the ISSES.

The user acceptance study focused on the interface between the inspectors and the ISSES equipment, and the more subjective attitudes and contextual environment that affect the adoption or rejection of advanced systems such as the ISSES. As noted in the Evaluation Plan, a natural overlap exists between the system performance and the user acceptance aspects of the independent evaluation. Ideas drawn from the user acceptance study affected the system performance results, and vice versa; however, the evaluation team attempted to maintain a distinction between the two studies.

For completeness, the user acceptance interview questions were intended to cover all ISSES subsystems, including the ALPR and the USDOT number reader, even though those two systems were not under evaluation. However, the evaluation team noted that the KVE respondents tended to say very little about the ALPR and USDOT number reader. This may be because those two subsystems were not integrated with any back-end databases to provide alarms that could aid in the real-time inspection selection process. Alternately, the radiation monitor (because it sounded audible alarms) and the thermal imaging system (because it showed live IR and video of vehicles passing near the scale house) may have been more prominent in the minds of the inspectors when asked about ISSES in general. Also, some of the inspectors may have been familiar with the thermal imaging system because of Kentucky's history of actively deploying the IRISystem vans for mobile enforcement using IR image technology. No conscious attempt was made to steer respondents toward or away from any of the ISSES subsystems.

7.2 Data Collection

Data to address the hypotheses of Objective 2.1 were collected from a variety of data sources, including on-site interviews and site observation visits. Both data sources enabled researchers to test the hypotheses associated with Objective 2.1. The first research hypothesis tested was whether inspectors believed that the ISSES equipment enabled roadside inspectors to perform their job functions better. As noted previously, there was an apparent disconnect between the purpose of the ISSES technology deployment (i.e., increase the rate of OOS orders) and the performance measures for KVE inspectors (i.e., complete inspections at a specified rate, with relatively little regard for the rate of OOS orders).

In order to best address this hypothesis, it was important to understand what the ISSES equipment actually does and how the ISSES could be improved. This was accomplished through in-person and telephone interviews as well as field observations with inspectors and weigh station staff to gauge the ease-of-use of the ISSES, its benefits, disadvantages, or underutilized capabilities, and the lessons that inspectors and other stakeholders have learned through the early deployment and day-to-day use of the ISSES. Additionally, user feedback was useful in documenting the cooperation among stakeholders in the deployment process; how any problems were overcome; what lessons were learned on any technical, business, or institutional issues encountered; and how these issues were handled.

The next research hypothesis tested was whether inspectors believed that ISSES should be deployed more widely. In order to address this hypothesis, it was necessary to understand the potential benefits of broader ISSES deployment. This was accomplished through in-person and telephone interviews as well as field observations with inspectors and weigh station staff to collect opinions on topics such as whether ISSES would yield greater benefits if it were to be integrated with state and national systems, whether the components worked satisfactorily in a stand-alone mode, whether data originating from ISSES in London would be useful if made available to inspectors in other jurisdictions, and which features would motivate inspectors at the London site or other sites to rely on ISSES data.

Another research hypothesis tested whether officials at similar deployment sites believed their system enabled them to perform their job functions better. In order to understand the views of other sites, telephone interviews as well as email exchanges with inspectors and weigh station staff at Kentucky sites similar to the deployment site in London were conducted.

The next research hypothesis tested whether inspectors found the training and user documentation for ISSES to be helpful to them in their normal course of duties. This hypothesis was carried out through in-person and telephone interviews as well as field observations with inspectors and weigh station staff to understand the kinds of training that were offered to KVE inspectors, the shape of the "learning curve" for mastering the various features of the system, and whether the inspectors perceived their training to have been beneficial in using the ISSES. The results from these comments should help Kentucky and other sites develop appropriate training and user documentation as additional systems are deployed.

Another aspect of Objective 2.1 was to quantify deployment and operating costs related to the ISSES. In order to best address this hypothesis, it was important to identify the costs of purchased and installed materials and system equipment, related software integration, and vendor labor. Actual recurring costs to operate and maintain the systems were obtained. Such operations and maintenance costs included technical support, repairs, equipment replacement, software upgrades, and supplies and materials to keep the ISSES in operating order throughout its expected service life.

Several data collection planning activities were completed for the user acceptance aspect of the Kentucky evaluation. First, a set of user acceptance interview questions were created. Second, site visits with various Kentucky Transportation Center (KTC) and Kentucky Vehicle Enforcement (KVE) personnel were conducted to learn about the ISSES equipment and to observe weigh station staff perform their duties in relation to the ISSES in and around the scale house.

An initial planning visit took place on January 24, 2007. Additional user acceptance field observations and interviews were scheduled to take place in June 2007 at the London site. To coordinate the June visit, contact was made with Captain David Marcum of KVE at the London site via email and telephone to schedule a time to conduct the user acceptance interview and to determine what staff, including sworn law enforcement officers and regulatory weight and safety inspectors from KVE, would complete the interview. User acceptance interview questions were sent to KVE personnel prior to the site visit.

For the user acceptance study, interviews were conducted during a site visit to the London site on June 20, 2007, near the end of the two-week field observation period. The interview was presented as part of a research effort to assist Kentucky and the deployment partners in measuring the degree of user acceptance and the perceived value and usability of the ISSES. For the London site, four individuals were identified as participants. The user acceptance site visit and all interviews were conducted on the same day.

Additionally, weigh station staff from other weigh stations in Kentucky were contacted to participate in the user acceptance interview. Kenton County and Simpson County weigh station facilities each had one KVE staff member participate in the one-on-one interview portion of the study. These additional interviews were administered via email during the July and August 2007 timeframe.

The target as given in the Test Plan (USDOT 2007c) was to conduct three to four individual interviews for the user acceptance portion of the evaluation. This goal was met. Focus groups were not conducted as part of the user acceptance study; however, during the user acceptance site visit and during other visits during June 2007, researchers held informal discussions with several weigh station staff in the scale house to glean general information about the inspection operations of the weigh station as well as the ISSES equipment.

7.3 Data Analysis

Following on-site data collection, researchers compiled participant feedback from the field observations and one-on-one user acceptance interviews into a table that enabled them to analyze and document the degree of user acceptance and the perceived usefulness and usability of the ISSES technology deployment. The original user acceptance interview guide is attached to this report (see Appendix B) and consists of 29 questions divided up into six sections, A through F. Some of the questions or interview prompts consisted of several statements or subquestions. Table 7-1 shows the question groups, topics, and the numbers of questions in each group.

Table 7-1. User acceptance interview question topics.

Section	Topic	Number of Questions
A	General questions about ISSES	6
B	Use of the ISSES equipment	7
C	Training	3
D	Inspection selection efficiency	5
E	Future deployments	5
F	Hypothesis evaluations (true/false)	3
	TOTAL	29

All questions were intended to give participants the opportunity to provide their candid opinions about the ISSES and their experiences with ISSES to date.

As noted, six participants from three Kentucky weigh stations provided input to the user acceptance interview questions. A complete transcript of the responses by question is presented in Appendix C.

7.4 User Acceptance Results

This section summarizes the user acceptance interview outcomes and identifies trends observed among the responses. Following the summary, responses to individual questions are presented, providing count and percentage data to aid in analyzing responses. Selected responses (in both paraphrase and direct quotations) are included below, when appropriate and relevant, to highlight views representative of a number of respondents.

7.4.1 Prevailing Themes Among Respondents

The purpose of this section is to summarize the findings of the interviews and site observations and to present a discussion of the prevailing themes that appeared in the user acceptance data. The main two findings are as follows:

1. **Staffing and training were seen as main barriers to active use of ISSES in everyday KVE inspection operations.**

2. **The majority of inspectors said ISSES appeared to be user-friendly, and that training is necessary to help them make full use of its capabilities.**

Several prevailing themes appeared in the data, as described below:

Training. In many replies, respondents cited lack of proper training as being either the main reason or part of the reason they had not used any part of the ISSES equipment. In many instances, respondents indicated that with adequate training and user documentation they could come to appreciate and utilize the equipment. According to KTC, some training and exercises had been conducted at the time of the initial deployment in 2005 and since then; however, training should be offered frequently for all staff, especially new hires. Staffing levels were also seen as an important barrier to using ISSES during daily inspections. There is a perceived scarcity of staff resources to make use of the information being generated by ISSES.

Based on respondent feedback, training should include a discussion of how ISSES can augment current inspection selection practices, which are primarily visual inspection and observation, the use of WIM sensors, and queries of external data sources. For the radiation monitor, training should highlight how to interpret the truck profiles listed on the ISSES screen and how to distinguish and read radiation dose rate values. For the thermal imaging equipment, training should include a thorough explanation of scenarios in order for inspectors to be able to recognize brake violations and other patterns. Three of the six respondents felt that the thermal imaging device should benefit them since it seemed “easier to locate possible brake defects” than working at a location without it.

