Intelligent Transportation Systems
Field Operational Test
Cross-Cutting Study

Commercial Vehicle Operations - Roadside

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16. Abstract

Commercial Vehicle Operations - Roadside report discusses the findings and conclusions exclusively from Field Operational Tests (FOTs) of roadside Intelligent Transportation Systems (ITS) for Commercial Vehicle Operations (CVO). The FOTs considered in this report include: The technologies demonstrated by the Field Operational Tests (FOTs) discussed in this report include Geographic Positioning Systems (GPS), Dedicated Short-Range Communications (DSRC), License Plate Recognition (LPR), Weigh In Motion (WIM), Road Weather Information Systems (RWIS) and Downhill Speed Information Systems (DSIS). The FOTs considered in this report include: Tranzit Xpress Systems, Advantage I-75 Mainline Automatic Clearance Project, Wisconsin/Minnesota Automatic Out-Of-Service, Oregon Green Light Commercial Vehicle Operations Test, Heavy Vehicle License Plate/ Crescent, Idaho Out-Of-Service, Dynamic Downhill Truck Speed Warning System Test, International Border Crossing Tests and Automated Mileage and State Line Crossing Operational Test. The report findings are organized in the categories of impact, user response, technical lessons learned and institutional challenges and resolutions. This report highlights the successes and problems these tests encountered while attempting to develop the technologies appropriate to effectively automate commercial vehicle administrative processes.

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EXECUTIVE SUMMARY

This report discusses the findings and conclusions from fourteen different field operational tests of roadside Intelligent Transportation Systems (ITS) for Commercial Vehicle Operations (CVO). Roadside ITS/CVO systems consist of those implementations aimed at improving commercial vehicle safety and efficiency through the use of in-vehicle or infrastructure-based technologies, or a combination of both.

The technologies demonstrated by the Field Operational Tests (FOTs) discussed in this report include Geographic Positioning Systems (GPS), Dedicated Short-Range Communications (DSRC), License Plate Recognition (LPR), Weigh In Motion (WIM), Road Weather Information Systems (RWIS) and Downhill Speed Information Systems (DSIS).

The findings from these FOTs demonstrate that commercial vehicle electronic screening systems offer both time and cost savings to motor carriers that choose to enroll in one of the programs offering weigh station by-pass. Testing indicates that for every weigh station by-passed, savings of up to nearly 5 minutes, and 0.2 gallons of fuel, can be realized even without queuing or stop and go traffic. Since both tine and fuel are precious commodities, these savings translate directly to a carrier's bottom line.

Electronic screening has also further demonstrated its potential as a force multiplier for state enforcement efforts. By accessing information regarding Out-Of-Service (OOS) orders using LPR technology linked to a state database, two states effectively improved the odds of identifying vehicles operating in violation of a standing OOS order.

Electronic screening met with more limited success within the often constricted international border crossing environment, where DSRC antenna placement and tuning become very important

Using a GPS system, a map database, and an algorithm designed to calculate mileage accrued in different states, one program effectively demonstrated that improvements in accuracy and reductions in workload associated with reporting apportioned mileage for fuel tax returns are possible.

Not surprisingly, users generally responded favorably to those systems that proved reliable and accurate, and were perceived to offer some value. Electronic screening systems, in most instances, met with favorable responses from both carriers and state agencies, with the exception being some border crossing users. Users of systems designed to improve the accuracy and timeliness of information regarding the contents of hazardous materials (HazMat) shipments were receptive to the information, but were reluctant to view them as more than a supplement to existing methods. The mileage apportionment system met with acceptance, but was deemed to have limited value as a standalone system.

Video imaging and LPR continued to demonstrate some shortcomings, while DSRC, GPS and WIM continued mainstream proliferation. The effectiveness of DSIS and RWIS has yet to be demonstrated.

Carrier participation and privacy, jurisdictional coordination, and DSRC standards continue to be a concern, though progress has been made.

REPORT BACKGROUND

In 1991, the U.S. Department of Transportation (USDOT) initiated a new program to address the needs of the emerging ITS field. This program solicited and funded projects, called FOTs. The tests were sponsored and supported by several administrations of the Department, including the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the National Highway Traffic Safety Administration (NHTSA).

The FOTs demonstrated potentially beneficial transportation products, technologies, and approaches. The FOTs implemented these products, technologies, or approaches on a limited scale under real-world operational conditions. These tests were an interim step bridging the gap between conventional research and development (that formed the idea), and full-scale deployment (that would see wide-spread use of the idea). FOTs typically included a local or regional transportation agency, as well as the FHWA, as partners in the project. The partners often included private sector providers of the equipment, systems, and services interested in demonstrating their idea. The FOTs concentrated on user service areas needing a "proof of concept" in order to achieve deployment goals.

A fundamental element of each test was an independent, formal evaluation. The evaluation produced a final report that detailed the test's purpose, methods, and findings. The evaluation aspect of the test was intended to assess whether the product, technology or approach provided effective solutions at acceptable levels of cost, schedule, and technical risk.

As the sponsoring organization and a partner in many of the FOTs, the FHWA played a central role. FHWA supported the tests by providing a standardized set of evaluation guidelines and by helping coordinate and promote the relationships among test partners. The FHWA also acted as the communications clearing house collecting reviewing, and disseminating information about the tests.

Among the more than 80 FOTs, several tests encompassed the same or similar areas of interest. The FHWA is preparing several "cross-cutting" studies that compare or synthesize the findings of multiple tests within a particular area of interest. The purpose of this series of studies is to extract from the separate tests the common information and lessons learned that are of interest to ITS practitioners and that could improve the testing and deployment of future applications of the subject technology.

This study focuses on the topic of Roadside Commercial Vehicle Operations systems and technologies.

INTRODUCTION

Commercial vehicles: large trucks, vans, buses and special purpose vehicles, constitute a major segment of the vehicle population that travels the nation's roads. The owners and operators of these commercial vehicles face substantial challenges that impact their business. These challenges include intense and often complicated regulation, frequent inspections, driver fatigue, and the need for efficient transport on highways that are often severely congested. These challenges have created an opportunity to explore the application of new technologies to address them. Also, the intensely competitive nature of the motor carrier industry has created the incentive for rapid mobilization of technology that will help save time, reduce costs and improve safety. The set of technologies and methods aimed at commercial vehicle transportation fall under the CVO umbrella of ITS.

The development and assessment of these technologies have been supported by FHWA through several FOTs. Some of these tests focused on the administrative processes associated with CVO. The administrative part is covered under a separate cross-cutting report titled "Intelligent Transportation Systems Field Operational Test Cross-Cutting Study: Commercial Vehicle Administrative Processes."

This report deals with the technology deployed at the roadside and inside the vehicle that enables the CVO strategies and processes. The tests analyzed for cross-cutting issues in this report employed a wide spectrum of technologies. These technologies include GPS used for Automatic Vehicle Location (AVL), DSRC used for Automatic Vehicle Identification (AVI), LPR, WIM, RWIS, downhill speed information systems, and Automatic Vehicle Classification (AVC) systems. Each of these technologies has been, or is being evaluated as part of the FOT program. As a result, there are important lessons to be learned and cross-cutting issues that can be identified when these technologies are viewed from a perspective that spans the different FOTs.

This report was prepared using material gathered as part of Booz•Allen & Hamilton's work to provide evaluation oversight support of ITS FOTs. This material includes published and unpublished information prepared by the test personnel and evaluators as well as information gathered in meetings and conversations with test and evaluation personnel.

Booz•Allen was involved in the conduct of several of these test evaluations. The reports prepared by the test personnel and evaluators present the findings, results, and conclusions of the tests themselves. This report interprets the results of the tests with common CVO-roadside elements in an attempt to extract lessons that cut across the group of tests.

FOTs Considered In This Analysis

This report draws its findings from nine ITS FOTs. These tests are:

- **Tranzit *Xpress* Systems (TXS)**—was conducted in northeast Pennsylvania in 1996 and 1997. TXS has been completed and a Final Evaluation Report has been published.