Equipment. Respondents provided most useful information about two of the ISSES subsystems, the radiation monitor and thermal imaging device. In many replies, respondents considered most ISSES radiation alarms to be caused by routine, naturally occurring substances (e.g., brick, porcelain, clay) or licensed, placarded medical products. Respondents indicated the radiation monitor needs to be fine-tuned to reduce nuisance alarms. The system is perceived as “very sensitive.” Inspectors do not want to waste time chasing down every truck.[6] [As a point of reference, during the field observation, approximately 500 gamma alarms and nine neutron alarms were recorded by ISSES in 12 days.] According to the vendor, every ISSES site is provided with a hand-held radiation detector, along with software allowing inspectors to download data from the hand-held detector to the electronic record of the inspection. Several respondents noted that hand-held radiation detectors, while not recognized by them as being part of ISSES, complemented the radiation portal monitor. The hand-held device, which is deployed at every ISSES site, can zero in on a problem when the truck is in the inspection shelter. (See the response to Question #A4 below.)

In many answers, respondents indicated that they rely on the thermal imaging device with the greatest confidence because they can “actually see trucks on the screen” and believe it enables

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[6] The KTC indicated that the nuclear detection subsystem at the Laurel County ISSES site had been adjusted in the fall of 2007 (after the time of these interviews) to greatly reduce the frequency of nuisance alarms.

them to perform their job functions better. It appears to be easy to use, even given little training, and training could only help inspectors make better use of this subsystem. Respondents also said that having the thermal imaging device on site has more benefits than IRISystem vans, although one could complement the other, similar to the combination of the hand-held and fixed portal radiation monitors. On several occasions, respondents raised the point that the thermal camera shows only one side of truck, and they would like to be able to view both sides of the vehicle as it passes the thermal camera location. One characteristic of the thermal imaging system is that it tends to show defects more clearly on the far-side axles of the truck, partly because the tires and rims do not obstruct the line of sight from the camera to the brakes and other components that are most subject to over- or under-heating. Cameras placed on both sides of the lane of travel would thus allow the inspector to view the insides of the wheels on both sides of the truck more clearly.

Lessons Learned. Respondents provided useful lessons learned regarding how ISSES would yield greater benefits for future deployments if it were integrated with state and national systems:

Lesson learned 1: Train early and retrain periodically to account for new staff. Respondents speculated that they could provide additional input or different answers to the user acceptance interview questions if they had had training on the equipment, since many respondents admitted their unfamiliarity with the equipment. Future evaluations could include revised one-on-one interviews as well as focus groups to bring together several trained users in a group setting to discuss and listen to their issues and concerns about the features of the ISSES.

Lesson learned 2: Carefully consider where equipment is sited before installation and obtain input from inspectors. As it is installed now, it appears that the equipment is located too far down the approach ramp from the mainline, at a point that is too close to the scale house. Inspectors need adequate time to interpret information from ISSES and then decide whether to stop a given vehicle. In the current setup, by the time the vehicle arrives, it is often too late; inspectors need more time to visually inspect IR imagery and other ISSES signals. The Kenton site, installed after the Laurel site, provided more distance from the ISSES equipment to the scale house, primarily for the time required for the system to recognize and process the USDOT numbers and license plate numbers.

Changing the siting of the equipment could also help the triggering and correlation process, especially when two trucks are very close together in line. The current ISSES occasionally generates extra data records across the various subsystems, making it difficult to relate, for example, ALPR values with USDOT number values, or with radiation profile values. The topic of triggering issues, including the tradeoffs required when deploying a system that combines both highway safety and homeland security functions, is covered in more detail above in System Performance.

Lesson learned 3: Provide equipment documentation and user guides along with contact information on-site (e.g., if a radiation alarm goes off) that affords inspectors access to personnel with a working knowledge of equipment.[7]

[7] KTC indicated that, now that a maintenance contract has been established with the vendor, each ISSES site has contact information posted for the on-site technical support person from IIS, giving KVE enforcement personnel consistent access to help if they have a question or a problem with the equipment.

Overall, the ISSES system works as designed, but KVE staff—because of their workload, primary duties, and enforcement performance measures—perceive watching the ISSES screens to be very time-consuming in terms of meeting the quotas that are set out for them in their jobs.

7.4.2 Question-by-Question Summary

This section provides counts of responses per question (out of a total of six interviews conducted with KVE personnel) and, following a recap of each question, a qualitative description and interpretation of the responses collected.

A. General Questions about ISSES

(Q#A1) HAVE YOU USED ANY PART OF THE ISSES TECHNOLOGY? IF SO, PLEASE LIST THE SUBSYSTEMS YOU HAVE USED. ALSO NOTE ABOUT HOW MUCH YOU HAVE USED THE SUBSET AND FOR HOW LONG.

Of the six respondents, five reported being familiar with some part of the ISSES technology, namely the radiation monitor and thermal imaging camera.[8] Respondents noted they had used the subsystems anywhere from several months to eight months. There appeared to be less familiarity with the laser scanner. One respondent had seen the license plate reader and USDOT reader, but had never seen it in operation.

(Q#A2) DOES THE ISSES EQUIPMENT APPEAR TO BE USER-FRIENDLY?

Of the six respondents, six reported essentially that "when it's working it's friendly." Four respondents noted that either no initial training was provided or with training it could be considered user-friendly. One respondent noted that different vendor personnel visit the site frequently to make repairs. The same respondent estimated that the ISSES equipment worked 20% of the time and said the equipment screens were frequently password-protected.

(Q#A3) IF YOU HAVEN'T USED ANY PART OF THE ISSES EQUIPMENT, CAN YOU EXPLAIN WHY YOU AREN'T USING IT? (E.G., TIME ISSUES, STAFFING, TRAINING ISSUES)

Of the six respondents, all six reported that lack of training was either the main reason or part of the reason they hadn't used any part of the ISSES equipment. In addition, staffing issues (being short staffed) and timing were also identified as factors. Inspectors have to conduct a designated number of inspections per week. They reported having enough to do without watching the ISSES screens.

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[8] In response to this finding from the interviews, the KTC indicated that there would have been no reason to expect enforcement personnel to be familiar with or to have used the LPR and USDOT number reader, because KTC is still evaluating the performance of these systems as part of the state's CVISN program. Additionally, since the laser scanner does not have a user interface, and given that it is used to trigger other systems, enforcement personnel would not be expected to be familiar with this system.

(Q#A4) WHAT DO YOU WANT FROM THE ISSES EQUIPMENET (OR ANY TECHNOLOGY FOR THAT MATTER)? AND, IS THERE INFORMATION THAT IS DIFFICULT FOR YOU TO OBTAIN THAT A TECHNOLOGY WOULD MAKE EASIER?

Each of the six respondents provided varying responses. Two respondents indicated they wanted training on the ISSES equipment. One of these respondents would like the hand-held radiation detector to be more integrated with ISSES because it complements the radiation portal monitor. Two respondents also found that the radiation monitor needs to be finely tuned or have an alarm cutoff to limit nuisance alarms on common, natural materials (e.g., kitty litter, bricks). As one respondent put it, “You want to hear every alarm, but you don’t want to chase down every truck.” Another respondent would like for the thermal imaging camera to view both sides of the vehicle, as it would make the inspection process easier. Two other respondents indicated that the record of trucks coming through is beneficial, and that real-time information would be useful in locating violations.

(Q#A5) WHAT WOULD MAKE YOU, OR OTHERS YOU WORK WITH, USE ISSES OR UTILIZE IT MORE THAN YOU ARE CURRENTLY USING IT?

Of the six respondents, five noted that they would use ISSES more than they are currently using if they had training on the equipment. One respondent stated that staffing was more of an issue than training. If someone was hired to sit and solely monitor ISSES, it would be used more than it is currently being used.

B. Questions Specific to any Portion of the ISSES Equipment

(Q#B1) DO YOU RECOGNIZE NOTICEABLE GAPS IN THE DATA PROVIDED BY THE ISSES (OR A PARTICIULAR SUBSYSTEM)?

Of the six respondents, five provided responses. Two respondents said they did not recognize noticeable gaps in the data provided by ISSES. Notably, the thermal imaging equipment was singled out as a system that generated very few data gaps, which was viewed as a positive feature. However, one respondent was not sure what to even look for. This uncertainty relates to another respondent comment, not knowing when the equipment is working because it is password-protected and the individual had evidently not been trained in login procedures.

(Q#B2) DOES THE ISSES GENERATE TOO MUCH INFORMATION FOR WEIGH STATION STAFF TO APPRECIATE AND USE IN THE TIME AVAILABLE FOR AN INSPECT/BYPASS DECISION?

Of the six respondents, five provided responses. Two respondents said they could not answer because they do not know enough about the system. Notably, one respondent said, “Let’s have this conversation again in six months after training.” One respondent said that it generated too many audible radiation alarms, while two respondents commented that they utilized the thermal imaging equipment. One of these respondents said that in the time inspectors have available for an inspect/bypass decision, the thermal imaging device could be sited further away to work better and allow them to make a decision in the time allotted.

(Q#B3) ARE THERE ISSES FEATURES OR FUNCTIONS THAT COULD BE CHANGED OR THAT FUTURE UPGRADES COULD OFFER?

Of the six respondents, five provided responses. In response to features that could be changed, one respondent would like to retrieve information (e.g., location and quantity) from the radiation portal monitor and have that information e-mailed to the appropriate party. Another respondent would like to change the thermal imaging device, by incorporating a camera to capture IR data from the other side of the vehicle. Two respondents commented on the license plate reader operation and integration into other databases (e.g., the National Crime Information Center, or NCIC).