- **Advantage I-75 Mainline Automatic Clearance Project (Advantage I-75)**—was conducted on I-75 and Highway 401 corridor stretching from Florida to Ontario, Canada, through Georgia, Tennessee, Kentucky, Ohio, and Michigan. This test is complete, and the Final Evaluation Report is currently in draft form.

- **Wisconsin/Minnesota Automatic Out-of-Service Verification Test (WI/MN OOS)**—was conducted on the I-90/I94 corridor in Wisconsin/Minnesota. The testing phase of the project is complete and an Evaluation Report has been published.

- **Oregon Green Light Commercial Vehicle Operations Test (Oregon Green Light)**—is being conducted throughout Oregon. Systems have been installed and some preliminary test results were received in early 1998. The Final Report is due in 2000.

- **Heavy Vehicle Electronic License Plate (HELP)/Crescent**—was conducted along the I-5 corridor from British Columbia, Canada through California, and east along I-10 to Texas, where it continued on I-20. The operational testing phase ended in September 1993, and several Evaluation Reports have been published.

- **IDAHO Out-Of-Service Test (ID OOS)**—is being conducted at the east Boise port-of entry. The system became operational in 1998. Detailed test results are expected in late 1998.

- **Dynamic Downhill Truck Speed Warning System Test (DTSW)—**was conducted at the Eisenhower tunnel on I-70 in Colorado. An Evaluation Report is expected in late 1998.

- **International Border Crossing Tests—**are being conducted at six different locations throughout the United States–two sites on the United States border with Canada, and four sites along the United States border with Mexico. One test, conducted at the Otay Mesa, California, international port facility, is complete. The system has been in operation since September 1996. The operational test ended in March 1998, and the Final Evaluation Report has been published. Among the remaining sites, three are conducting evaluations. Expedited Processing at International Crossings (EPIC), which is located in Nogales, Arizona, is scheduled to end in August 1998. The Peace Bridge International Border Crossing System, located in Buffalo, New York, will conclude in October 1998. The Ambassador Bridge Border Crossing System (ABBCS) will be completed in June 1999.

- **Automated Mileage and State Line Crossing Operational Test (AMASCOT)—**was conducted in the states of Iowa, Minnesota and Wisconsin. A Final Evaluation Report was completed in May 1996.

TXS

The goal of the TXS ITS FOT was to evaluate the ability of advanced communications and information handling technologies to improve emergency response capabilities to Hazardous Material (HazMat) incidents. The TXS employed an information dispatching and operations center, and a combination of on-board electronics and off-vehicle devices to gather and distribute information on the transport of HazMat. It featured one-time data entry for electronic shipping papers as well as providing vehicle and cargo location, status, and theft indication. These information capabilities were intended to provide improved response to HazMat incidents by the provision of early notification to first responders. They were also intended to enhance operational efficiency by reducing the time and costs to commercial vehicle operators and cargo recipients by the reduction of paperwork, streamlining of data entry, reduction of fines, and improvement in incident clean-up time and safety.

When an incident occurs, the TXS would allow the rapid dissemination of information, regarding the cargo and the nature of the incident, by the driver. In case the vehicle becomes disabled, this information could also be rapidly retrieved electronically by emergency response personnel to configure an optimal response to the incident. These systems were coupled with a relational database that maintained data on the customer, stops, bill of lading, and material. This combination provided the operator with the additional capability of maintaining and updating shipping information.

Advantage I-75

The Advantage I-75 is one of a series of tests designed to evaluate various technical and institutional aspects of using mainline automatic clearance for commercial vehicles. The project involved equipping 4,500 trucks with transponders and 30 weigh stations with AVI readers. The AVI readers identify transponder-equipped trucks and verify their weight, size and credentials from a database. Upon verification of credentials, the truck received audible and visual signals that indicated permission to by-pass the weigh station.

The project evaluation included four tests. The motor carrier fuel consumption test investigated savings to be accrued by eliminating or reducing of stops. The weigh station test investigated travel time savings from the elimination or reduction of stops. The jurisdictional issues test examined institutional issues encountered in implementing mainline automatic clearance. Finally, a weigh station simulation effort was conducted, in which seven weigh stations along the corridor were modeled.