(Q#B4) WHAT BENEFITS DOES THE ISSES OFFER? DO THESE BENEFITS MAKE YOUR JOB MORE CONVENIENT/EASIER COMPARED TO THE LEGACY SYSTEM?

Of the six respondents, four provided responses. Two respondents said that ISSES did not make their job easier; one respondent added the caveat that ISSES would offer benefits if weigh station staff knew how to utilize the equipment. One respondent does not use ISSES enough to comment on the offered benefits. One respondent said ISSES gives a heads up with respect to the thermal imaging and radiation monitor. It is good to have both (a) the hand-held detector to verify truck contents at the inspection shed and (b) the stationary portal monitor at the scale house.

(Q#B5) WHAT ASPECT OF THE ISSES EQUIPMENT ENABLES YOU TO PERFORM YOUR JOB FUNCTION BETTER?

Of the six respondents, five provided varied responses. Three respondents felt that the thermal imaging device should benefit them since it seemed "easier to locate possible brake defects" than working at a location without it. Another respondent said the "heads up" aspect of the ISSES equipment enabled him to perform his job function better. In this context, "heads up" meant that the system gave the inspector advance notice of a potential problem with a vehicle entering the station and additional information about that vehicle (see question #D6 below).

(Q#B6) COMMENT ON THE SYSTEM. DOES THE ISSES EQUIPMENT PERFORM AS EXPECTED, BASED ON THE SPECIFICATIONS OR PRODUCT LITERATURE? IF NOT, ELABORATE ON THE PERFORMANCE OF THE PARTICULAR SUBSYSTEM.

Of the six respondents, two provided responses. One respondent essentially said he could not appropriately answer the question because they have not received adequate training. The other respondent said the thermal imaging device performs satisfactorily, while the other subsystems were unsatisfactory and unreliable in their daily functions. The four remaining respondents indicated that they could not comment on the system.

(Q#B7) DOES ONE SUBSYSTEM ADD MORE VALUE THAN ANOTHER, OR DO ALL SUBSYSTEMS EQUALLY HELP YOU PERFORM YOUR JOB FUNCTION BETTER? (E.G., "SUBSYSTEM X HELPS STAFF PERFORM THEIR JOB FUNCTIONS BETTER, BUT SUBSYSTEM Y IS DIFFICULT AND TIME-CONSUMING TO INTERPRET")

Of the six respondents, four provided comments. One respondent said he could not respond to the question because he does not know enough to answer appropriately. Another respondent said that none of the subsystems assisted him or helped him do his job better. Another respondent said the radiation monitor provides value, while two of the respondents said that the thermal imaging device adds value and provides more information.

C. Training

(Q#C1) HAS TRAINING BEEN PROVIDED FOR THE USE OF THE ISSES EQUIPMENT? IF SO, HOW LONG DID THE TRAINING LAST? IF NOT, HOW MUCH TRAINING WOULD BE NEEDED TO BECOME PROFICIENT IN ANY OF THE ISSES SUBSYSTEMS?

Of the six respondents, a 100% response rate was received. All six respondents said that training had not been provided for the use of the ISSES equipment.[9] Personnel turnover and hew hires, however, may have contributed to this reported gap in training. Two respondents felt that two days of training on the ISSES equipment could be an appropriate length of time for training. One respondent noted that he had received informal, on-the-spot training as technicians worked on the system, and considered it self-motivated training.

(Q#C2) ARE SPECIFICATIONS OR DOCUMENTATION (E.G., USER'S MANUAL) ON THE ISSES EQUIPMENT AVAILABLE ON-SITE? WAS IT DETAILED ENOUGH? WHAT DETAILS WERE MISSING? WHAT KIND OF ADDITIONAL DOCUMENTATION WOULD BE USEFUL?

All six respondents seemed to be very unclear as to what specifications and documentation were available for the ISSES equipment on-site. Some respondents mentioned basic response guides and flowcharts being available as well as radiation portal monitoring information.[10] Additional documentation that would be useful to respondents could include user-friendly training manuals, (i.e., "Cliffs Notes" format guidance), flowcharts, or a quick reference guide.

(Q#C3) HOW DO INSPECTORS OR MANAGERS DEAL WITH THE POTENTIAL LIABILITY FOR MISSED DETECTIONS OF UNSAFE OR HIGH-RISK TRUCKS, WHICH MIGHT TRAVERSE THE WEIGH STATION AND THEN BECOME INVOLVED IN A CRASH CAUSED, FOR EXAMPLE, BY FAULTY BRAKES? IS THERE AN ISSES OPERATING PROTOCOL THAT HELPS INSPECTORS DETECT AS MANY UNSAFE TRUCKS AS POSSIBLE OR PRACTICAL, AND IF SO, HOW EFFECTIVE IS THAT PROTOCOL?

All six respondents interpreted this question differently. None of the respondents had seen an operating protocol, and one respondent directed researchers to check policies and procedures through KVE HQ. One respondent said that manpower is an issue, because no personnel are solely assigned to monitor the ISSES screens. Another respondent said that ISSES does not

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[9] In response to this finding from the interviews, the vendor indicated that training had been provided to Laurel County inspectors by ORNL at the time of the system commissioning in 2005. Later, training was provided in Frankfort by the Domestic Nuclear Detection Office (DHS), on response protocol, the use of the hand-held radiation detector, and how to transmit the radiation profile data to the appropriate entities.

[10] In response to this finding from the interviews, the KTC indicated that a response protocol for weigh station personnel to use when a radiation alarm was activated by a truck was developed by the Department of Vehicle Regulation and the Kentucky Office of Homeland Security. After the training in Frankfort, an exercise was conducted by the Domestic Nuclear Detection Office (DHS), in which Laurel County weigh station personnel responded to an alarm, followed the protocol, conducted the inspection using the hand-held detector, and notified the appropriate agencies of the problem.

show him everything that could be faulty on the truck (e.g., the thermal imaging device does not identify broken air reserve tanks, things under the truck that could fall out, straps, etc.).

D. Selection Efficiency

(Q#D1) OTHER THAN INFORMATION FROM THE ISSES, WHAT SPECIFIC DATA IS COLLECTED FROM THE COMMERCIAL VEHICLE PRIOR TO MAKING A DECISION ON WHETHER TO INSPECT?

Of the six respondents, five responses were provided. Visual inspection occurs at the officer's or inspector's discretion. Specific data collected from the vehicle prior to making a decision on whether to inspect includes general appearance or condition of vehicle, USDOT number, company name, tire condition, past experience with a particular carrier, and vehicle weight and tax information.

(Q#D2) HOW IS THIS INFORMATION COLLECTED (SENSORS, WIM, CAMERAS, EYESIGHT, ETC.)?

Of the six respondents, five responses were received. All five respondents indicated that eyesight is the primary means to make a decision on whether to inspect. Four of the respondents also added that the WIM sensor coming off the interstate was utilized. One respondent also added data entry as a means to make vehicle decisions.

(Q#D3) ARE ANY EXTERNAL DATA SOURCES (SAFER, SAFESTAT, QUERY CENTRAL) USED TO SUPPLEMENT DATA COLLECTED AT THE SITE?

Of the six respondents, five provided responses. To supplement data collected at the site, two respondents use all three external data sources: SAFER, SafeStat, and Query Central. Three respondents said they only use SAFER and Query Central, and do not use SafeStat.

(Q#D4) WHAT ARE THE MAIN PIECES OF INFORMATION COLLECTED FROM THE KENTUCKY CLEARINGHOUSE DATABASE TO HELP WITH INSPECTION SELECTION DECISIONS?

Of the six respondents, two provided detailed responses. Both respondents use the Kentucky Clearinghouse to check whether the vehicle has current tax or insurance credentials. One respondent added that this check took place after the inspection decision had been made and the vehicle had been stopped.

(Q#D5) BASED ON ALL DATA COLLECTED, HOW ARE DECISIONS RELATED TO INSPECTIONS MADE? WHAT METHODOLOGIES PLAY A ROLE IN THE DECISIONS (ISS ALGORITHM, INSPECTOR JUDGMENT, ETC.)? HOW MUCH IS BASED ON DATA COLLECTED AND HOW MUCH IS BASED ON INSPECTOR OBSERVATION AND JUDGMENT?

Of the six respondents, five provided responses. All five respondents noted that inspector observation and judgment come into play, sometimes solely, to determine obvious violations (e.g., flat tires, broken headlights, placard violations, or when alarms sound). One respondent estimated that 75% of the decision is driven by inspector observation, while the remaining 25% is data-driven. One respondent noted that the SAFER database played a role in inspection selection process.

(Q#D6) HOW HAS THE INSPECTION SELECTION PROCESS CHANGED WITH THE INTEGRATION OF ISSES AT THE LONDON [KENTON/SIMPSON] SITE?

Of the six respondents, five provided responses. Four respondents indicated that the inspection selection process has not changed much or at all with the integration of ISSES. One respondent noted that WIM, not ISSES, has increased the number of overweight vehicles pulled over for inspection. The ISSES change is that it provides a "heads up" to inspectors.

E. Future Deployments

(Q#E1) WOULD THE ISSES YIELD GREATER BENEFITS IF IT WERE MORE FULLY INTEGRATED WITH STATE AND NATIONAL SYSTEMS, SUCH AS QUERY CENTRAL, STATE INSPECTION OR LICENSING DATABASES, SAFER, COMMERCIAL DRIVER LICENSE INFORMATION SYSTEM (CDLIS), NATIONAL LAW ENFORCEMENT TELECOMMUNICATION SYSTEM (NLETS), ETC.?

Five of the six respondents indicated that ISSES would yield greater benefits or would be more useful if it were integrated with state and national systems or licensing databases. Of those respondents, one said that the current process relies on going to one to two places to get information (e.g., to run a USDOT number), so having everything tied together would make an inspector's job easier. The sixth respondent did not have an idea as to whether ISSES would yield greater benefits if more fully integrated with other systems.

(Q#E2) DOES EACH ISSES SUBSYSTEM WORK SATISFACTORILY IN A STAND-ALONE MODE?

Of the six respondents, five provided responses. One respondent indicated that from what he knows, each ISSES subsystem works satisfactorily in a stand-alone mode. Another respondent indicated ISSES should be integrated with what is already available on-site for inspectors and "weaved into databases" (e.g., Query Central). Two respondents were unable to comment on whether each ISSES subsystem worked satisfactorily in a stand-alone mode.

(Q#E3) WOULD THE ISSES DATA BE USEFUL IF MADE AVAILABLE TO INSPECTORS IN OTHER JURISDICTIONS (E.G., OTHER PARTS OF THE STATE OR SIMILAR ROADSIDE SYSTEMS IN OTHER STATES)?

Of the six respondents, all six provided a response. Five respondents indicated that it would indeed be useful if ISSES data were made available to inspectors in other jurisdictions. A respondent commented that the more people who know how to operate the system, "the better."

(Q#E4) WHAT ASPECTS OF THE ISSES DATA DO YOU RELY ON WITH THE GREATEST CONFIDENCE? IF THERE ARE NO ASPECTS THAT YOU RELY ON, WHAT CHANGES TO THE SYSTEM MIGHT MOTIVATE YOU TO USE AND RELY ON THE DATA?

Of the six respondents, all six responded to various degrees. Two respondents rely on thermal imaging data because you can "actually see trucks on the screen." Other respondents would like to gain familiarity with the equipment before commenting on what aspects they rely on or what changes to the ISSES equipment might motivate them to use and rely on the data.

(Q#E5) CAN YOU SHARE ANY LESSONS LEARNED THAT WOULD PERHAPS BE USEFUL TO OTHER STATES CONSIDERING THE DEPLOYMENT OF SIMILAR EQUIPMENT? (E.G., WORKING WITH EQUIPMENT, TRAINING, LOCATION OF THE EQUIPMENT ON-SITE, ETC.)

Of the six respondents, all six provided a response. In terms of sharing lessons learned, two respondents said that part of the cost of the ISSES equipment should include the cost of training and to make sure that both initial and follow-up training are provided to introduce new staff to the equipment, especially the operation of the system. Two respondents said that as far as a lesson learned, the location of equipment should be considered carefully before installation. Inspectors have to be given sufficient reaction time to stop a vehicle. The two remaining respondents did not report any lessons learned.

F. User Acceptance Hypotheses

(Q#F1) INSPECTORS BELIEVE THAT ISSES ENABLES ROADSIDE INSPECTORS TO PERFORM THEIR JOB FUNCTIONS BETTER. TRUE OR FALSE

All six respondents provided a response. Three respondents answered true, two respondents answered false, and one respondent was unable to answer. One respondent who answered false indicated it was because they don't rely on the ISSES all the time because they do not have the time or staffing to do so. The other respondent who answered false said that because he did not know how to use the equipment, he did not believe it helps him perform his job functions better.

(Q#F2) INSPECTORS BELIEVE THAT ISSES SHOULD BE DEPLOYED MORE WIDELY. TRUE OR FALSE

Of the six respondents, all participants provided a response. Three respondents answered true (with the caveat that proper training would be necessary), two respondents answered false, and one respondent was unable to answer.

(Q#F3) INSPECTORS FOUND THEIR TRAINING AND USER DOCUMENTATION FOR ISSES TO BE HELPFUL TO THEM IN THEIR NORMAL COURSE OF DUTIES. TRUE OR FALSE

Of the six respondents, five participants provided a response. One respondent answered true (again with the caveat of proper training), two respondents answered false, and two respondents did not provide a true or false response because they have not been trained yet to answer the question as to whether training and documentation for ISSES is helpful to them in their normal course of duties.

7.5 System Deployment and Operating Costs Results

The system cost study focused on the economic dimensions of the deployment, for both one-time start-up costs and recurring (annual) costs to operate and maintain the ISSES. Data on actual costs incurred were supplemented by best estimates for those costs that are not available.

Data collection for the system deployment and operating costs was made via contact with the KTC to identify the various costs associated with purchased and installed materials and system equipment, related software integration, and vendor labor.

The KTC has provided a copy of a bill of sale dated 6/2/2005 with cost data and general system specifications. This bill states that the total cost of installing ISSES at the Laurel County weigh station was $350,000. This total cost includes the: radiation detection component; thermal imaging component; license plate reader component; and site preparation and installation. All installed equipment is included in the bill of sale except two rack mount servers. The KTC, which was involved in ISSES contracting between the state and the vendor, reported that funds from Oak Ridge National Laboratory were also used in the original Laurel County installation and deployment, and that subsequent systems installed in other Kentucky counties have actually cost the state approximately $500,000 each to procure and install.

The original budget for the Laurel County ISSES did not provide funding for training or system maintenance. According to the KTC and the vendor, however, recurring (annual) costs for hardware to operate and maintain the equipment have been fairly low. The system is based on low-amperage sensors and communication systems, and does not cause a large electrical current draw. Equipment repairs and replacement of parts, as described below, have been largely due to lightning strikes and electrical power service interruptions, not due to ISSES equipment defects. In November 2006, the KTC entered into a service contract with TransTech to make one field technical support person available at approximately 60% of full-time on-site to cover the three installed ISSES locations for one year, and at about half of the first year's time commitment for two years thereafter. While the technical support person also participates in client- and vendor-driven data collection projects and other activities outside of this on-site service commitment, his main role is to be available to troubleshoot any maintenance issues, monitor the site remotely, make any repairs on-site as needed or requested by KVE or KTC, provide training to operators/inspectors at each of the sites, and identify and test ISSES enhancements.[11] The cost of this maintenance and technical support from November 2006 through August 2007 has been approximately $109,000. This amount has covered the ISSES maintenance duties listed above, but some fraction of the field support technician/analyst's time within this contract has been devoted to administrative activities, software programming support, and communications protocol development for the nuclear detection subsystem unrelated to the monitoring, repair, and maintenance of the ISSES. Thus, the entire $109,000 has not been attributable to operating and maintaining the ISSES hardware and software.

TransTech is providing periodic maintenance status reports to the KTC (see Appendix E). According to the KTC, TransTech is supposed to submit periodic status reports, based on daily status reports. These reports are obtained by a TransTech field support technician who can connect remotely to see if the ISSES systems are up and running. When a problem arises, the TransTech technician attempts to troubleshoot the problem remotely, and on some occasions makes site visits to troubleshoot problems. Between May and August 2007, four maintenance records had been sent to the KTC.

It appears that, based on respondent input, observation, and other correspondence (see Appendix E), ISSES requires frequent maintenance because of system troubleshooting and power

[11] The first such training session was a two-day training session held on July 31 and August 1, 2007, provided to personnel at the Kenton County inspection station. The training session focused on the operation of the thermal imaging system.

interruptions, the latter type being considered unscheduled maintenance. It is difficult to delineate whether the maintenance (both unscheduled and preventive/planned) is monthly, weekly, or daily because of the nature of the troubleshooting (e.g., lightning strike versus software modification).

8.0 Conclusions and Implications

8.1 Overall Conclusions and Lessons Learned

- The KVE inspectors at Laurel County were not using the ISSES to any great extent during the period of the field study. According to interviews with inspectors and with staff from the KTC, the ISSES hardware was functioning satisfactorily, but the state's scarcity of resources and staff prevent inspectors from having the time to use the information being displayed by the ISSES. The ISSES was in place and operating at the inspection station, but was not being used to any effective extent during the period of the evaluation.

- The portions of the ISSES under evaluation in this study appeared to perform as designed. KVE staff assigned to the Laurel County weigh station, because of their workload and their primary inspection duties, tend to perceive that spending time watching the two ISSES interface screens or monitors is too time-consuming and does not represent an efficient use of their time. The ISSES software and components now deployed—though operational—are considered to be in a development mode as of late 2007.

- The vendor informed the evaluation team that the company attempted to use commercial, off-the-shelf technologies for the ISSES whenever possible. While this approach provides advantages with respect to reducing first costs and allowing the state to begin using subsystems like the thermal inspection camera and radiation monitor immediately in a stand-alone mode, it also increases the cost and difficulty of integrating disparate commercial systems.

- The deployment took place in a larger enforcement context that has up to now emphasized and rewarded inspectors for the numbers of inspections they complete, not necessarily for achieving high rates of OOS orders. Thus the purpose of the ISSES (to help inspectors focus on the trucks with the worst safety records, and in effect drive upward the rate of OOS orders) is not directly aligned with the traditional goals of the inspectors in Kentucky. This institutional disconnect affected the degree to which the inspectors perceived the ISSES as helping them achieve their personal and organizational job goals.