WI/MN OOS

The OOS verification system was installed at four inspection stations on the I-90/I-94 corridor—three in Wisconsin and one in Minnesota—to assess its capability to identify trucks or drivers operating in violation of OOS orders. As a commercial vehicle proceeded through one of the four inspection stations (safety and weight facilities) along the test corridor, a scanner read the license plate. The system compared the reading to licenses contained in an OOS vehicle database using specially designed software operating on a personal computer (PC) at each station. If the software found a match of the reading, the system sounded an alarm to inform inspectors. Inspectors could then take whatever action necessary to insure that the problem that had caused the driver or vehicle to be placed OOS had been corrected. State Patrol inspectors in both states had electronic access to the shared OOS database.

The test maintained the OOS vehicle database on a mainframe computer in Wisconsin. All inspection stations involved in the test were linked to the mainframe in real-time. The system updated the OOS database on the PC using a download from the mainframe. The update occurred frequently enough that a truck that was put out-of-service at a station, and then left the station, would be identified at the next station.

Oregon Green Light

The Oregon Green Light ITS FOT is an evaluation of three major technical components intended to enhance CVO throughout Oregon. An electronic pre-clearance system employs transponders and WIM devices to reduce required stops by commercial vehicles at 22 weigh stations. A RWIS collects weather data, processes it, and automatically informs motorists of abruptly changing weather conditions. Finally, a DSIS calculates and displays a safe downhill speed for each passing truck.

The goal of the electronic pre-clearance system is to improve highway safety at and around weigh stations. The system is intended to streamline commercial vehicle traffic flow. The intended results are the reduction of time lost at weigh stations, lower fuel consumption and air pollution, reduction in the number of vehicles that exit and rejoin the traffic stream at weigh and inspection stations, and allowing for the improved allocation of enforcement resources. To use the system, participating trucks are equipped with transponders that electronically identify the truck to roadside readers as the trucks approach weigh or inspection stations.

The purpose of the DSIS is to increase road safety by reducing the average downhill speed of trucks. The DSIS measures the vehicle weight using WIM and reads the license plate using a video system, then computes an advisory speed for each vehicle and displays it on a VMS next to the vehicle's license plate number.

The RWIS aims to increase the safety of all motorists by reducing average speeds in inclement weather and by providing pre-trip travel planning information (for example, on the Internet or through kiosks). The RWIS uses a sensor package to measure air and pavement temperatures, dew point, wind speed, visibility and precipitation, and an on-site Remote Processing Unit (RPU) autonomously detects hazardous conditions and displays a warning message on VMSs. As an additional benefit, the

RWIS reduces the application of environmentally harmful abrasives.

HELP/Crescent

The Crescent Project was the demonstration phase of the HELP program. The Crescent system integrated the use of AVI, AVC, WIM, in-vehicle system, electronic data, and communication technologies to electronically screen commercial motor vehicles.

The program helped the state, motor carrier industry, and service provider participants to assess the benefits and obstacles of HELP services through real-world experience. The HELP program evolved over time, adding to, developing, and refining the services conceived at its inception. The resulting objective of Crescent Project was to enable a legal truck to drive along the entire project roadway network without having to stop at weigh stations or ports of entry.

Crescent established approximately 40 specially equipped weigh station and port of entry sites along a corridor from British Columbia south along I-5 through California, then east along I-10 to Texas, and branching onto I-20 (hence the name Crescent). A central computer stored information about participating trucks which were equipped with electronic transponders. The transponders identified trucks to local weigh stations along the routes. The truck information was used in conjunction with WIM, AVI and AVC technologies to enable trucks to by-pass the weigh station process if determined to be "legal".

ID OOS

The ID OOS ITS FOT evaluates an electronic enforcement tool for OOS orders. The system operates by electronically registering trucks placed OOS by entering both the vehicle's license plate image and its transponder identification in a database. As trucks leave a weigh station, the test equipment checks if the truck has been registered as OOS. If it has been registered as OOS, the system sounds an alarm and notifies the State Police.