- Lack of training was seen as another obstacle to more effective use of the ISSES. One KVE officer said, "It is a good system but there is no one sitting over the monitors watching the results."

8.2 System Performance Conclusions

- The radiation monitor appears to alert inspectors to potential radiation hazards. No attempt was made to simulate radiation-emitting loads to formally test the rates of false positive alarms or false negative (missed detection) alarms. A tendency for nuisance gamma alarms caused by naturally occurring substances, however, has the effect of making inspectors more likely to ignore all of the gamma radiation monitor alarms. As a rule, the KVE inspectors do attend to neutron alarms, which sound different in the scale house and are much fewer in number than the gamma alarms. An isotope identification capability recently deployed at the two newer ISSES stations (Kenton and Simpson) has also reduced the number of nuisance alarms. Data are being collected to develop computer-based "risk matrices" to further limit the number of nuisance radiological alarms in the future.

- The thermal inspection device enables inspectors to see potential heat-related defective or malfunctioning equipment that might be missed in a visual review, and archives video data for follow-up review. The effectiveness of the thermal inspection system appears to vary depending on the training, experience, and skills of the operator, especially in synchronizing the views of the ground-level IR/color camera and the gable-mounted color overview camera.

- The laser scanner appears to log every truck passing through the ISSES apparatus, but its adjustment is such that the system generates a certain number of extra (blank) records or extra trigger events, which is an impediment to later review of traffic data. For the sample of data reviewed for this evaluation, some gaps in the time synchronization were noted.

- The ISSES appears to perform with a minimum of unscheduled downtime. Partly owing to the exposed geographic location of the Laurel County weigh station, the hardware has been subject to several outages caused by lightning strikes and other power drops or interruptions. The system has experienced a low rate of hardware failure, other than some events related to the reliability of electrical power to the site.

- Based on experience at the first (Laurel) ISSES site, the location of the visible lighting fixtures was changed from the passenger side to the driver's side at Kenton to reduce the amount of stray light reaching the mainline of traffic. Also, the Kenton ISSES equipment was positioned approximately twice as far upstream from the scale house as the ISSES equipment at Laurel, in principle allowing Kenton inspectors more time to make decisions based on the system's output.

- As of mid-2007, the system appeared to be at a late stage in the product development cycle, not completely in full-scale production mode, but well beyond the field test prototype stage. It was not yet integrated with any current or historical state or national databases, which affected its usefulness for real-time enforcement applications, but it appeared to be functioning well in stand-alone mode.

8.3 Inspection Efficiency Conclusions

- A series of scenarios was constructed to compare Kentucky's current inspection selection methods with various progressive options for integrating ISSES and similar CVISN screening technologies at the state's weigh stations. The scenarios also explored variations in the inspection selection criteria that states could use in trying to focus their finite resources on the highest-risk carriers, vehicles, and drivers. Substantial potential reductions in crashes, injuries, and fatalities were predicted from wider deployment of ISSES. Estimates were made using statistical modeling.

- The roadside enforcement (RE) scenarios were defined as follows:
  - RE-0: Random Selection
  - RE-1: Baseline—Pre-ISSES/CVISN
  - RE-2: Mainline Electronic Screening based on ISS Score
  - RE-3: Electronic Screening based on Kentucky OOS Rate Inspection Selection Algorithm
  - RE-4: Electronic Screening based on high vehicle and/or driver OOS rates
  - RE-5: Electronic screening based on high driver OOS or brake violation rates
  - RE-6: Electronic screening based on IR screening and high driver OOS violation rate.

- According to the model, current roadside enforcement strategies (RE-1) are responsible for avoiding 126 truck-related crashes, which represents about 4.4 percent of the 2,853 crashes in Kentucky that occur annually, based on 2005 crash statistics. Furthermore, it is estimated that current roadside enforcement activities are responsible for preventing 33 injuries and 2 deaths.

- The safety benefits realized increases with each scenario RE-2 through RE-6. The maximum benefit is achieved with RE-6, where 755 crashes (629 more than in the baseline scenario) are avoided if the top 5 percent of vehicles in terms of driver OOS violations are inspected in conjunction with IR screening. This implies that about 26 percent of Kentucky's 2,853 annual truck-related crashes could be avoided under RE-6. In reality, this figure is an overestimate, because national crash rates were used in the safety benefit calculations, in turn because reliable crash rates for Kentucky were not available.

- In terms of injuries and fatalities, the incremental benefits range from 16 to 163 fewer injuries per year, and up to 7 fewer fatalities per year.

- To put the crash avoidance numbers into context, consider that the number of large trucks involved in crashes in Kentucky (2,853) is low relative to the 441,000 large trucks involved in crashes nationally, representing only 0.6 percent of national crashes. Also, the percent of Kentucky crashes relative to the number of inspections performed in Kentucky is about 3.3 percent. Comparatively, the national rate of crashes relative to the number of inspections is about 16 percent. Therefore, relative to the number of inspections, Kentucky's crash rate is smaller than the national crash rate. The exact reason for this is unknown, but possible explanations include a lower volume of traffic in Kentucky, less congested highways, or a smaller number of large cities.

- Recalculating the safety benefits achieved when the national number of vehicle and driver inspections in 2005 is used instead of Kentucky inspection figures finds that implementing scenario RE-6 avoids about 6.5 percent of all national crashes.

- A supplemental analysis of the use of real-time credentialing data to supplement current and historical safety information at the roadside demonstrated a loose correlation between a given carrier's credentialing status and the same company's safety rating. In this analysis, credentials such as IFTA and the Kentucky Weight Distance Tax were compared with ISS safety risk rating categories.

8.4 User Acceptance/Cost Conclusions

- As noted above, staffing and training were seen as main barriers to active use of ISSES in everyday KVE inspection operations. The majority of inspectors said ISSES appeared to be user-friendly, and that (compared to the training offered at the Laurel County site), more training is necessary to help them make full use of its capabilities.

- Respondents considered most ISSES radiation alarms to be caused by routine, naturally occurring substances (e.g., brick, porcelain, clay) or licensed, placarded medical products. Respondents indicated the radiation monitor needs to be fine-tuned to reduce nuisance alarms. After the time of the user acceptance interviews, the ISSES at the Laurel County site was adjusted to reduce the prevalence of nuisance alarms.

- Respondents indicated that they rely on the thermal imaging device with the greatest confidence because they can "actually see trucks on the screen" and believe it enables them to perform their job functions better. It appears to be easy to use, even given little training, and training could only help inspectors make better use of this subsystem.

- As for lessons learned from the Laurel County deployment, designers should carefully consider where equipment is sited before installation and obtain input from inspectors. As it is installed now, it appears that the equipment is located too far down the approach ramp from the mainline, at a point that is too close to the scale house. Inspectors need adequate time to interpret information from ISSES and then decide whether to stop a given vehicle.

- Deployment teams should provide equipment documentation and user guides along with contact information on-site (e.g., if a radiation alarm goes off) that affords inspectors access to personnel with a working knowledge of equipment. After the time of the user acceptance interviews, contact information for technical support was posted on the ISSES equipment at Laurel County.

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Appendix A.
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Appendix B.
Interview Guide

Kentucky Commercial Vehicle Safety Applications Evaluation
Contract No. DTFH61-02-C-00134, Task Order BA34018

June 20, 2007

The overall purpose of the Kentucky Commercial Vehicle Safety Applications (CVSA) Evaluation is to provide an independent assessment of the performance, usability, safety benefits, and wider applicability of an advanced system for screening trucks at the roadside. The system, known as the **Integrated Safety and Security Enforcement System (ISSES)**, is being deployed along interstate highway routes by the Kentucky Transportation Cabinet, under a grant from the Federal Motor Carrier Safety Administration. The present evaluation is focused on the first deployment, at Laurel County, near London, Kentucky, on I-75 northbound.

The **ISSES** technology is intended to give inspectors real-time information about trucks passing by the scale house at a slow ramp speed through several integrated subsystems: a radiation monitor, a thermal (infrared, or IR) inspection device, a laser scanner/vehicle detector, a license plate recognition system, and a USDOT number reader.

Goals of the evaluation are to estimate whether the **ISSES** will make highways safer and more secure, and to determine how the **ISSES** makes the commercial vehicle inspection process more efficient and effective. The intent of this survey is to determine the degree of user acceptance and the perceived usefulness and usability of the **ISSES** as deployed. The overall evaluation will document the performance and benefits of the **ISSES** from a national point of view and will provide practical information on commercial vehicle safety and efficiency that will be useful to other states considering the deployment of similar equipment.

Contact information is requested below to document who participated in the survey and the date in which it was conducted; however, *responses will be merged into the final report and will be kept anonymous.*

Date	
Name of Respondent	
Title	
Contact Information (E-mail or phone)	
Other Notes	

At any time during the survey, the participant may respond to a question with “not applicable” or “prefer not to answer” or some other variation.

A. General Questions about ISSES

1. Have you used any part of the ISSES technology? If so, please list the subsystems you have used. Also note about how much you have used the subsystem and for how long.
2. Does the ISSES equipment appear to be user-friendly?
3. If you haven't used any part of the ISSES equipment, can you explain why you aren't using it? (e.g., time issues, staffing, training issues)
4. What do you want from the ISSES equipment (or any technology for that matter)? And, is there information that is difficult for you to obtain that a technology would make easier?
5. What would make you, or others you work with, use ISSES or utilize it more than you are currently using it?

B. Questions to be asked if interviewee uses any portion of the ISSES Equipment

1. Do you recognize noticeable gaps in the data provided by the ISSES (or a particular subsystem)?
2. Does the ISSES generate too much information for weigh station staff to appreciate and use in the time available for an inspect/bypass decision?
3. Are there ISSES features or functions that could be changed or that future upgrades could offer?
4. What benefits does the ISSES offer? Do these benefits make your job more convenient/easier compared to the legacy system?
5. What aspect of the ISSES equipment enables you to perform your job function better?
6. Comment on the system. Does the ISSES equipment perform as expected, based on the specifications or product literature? If not, elaborate on the performance of the particular subsystem.
7. Does one subsystem add more value than another, or do all subsystems equally help you perform your job function better? (e.g., "Subsystem X helps staff perform their job functions better, but Subsystem Y is difficult and time-consuming to interpret")

C. Training Questions:

1. Has training been provided for the use of the ISSES equipment? If so, how long did the training last? If not, how much training would be needed to become proficient in any of the ISSES subsystems?
2. Are specifications or documentation (e.g., user's manual) on the ISSES equipment available on-site? Was it detailed enough? What details were missing? What kind of additional documentation would be useful?
3. How do inspectors or managers deal with the potential liability for missed detections of unsafe or high-risk trucks, which might traverse the weigh station and then become involved in a crash caused, for example, by faulty brakes? Is there an ISSES operating protocol that helps inspectors detect as many unsafe trucks as possible or practical, and if so, how effective is that protocol?

D. Selection Efficiency

1. Other than information from the ISSES, what specific data is collected from the commercial vehicle prior to making a decision on whether to inspect?
2. How is this information collected (sensors, WIM, cameras, eyesight, etc.)?
3. Are any external data sources (SAFER, SafeStat, Query Central) used to supplement data collected at the site?
4. What are the main pieces of information collected from the Kentucky Clearinghouse database to help with inspection selection decisions?
5. Based on all data collected, how are decisions related to inspections made? What methodologies play a role in the decisions (ISS algorithm, inspector judgment, etc.)? How much is based on data collected and how much is based on inspector observation and judgment?
6. How has the inspection selection process changed with the integration of ISSES at the London site?

E. Future Deployments: (perhaps discuss these questions as a group if possible)

1. Would the ISSES yield greater benefits if it were more fully integrated with state and national systems, such as Query Central, state inspection or licensing databases, SAFER, Commercial Driver License Information System (CDLIS), National Law Enforcement Telecommunication System (NLETS), etc.?
2. Does each ISSES subsystem work satisfactorily in a stand-alone mode?
3. Would the ISSES data be useful if made available to inspectors in other jurisdictions (e.g., other parts of the state or similar roadside systems in other states)?
4. What aspects of the ISSES data do you rely on with the greatest confidence? If there are no aspects that you rely on, what changes to the system might motivate you to use and rely on the data?
5. Can you share any lessons learned that would perhaps be useful to other states considering the deployment of similar equipment? (e.g., working with equipment, training, location of the equipment on-site, etc.)

F. Please answer True or False to the following statements:

1. Inspectors believe that ISSES enables roadside inspectors to perform their job functions better.
2. Inspectors believe that ISSES should be deployed more widely.
3. Inspectors found their training and user documentation for ISSES to be helpful to them in their normal course of duties.

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Appendix C.
Interview Response Transcript

Notes made by the interviewer on the responses to in-person and telephone interviews among six KVE personnel are transcribed below. Respondent code numbers, R1, R2, etc. are used to preserve the anonymity of respondents while illustrating continuity across multiple answers per respondent. Four respondents were assigned to the Laurel County site at the time of the interviews (June 2007), and one respondent each was from the Kenton and Simpson County sites.

A. General Questions about ISSES		
A1	Have you used any part of the ISSES technology? If so, please list the subsystems you have used. Also note about how much you have used the subsystem and for how long.	
	R1	Yes, R1 uses the thermal inspection/IR device. R1 familiarized himself with the technology several months ago. Also uses the radiation monitor, both the fixed and hand-held units. The radiation monitor alarms “a lot” for items like kitty litter and brick, both of which emit gamma rays. The audible alarms are different [i.e., items that emit higher gamma rays (40, 50, even 60,000) produce noisier/higher sounding alarms]. Bricks (~ 4-5,000) produce a lower sound. In short, R1 uses both technologies daily. Higher number equals higher sound.
	R2	Yes, some basic training on IR device and radiation monitor and laser scanner.
	R3	Is familiar with radiation and IR device, not as much laser scanner/vehicle detector. Has been on-site when alarm occurred. Called phone number on ORNL, 12 to 13 agencies showed up, sirens going, including FBI. It was shingles that triggered alarm. Would like to put heads together to develop an SOP (e.g., if alarm goes off, use hand-held radiation device and email Frankfort Fusion Center. Vendor should have done more “in the event of…” No formal training provided, no notice that it was here. In the 2 years R3 has been there, he’s had training for hand-held radiation device – separate vendor.
	R4	Yes, R4 used radiation monitor and has “heard it alarm,” knows how to review alarm, location, but has “limited knowledge to overall use.” Watched brakes on IR screen. Seen LPR and USDOT reader, but never seen in operation.
	R5	No.
	R6	Yes, R6 has used the thermal imaging equipment for about 8 months at this location.
A2	Does the ISSES equipment appear to be user-friendly?	
	R1	For the most part, yes. Only problem is that with the radiation monitor, there was no initial training. They were getting alarms left and right. Is now “comfortable” with radiation monitor. Brought up personnel issue. (Blue uniforms are KVE inspectors, inspectors use IR; Tan uniforms are KVE road officers.) Two inspectors currently at weigh station, hired two more, one is starting in July. Staffing the technology is an issue. The idea is, once inspectors and officers get recognition training, they still aren’t sure of the capabilities of the technologies, “not sure if technology is functioning [correctly].” They just don’t know enough about it, “not sure who is responsible for training to get us on the same page.” Believes the ISSES equipment needs to remain there.
	R2	When it’s working it does. People are always in and out making repairs and the screens are password protected. Different face each time; they do what they have to do, repair, and leave. Vendor has had show and tell with other states (OH, VA, WV, MS, TN, an MO); however technicians never ask for inspectors’ feedback. Estimates it works “20% of time,” times out, a “user ID” screen shows up, and sometimes starts up remotely. Does someone monitor the system remotely? If yes, why do they have to come on-site to make repairs?
	R3	Training would make it user friendly.
	R4	With training, yes. Password issue.
	R5	Personnel have not been adequately trained at this point. R5 cannot say.
	R6	Yes.
A3	If you haven’t used any part of the ISSES equipment, can you explain why you aren’t using it? (e.g., time issues, staffing, training issues)	
	R1	No training yet to become familiar with it. In R1’s position, he doesn’t do a lot of hands-on inspection.
	R2	Time issues is a major thing. R2 has to conduct so many inspections per week. Staffing and training are also issues.

	R3	All three (timing, staffing, and training). There is so much to do and not enough people to watch machine, but lack of training is biggest culprit.
	R4	Access to equipment and training.
	R5	Lack of training on equipment.
	R6	Not been trained on radiation equipment.
A4	What do you want from the ISSES equipment (or any technology for that matter)? And, is there information that is difficult for you to obtain that a technology would make easier?	
	R1	Main thing R1 wants is training. Hand-held radiation detector complements radiation portal monitor. "Definite" thing to have if you have a portal monitor. The portable hand-held unit provides a confirmation of what it is, which also adds a safety benefit [to the inspector]. It is R1's understanding that any radioactive material can be shielded, even a dirty bomb.
	R2	[IR/thermal imaging system] shows one side of vehicle. Would like split screen to see other side of vehicle. Put equipment too close to building; by the time the truck arrives [at the scale house] it's too late. The radiation monitor is "very sensitive" and can result in wasted time if it alarms too frequently. "You want to hear every alarm, but you don't want to chase down every truck."
	R3	Can't think of anything else. R3 is "sure it's a good piece of equipment," but is not generating the return on investment that it could be generating. States come in and visit the system, but they can't tell them how to use it. The system is in password protected mode, black screen. R3 has never been given info, and hitting enter twice doesn't even work (earlier instructions provided to them).
	R4	Record of trucks coming though is beneficial. A record is nice. The radiation monitor is nice to have because of the nature of shipments. Needs to be finely tuned to limit false alarms on bricks and toilets. Needs an alarm cutoff. So many alarms going off.
	R5	Training, reference materials, contact information that allows inspectors access to personnel with a working knowledge of equipment.
	R6	Real-time information that would be useful in locating violations that occur within the facility.
A5	What would make you, or others you work with, use ISSES or utilize it more than you are currently using it?	
	R1	Training.
	R2	Hire someone to sit and monitor ISSES. Thinks it's staffing more than training.
	R3	Training.
	R4	More training to familiarize us with equipment.
	R5	Just knowing how.
	R6	Initial training on the equipment.
B. Questions to be asked if interviewee uses any portion of the ISSES Equipment		
B1	Do you recognize noticeable gaps in the data provided by the ISSES (or a particular subsystem)?	
	R1	No idea.
	R2	No, not sure what to look for though.
	R3	The gap is that [inspectors] never know when equipment is working because it is password protected. (Kentucky Transportation Center staff visited the station and it was a big disappointment to see that it wasn't working. Vendor technical support specialist has been there about 3 weeks.)
	R4	Noticeable gaps in operation. More days not working than working. IR device is pretty consistent, "a lot more reliable."
	R5	N/A
	R6	No gaps noticed with thermal equipment.
B2	Does the ISSES generate too much information for weigh station staff to appreciate and use in the time available for an inspect/bypass decision?	
	R1	Again, can't answer because R1 doesn't know enough about system. "Let's have a conversation again in 6 months" after training.
	R2	For audible radiation alarms, 90% of them are a waste of time. In terms of too much information, "Yes, in that it is constantly sending off alarms."
	R3	Don't know.
	R4	Not really. R4 utilizes ISSES for brakes. For the IR siting, it could work [better] further away, not closer that's for sure. (But not too far away, either, because inspectors could mix up trucks.)
	R5	N/A
	R6	No for thermal equipment. Unable to answer for the radiation equipment.
B3	Are there ISSES features or functions that could be changed or that future upgrades could offer?	
	R1	For radiation portal monitor, R1 would like to retrieve information such as where the radiation is located, how much is there, and generate an "e-mail to whomever." R1 can do this with the hand-