When a truck is placed OOS, the inspector registers a report of the violation in a database at the weigh station and issues a transponder to the driver. The system captures an image of the vehicle and registers the transponder number associated with the violation. When the violation has been corrected (for example, the brakes are repaired or the driver is sufficiently rested), the operator can tentatively clear the violation by interacting with a kiosk at the weigh station.

To prevent trucks from leaving the facility before correcting the violation, the system again reads the vehicle image on the way out of the weigh station. The system then compares this image to the one taken previously. If the image matches that of a truck that had been placed OOS and whose violations have not been cleared, the system triggers an alarm and sends a fax to the Idaho State Police. The fax sent to the police includes the image of the license plate as well as additional information so that the police can apprehend the vehicle.

DTSW

The DTSW ITS FOT will evaluate a driver advisory system for long, steep downgrades. The project seeks to affect commercial vehicle driver behavior by providing vehicle-specific, safe downhill speed messages. The system operates by automatically weighing and classifying trucks as they approach a long downhill section of highway. Considering the weight and class of the truck, the system calculates a safe descent speed. Each truck receives a vehicle-specific, recommended safe speed message on a VMS.

The DTSW system consists of inductive loops that trigger the WIM sensors, VMSs, and computer hardware and software. A second set of loop detectors and WIM strips are located on the downgrade 1.5 miles beyond the initial station. Both sets of loops and WIM strips record each vehicle's time of passage, configuration, speed and weight.

International Border Crossing Tests

The primary goal of the International Border Crossing FOTs is to deploy ITS technologies designed to expedite the processing of commercial freight movements at international land borders. As part of the International Border Clearance (IBC) Program, the FHWA has worked with the United States Customs Service of the United States Treasury Department to jointly implement an electronic border crossing system. The system aims to significantly reduce the delay incurred by commercial vehicles at international points of entry.

The various systems address delays at border crossing sites by providing for the electronic exchange of customs, immigration, and transportation data between the trade community and the appropriate regulatory agencies. Using a three-stage electronic screening process, the systems provide the capability to store and forward the carrier, vehicle, and cargo information required to process vehicles through the ports.

Using dedicated short-range communications DSRC AVI technology, the system performs a series of three vehicle transponder reads, and sends a response to the transponder at two of the locations. The first read alerts the United States Customs system of the vehicle's arrival, and triggers the retrieval of information regarding the shipment. The second read prompts the system to display the results of the Customs screening system to the agent at the compound. The third read is performed at the exit to the compound. Drivers are given an indication of their status at the second and third read points via a red or green light on the transponder, and a traffic signal adjacent to each location.

At the Peace Bridge and Ambassador Bridge sites, additional systems for Electronic Toll Collection (ETC) and Dedicated Commuter Lanes (DCL) have also been installed. Both systems rely on information stored on transponders to process bridge traffic. The ETC system automatically debits a prepaid account each time that a user crosses the bridge. The DCL system reads the transponder, and compares the identifier to a database containing immigration information. The inspector at the booth is notified of the status, at which point he/she can allow the vehicle to pass, or exercise the authority to search the vehicle or turn it back. In addition, other components, such as light curtains for automatic vehicle classification, VMSs to relay information to drivers, and magnetic swipe cards for drivers using the DCL were also incorporated into these systems.

The EPIC site added the capability to screen vehicles for compliance with credential requirements by using the DSRC identifier to poll a database containing credential information for each vehicle. The International Border Electronic Crossing (IBEX) system employed an on-vehicle electronic log, and also investigated the use of an electronic brake monitoring system.

AMASCOT

The AMASCOT project demonstrated and evaluated the feasibility of automating the collection of mileage-by-jurisdiction data and Electronic Data Interchange (EDI) for International Fuel Tax Agreement (IFTA) and International Registration Plan (IRP) reporting. The test demonstrated the capability of automated mileage reporting to reduce time and paperwork necessary for motor carrier compliance, and states administering, the regulatory processes for vehicle licensing, permitting and fuel tax filing—thus enhancing productivity of motor carriers and state agencies.

The test involved the motor carrier regulatory agencies in the states of Iowa, Minnesota and Wisconsin and 30 specially equipped interstate commercial trucks that collected mileage-by-jurisdiction data as they operated throughout the United States and Canada. Auditors and processing staff from the three states examined the data for compliance with IFTA requirements.

The technologies assessed as part of this report are summarized in Table 1.

	Technology										
Field Operational Test	GPS (Automatic Vehicle Location)	In-Vehicle Systems	Cellular Communications	DSRC	License Plate Recognition	Vehicle Imaging	Weigh-In-Motion	Road Weather Information Systems	Downhill Speed Information Systems	Automatic Vehicle Classification	Variable Message Signs
Tranzit XPress	X	X	X								
Advantage I-75				X			X			X	
Wisconsin/ Minnesota Out-Of-Service					X						
Oregon Greenlight							X	X	X		
CRESCENT		X		X			X			X	
IDAHO Out-of Service						X					
Dynamic Downhill Truck Speed Warning							X		X	X	X
Border Crossing											
IBEX		X		X							
EPIC				X	X						
Ambassador Bridge				X						X	X
Peace Bridge				X						X	
AMASCOT	X	X									

Table 1: CVO Roadside technologies by FOT

FINDINGS

In this section of the study, we will discuss the findings of each of the operational tests, and of the group as a whole, as they pertain to five key areas:

- **Impacts**—The degree to which the systems and services under test effected change
- **User Acceptance**—How test participants reacted to the systems and services
- **Technical Lessons Learned**—Insights gained regarding the technical performance, feasibility and approach toward each system and service
- **Institutional Challenges and Resolutions—**Issues encountered during the FOTs, and any resolutions reached, and insights into the impacts these issues may have on deployment of the systems and services
- **Deployability**—Insights regarding the degree to which the systems and services under test represent viable deployment alternatives.

IMPACTS

The actual and intended impacts stemming from the implementation of the systems and services deployed in each of the FOTs discussed in this report can be classified into one or more of five major categories: *time savings, fuel consumption, operational efficiency, safety, and cost savings*. Each of these topics is discussed in detail in this section.

Time Savings

The provision of time savings is a major goal of most of the FOTs discussed in this report. However, it can be said that a reduction in the amount of time consumed conducting the various aspects of CVO is most often a means, rather than an end. In the end, a reduction in the amount of time it takes to complete some task or set of tasks becomes meaningful when it is applied to some other, more tangible measure. These supplemental impacts are discussed under other subsections.

Electronic Screening

The primary means of providing en-route time savings for commercial vehicles has most often taken the form of DSRC based AVI systems. In each of these systems, information stored on a transponder mounted inside a vehicle's windshield is retrieved and used to query a database containing information on the status of the vehicle. The Advantage I-75, Oregon Green Light, HELP/Crescent, and each of the border crossing FOTs employed this technology, which is commonly referred to as electronic screening. In addition, the Advantage I-75, Oregon Green Light and HELP/Crescent employed WIM devices to allow for the screening of vehicles at mainline speeds. Three of these tests–Advantage I-75, HELP/Crescent, and IBEX–are complete, and offer some insights into the potential time savings associated with electronic screening.

The two weigh station by-pass systems demonstrated the ability for electronic screening to provide time savings. These savings accrued from the removal of the delays associated with deceleration, in-station activities, and

Average time savings per weigh station by-passed using electronic screening:

Advantage I-75 – 1.33 to 4.86 minutes

HELP/Crescent – 1.17 minutes

acceleration back to mainline speed. In the Advantage I-75 test, actual measured savings ranged from 1.33 to 4.86 minutes per weigh station by-passed. The amount of savings was a function of the configuration of the station itself, with larger savings accrued in by-passing weigh stations equipped with static scales, and the level of traffic at each location.

In the HELP/Crescent FOT, the average time savings from by-passing one of the weigh stations equipped with electronic screening was 1.17 minutes. Interestingly, drivers actually perceived average savings of over 4 minutes per by-pass.

The assessment of time savings for each of the border FOTs was difficult. While it appears reasonable to expect that the implementation of electronic screening will ultimately result in time savings, the operational environment within which these systems operated prevented this from occurring. Specifically, at each site, Customs officials were required to continue to process vehicles, drivers and cargo in accordance with current procedures. Nonetheless, it would be reasonable to speculate that, as the reliability of the systems reaches acceptable levels, and the level of trust in these systems increases, time savings are likely to be achieved. The magnitude of these potential savings is yet to be investigated. Since both the Ambassador Bridge and Peace Bridge evaluations include modeling efforts aimed at predicting these savings, additional data should be available in the near future.