		held, but not on portal.
	R2	See both sides of truck for IR device.
	R3	Don't know. Lapse in ALPR recognition perhaps, then when the ALPR system is working, the USDOT number system won't work. Inspectors use IR or radiation monitor during downtime.
	R4	As far as an ALPR addition, states check through NCIC database, hit on license plate, run it against NCIC database.
	R5	N/A
	R6	Unknown at this time.
B4	What benefits does the ISSES offer? Do these benefits make your job more convenient/easier compared to the legacy system?	
	R1	Don't use it enough; just radiation portal monitor when something goes wrong.
	R2	Doesn't see what it actually does. It does get USDOT number, but is no benefit to people on-site. Those who benefit [from ISSES] are those operating remotely.
	R3	No, it doesn't make job easier. ISSES would offer benefits if we knew how to utilize it.
	R4	Gives you a heads up with respect to IR and radiation monitor. Soil density meter example: R4 knew "right where to look" and then used hand-held radiation detector to verify (gave off loud alarm). Good to have both hand-held (to verify at scale house) and stationary portal monitor.
	R5	N/A
	R6	Unable to answer.
B5	What aspect of the ISSES equipment enables you to perform your job function better?	
	R1	Not much, but for vehicle inspectors, the IR should benefit them.
	R2	Haven't used it, don't know, and don't have time. R2 was trained on radiation monitor and IR device and does not feel that additional training is needed. The hand-held radiation detector is not enough insurance for him to feel safe.
	R3	IR device helps. The majority will be IR. R3 does not need training to distinguish between brake colors (i.e., white=hot; black=cold).
	R4	Heads up, additional information.
	R5	N/A
	R6	Seems to be much easier to locate possible brake defects with the IR/thermal system than working a location without it.
B6	Comment on the system. Does the ISSES equipment perform as expected, based on the specifications or product literature? If not, elaborate on the performance of the particular subsystem.	
	R1	Again comes back to training. Really don't know enough to answer.
	R2	No comment.
	R3	No idea.
	R4	IR pretty much performs satisfactorily; others unsatisfactory/unreliable as far as daily functions.
	R5	N/A
	R6	Unable to answer.
B7	Does one subsystem add more value than another, or do all subsystems equally help you perform your job function better? (e.g., "Subsystem X helps staff perform their job functions better, but Subsystem Y is difficult and time-consuming to interpret")	
	R1	Really don't know enough to answer.
	R2	Doesn't help R2 do his job better.
	R3	IR.
	R4	Radiation monitor and IR device provide more information.
	R5	N/A
	R6	Unable to answer at this time.
C. Training Questions		
C1	Has training been provided for the use of the ISSES equipment? If so, how long did the training last? If not, how much training would be needed to become proficient in any of the ISSES subsystems?	
	R1	No training has been provided. Not sure of a timeline, at least a couple days [would be needed]. Again, don't know the capabilities of the system to really give training timeline.
	R2	No training has been provided; some training for IR device and radiation monitor. R2 is accountable for so many inspections: 6 to 7 inspections/day; each inspection runs 45 minutes to one hour.
	R3	No training has been provided, and it's hard to say the amount of training needed. Nothing "over their heads." Nuclear scientists aren't on site.
	R4	As technicians work on system, they have given him info, more like self-motivated training, nothing formal.
	R5	No. Details of training content are unknown to me. I need more information to answer accurately.

	R6	Not at this time. Should need a couple of days to train.
C2	Are specifications or documentation (e.g., user's manual) on the ISSES equipment available on-site? Was it detailed enough, what details were missing? What kind of additional documentation would be useful?	
	R1	Some of it is, probably not all of it, though. R1 probably looked more through it than anyone. Some radiation portal monitoring information exists. Documentation [that would be helpful] include user-friendly training manuals and "cheat sheet" or "Cliff's notes."
	R2	Not sure if anything is here. There is a one-page flowchart on high-pitch radioactive protocol, provided by Frankfort, and maybe posted on wall.
	R3	Anything would be useful at this point.
	R4	Not that he's aware of. Useful info would be a flowchart or quick reference guide for different aspects of system.
	R5	No and N/A.
	R6	Basic response guides are available. Unable to answer without knowledge of operation of radiation equipment.
C3	How do inspectors or managers deal with the potential liability for missed detections of unsafe or high-risk trucks, which might traverse the weigh station and then become involved in a crash caused, for example, by faulty brakes? Is there an ISSES operating protocol that helps inspectors detect as many unsafe trucks as possible or practical, and if so, how effective is that protocol?	
	R1	Inspectors do not know if they missed a faulty brake; not sure IR would [either]. Officers will chase down vehicles running. If there is a protocol, he hasn't seen it.
	R2	ISSES doesn't show you things that could be faulty (e.g., broken air reserve tank, things under truck could fall out, straps). IR doesn't help here.
	R3	No.
	R4	No personnel assigned to monitor; manpower is an issue.
	R5	Check policies through KVE HQ. Again, you will need to contact KVE HQ for Policy and/or Procedures release.
	R6	Unable to answer.
D. Selection Efficiency		
D1	Other than information from the ISSES, what specific data is collected from the commercial vehicle prior to making a decision on whether to inspect?	
	R1	At officer's or inspector's discretion. A number of things: look at a truck and see a violation or they don't see anything. No "specific data" is collected unless they see something. Not designed to inspect "every 10th vehicle."
	R2	Condition of vehicle, USDOT number, company name, and tire conditions gives him an idea on whether to inspect.
	R3	General appearance of truck, past experience with a particular carrier and weight.
	R4	It's random; notice obvious violation.
	R5	N/A
	R6	Quick visual inspection and tax information that is obtained by data entry.
D2	How is this information collected (sensors, WIM, cameras, eyesight, etc)?	
	R1	Could be eyesight, sensors (one WIM on interstate, one on ramp) or cameras.
	R2	Eyesight. One WIM coming off interstate shown on a screen up front. Keeps an eye on WIM screen to help detect overweight and other stuff.
	R3	Eyesight, WIM.
	R4	Eyesight primary. IR camera and WIM are utilized the most. Trucks are automatically directed to scales. No in-house alarm. There is an audible alarm if it bypasses scale. Need another camera as to which audible truck is alarming.
	R5	N/A
	R6	Eyesight and data entry.
D3	Are any external data sources (SAFER, SafeStat, Query Central) used to supplement data collected at the site?	
	R1	Yes, all of them.
	R2	Uses SAFER & Query Central a lot. R2 doesn't use SafeStat.
	R3	Yes all three. Not so much SafeStat, more of "compliance review" safety score, past inspections.
	R4	Utilize SAFER and QC (weight and tires to SAFER).
	R5	N/A
	R6	SAFER and Query Central are used.
D4	What are the main pieces of information collected from the Kentucky Clearinghouse database to help with inspection selection decisions?	

	R1	Check with an inspector for this question.
	R2	Use Kentucky Clearinghouse to see whether truck has Kentucky fuel tax credentials.
	R3	If the vehicle is in the database, if their taxes and insurance are current.
	R4	Not sure.
	R5	N/A
	R6	None.
D5	Based on all data collected, how are decisions related to inspections made? What methodologies play a role in the decisions (ISS algorithm, inspector judgment, etc)? How much is based on data collected and how much is based on inspector observation and judgment?	
	R1	It's hand in hand, obvious violation equals inspection. Data and judgment comes into play, including SAFER database.
	R2	a) inspector judgment and b) solely based on inspector observations and judgment
	R3	Inspector judgment to determine flat tire, lights out, placard violations, obvious defects.
	R4	Pretty much solely judgment based on scales or alarms that go off.
	R5	N/A
	R6	Mostly based on judgment, 75% observation and 25% data based.
D6	How has the inspection selection process changed with the integration of ISSES at the London site?	
	R1	It has not changed much. Last year IRIS vans were used, on-site 1 to 2 times per month. It is expected to be back at least once a week. On-site IR system has more benefits than IRIS (is convenient); one could complement the other.
	R2	Don't think it's changed any.
	R3	Not a whole lot.
	R4	WIM, not ISSES, has increased number of overweight vehicles pulled over. ISSES change is that it now gives a "heads up."
	R5	N/A
	R6	Not at all.
E. Future Deployments: (perhaps discuss these questions as a group, if possible)		
E1	Would the ISSES yield greater benefits if it were more fully integrated with state and national systems, such as Query Central, state inspection or licensing databases, SAFER, Commercial Driver License Information System (CDLIS), National Law Enforcement Telecommunication System (NLETS), etc.?	
	R1	Yes, the way it is now you have to run USDOT number against 1 to 2 places to get information. To tie all together would make inspector's job easier.
	R2	Believe it would.
	R3	No idea.
	R4	USDOT readers connected to a database would be useful. Siting is an issue; where scanners are currently located makes it hard to make the inspection decision in time.
	R5	Yes.
	R6	I think that it would.
E2	Does each ISSES subsystem work satisfactorily in a stand-alone mode?	
	R1	Yes, from what R1 knows.
	R2	They should be together; too much stuff is separate. ISSES should be integrated with what is already available on-site for inspectors. ISSES should be "weaved into databases" (e.g., Query Central).
	R3	Don't know.
	R4	As far as scanners, slow down give them "more reaction" time. IR camera mount should be "no closer than where it is."
	R5	See previous answers.
	R6	Unable to answer.
E3	Would the ISSES data be useful if made available to inspectors in other jurisdictions (e.g., other parts of the state or similar roadside systems in other states?)	
	R1	Yes, it would be useful if everybody knew how to operate the system.
	R2	Yes, but still need a little convincing.
	R3	Don't know.
	R4	Yes, knowing truck came through "time stamped" would make it easier to verify log books. It would be a big database to keep up with though.
	R5	Yes.
	R6	I believe that it would be helpful.
E4	What aspects of the ISSES data do you rely on with the greatest confidence? If there are no aspects that you rely on, what changes to the system might motivate you to use and rely on the data?	
	R1	Would like to know more about it.

	R2	A lot more time to work with system.
	R3	IR because you can actually see trucks on the screen (and again little to no training).
	R4	IR.
	R5	N/A and again, see previous answers on workability and function.
	R6	Unable to answer, not familiar with equipment.
E5	Can you share any lessons learned that would perhaps be useful to other states considering the deployment of similar equipment? (e.g., working with equipment, training, location of the equipment on-site, etc.)	
	R1	Would like to know more about it
	R2	Location of equipment. Before installing, deployment team needs to gain knowledge about timing. When a radiation signal [alarm] is sent, an inspector can't stop the truck in time. Siting issue.
	R3	Part of the cost to the machines would include the cost of training.
	R4	Give enough reaction time to stop the vehicle; siting concerns.
	R5	After initial installation has been completed, make sure training follow-up has been planned to introduce the system to potential users; specifically operation of the system.
	R6	Not at this time.
F. Please answer true or False to the following statements:		
F1	Inspectors believe that ISSES enables roadside inspectors to perform their job functions better.	
	R1	True
	R2	False, because they don't rely on it all the time, because they don't have time.
	R3	False, again don't know how to use it.
	R4	True, because you have heads up advantage.
	R5	True.
	R6	Unable to answer.
F2	Inspectors believe that ISSES should be deployed more widely.	
	R1	True
	R2	False, need more time.
	R3	False, based on system here.
	R4	True, with training
	R5	From what I know, I feel that this is a valuable, usable system. As long as personnel are properly trained to make full use of and take proper advantage of all aspects of the system, I would say yes.
	R6	Unable to answer.
F3	Inspectors found their training and user documentation for ISSES to be helpful to them in their normal course of duties.	
	R1	True, if training was provided.
	R2	False, need more knowledge.
	R3	False, none received.
	R4	I'll answer it after it happens.
	R5	N/A
	R6	Not been trained yet.

Appendix D.
Prior Research on Infrared Brake Screening Technology for CMVs

This appendix comprises a short summary of the USDOT (2000) study conducted to evaluate infrared brake screening technology. The full report is available online at: http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//13339.pdf.

A study was conducted from June 1999 to May 2000 on behalf of FMCSA, in which a mobile IR camera-based inspection system (IRISystem) was evaluated in four states (FMCSA 2000). The IRISystem enables the operator to recognize wheels, tires, and other components that are markedly hotter or colder than normal, which can signify brake defects and other potential safety problems.

In the FMCSA study, 392 commercial motor vehicles were identified by the operator of the IRISystem and were pulled out of the traffic stream. These vehicles were subjected to a Commercial Vehicle Safety Alliance (CVSA) Level 1 inspection. Most of the vehicles selected for inspection had potential defects or problems as observed by the system operator. Some "control group" vehicles with no evident problems observed in the IRISystem screening were also pulled for Level 1 inspection, to reduce the potential for bias on the part of the Level 1 inspector.

Results from the vehicles selected for inspection using the IRISystem in this field study were compared with inspection results as recorded in the SafetyNet system for all inspections from 1997 to 1999 in the four participating states: Georgia, Kentucky, North Carolina, and Tennessee. The percentage of vehicles placed out of service (OOS) after IRISystem screening (59%) was significantly greater than the percentage of vehicles placed OOS using the previous screening methods (27%), or more than twice as effective. Of those vehicles placed OOS after IRISystem screening, nearly 80% were placed OOS for brake violations.

The percentage of vehicles with brake violations increased by 2.5 times, from 34% with current screening methods to 84% with IRISystem screening (FMCSA 2000, pg. ix).

It was noted that the brake violations reported in this study were not necessarily all OOS violations. That is, a vehicle could have a brake defect recognized as a violation in a CVSA Level 1 inspection, but the defect is not sufficient cause to place the vehicle OOS.

Other relevant findings from this study were:

1. The majority (90%) of the problematic wheels reported by the IRISystem operator were cold brakes (pg. 20).

2. The majority of problems identified during IRISystem screening were located on the trailer wheels on the far side of the CMV with respect to the IRISystem van. This may have been due in part to wheel covers on the near-side wheels, which obstructed the view of the brake components on those wheels, and the better lines of sight from the IRISystem to the far-side back wheels (pg. viii).

3. The presence of brake defects or deficiencies was a good indicator that other repairs were needed on the CMV (pg. viii).

4. Mainline screening of CMVs at speeds greater than 55 mph was attempted with the IRISystem, but it was determined not to be practical in this study (pg. 20).

Reference

USDOT. (2000). Evaluation of Infrared Brake Screening Technology: Final Report. Report prepared for Federal Motor Carrier Safety Administration, U.S. Department of Transportation, Contract No. DTFH61-96-C-0007. Report No. DOT-MC-01-007, NTIS PB2001-100010, EDL # 13339, available at: http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//13339.pdf.

Appendix E.
Maintenance Summary (April – August 2007)

For ISSES Equipment Deployment at Laurel, Kenton, and Simpson Counties (KY)

Item	Location / Date	Reason
1	Simpson Co. April 20, 2007	Vendor personnel moved the cables for the new scale console install. They discovered the DVR was not working. Working with Toshiba technical support, vendor personnel re-installed drivers, which returned it to working order.
2	Laurel Co. May 25, 2007	The USDOT number reader camera was not working. One of the fiber optics converters was defective. Vendor personnel replaced it, which resolved the issue.
3	Kenton Co. July 16, 2007	The thermal imaging camera stopped working, which vendor personnel attributed to a potential lightning strike. The manufacturer repaired the system by replacing a circuit board.
4	Simpson Co. August 2, 2007	The PTZ (pan-tilt-zoom remote video control) on the overview camera stopped working during a severe electrical storm. Vendor personnel returned the system to the manufacturer. The manufacturer repaired the system by replacing a circuit board.
5	Laurel Co. August 30, 2007	The thermal imaging camera stopped working, which vendor personnel attributed to possible lightning. The manufacturer repaired by replacing a circuit board.

Comments

- As far as the hardware components, the system has been very reliable.
- Because of power interruptions, mainly at the London site, vendor personnel have had to re-boot a server or re-cycle power to some devices a few times.
- Vendor personnel are investigating the need for installing and implementing uninterruptible power supply (UPS) systems at weigh station sites.
- ISSES software relies on many subsystem hardware/software components working properly in order to continue operating.
- The resolution of ISSES software issues occupies the majority of vendor technical support personnel time.
- ISSES software itself may not be the cause of the problem. All network and ISSES systems need to be manually restarted after power interruptions or other system issues. This is sometimes attainable via remote access; however on some occasions requires site visits and unavoidable downtime.
- Until an integrated plan for the hardware and software is implemented, the ISSES is vulnerable to downtime because of any potential hardware/software-related component issues.
- It is anticipated that downtime will be avoided once the production version of ISSES is installed.

Adapted from e-mail message from David Hunsucker, Kentucky Transportation Center, to independent evaluator, October 17, 2007.