Finally, while the publication of results from the Oregon Green Light FOT is some time off, because the technologies and practices employed in that effort are consistent with those exercised by the Advantage I-75 and HELP/Crescent projects, the resulting time savings are likely to be consistent, as well.

HazMat Incident Response

Time savings are especially important in responding to incidents, but once again, time savings represents an intermediate benefit. The ability to quickly and accurately assess an incident situation provides responding agencies the ability to deploy the proper equipment and personnel quickly, thus improving the likelihood of minimizing adverse impacts.

The Tranzit XPress FOT demonstrated a system to improve the timeliness and appropriateness of responses to HazMat incidents. An audience of first responders and motor carrier safety officers was asked to estimate the duration of several phases of a typical incident response action for situations where the information Tranzit XPress provides was available and where it was not. A comparison of average times indicates responders and motor carriers believe that some phases will be shortened with the use of Tranzit Xpress. These estimated time savings are presented in Table 2.

It should be noted, however, that the time savings in multiple phases are not necessarily additive, due to the likelihood that some activities may occur in parallel. Nonetheless, given the potential impacts associated with HazMat incidents, any reduction in response time can result in significant benefit.

Table 2
Estimated Response Activity Times

Emergency Response Phase	First Responder Time Estimates (minutes)		Carrier Time Estimates (minutes)	
	without TXP	with TXP	without TXP	with TXP
Hazardous material cargo recognition and identification	15.3	10.1	15.5	5.6
Emergency management agency or HazMat team notification of incident	21.7	15.9	20.7	7.3
Time required for secondary responders to reach the site	58.0	45.8	48.9	42.3

Fuel Consumption

According to trucking industry experts, the cost of fuel represents between 5 percent and 20 percent of overall operating costs for a given carrier. The average fuel economy for a typical new tractor-trailer is approximately 7 miles per gallon. Nationwide, trucks consume on the order of 25 billion gallons of diesel fuel annually. These figures underscore the importance the carrier industry attaches to efforts to promote fuel savings.

The Advantage I-75 test investigated whether the elimination or reduction of stops at weigh stations by transponder equipped commercial vehicle will result in measurable fuel savings. Fuel savings were estimated for three major weigh station types: the static scale design type, the ramp WIM design type, and the high speed ramp WIM design type. Test runs were conducted with trucks fitted with auxiliary fuel tanks that allowed for precise measurement of the fuel consumed. Test results indicated that trucks by-passing the static scale design type would realize fuel savings on the order of 0.16 to 0.18 gallons per by-passed station. Savings from by-passing weigh stations with ramp WIM scales were a more modest 0.06 gallons per by-pass.

These savings are likely to be more significant in instances where long weigh station queues are present. Previous studies of fuel consumption in queues suggests that fuel savings resulting from by-passing static scales may be twice as much when these queues are in stop-and-go driving conditions at an average speed of 4 miles per hour.

Average fuel savings per weigh station by-passed using electronic screening:

Static Scale Station – 0.16 to 0.18 gallons

Ramp WIM Station – 0.06 gallons

Increased Operational Efficiency

As stated earlier, time savings is often simply an intermediate benefit. For example, the time a truck driver might save in by-passing a weigh station may allow him to deliver his load sooner. If he's able to by-pass a number of stations during a single trip, the time savings might become significant. More importantly, this savings actually means that he may be able to run an additional load during a given driving period, or complete a longer more profitable delivery and the carrier may be able to derive a higher fleet utilization level by completing more movements in a given time period.

Additionally, the fuel savings associated with by-passing weigh stations has the potential to also allow for more flexibility in a carrier's decisions regarding when and where to purchase fuel. Both time savings and fuel savings would improve the carrier's operational efficiency, and lead to potential increases in revenue and profit.

While none of the FOTs discussed in this report specifically addressed operational efficiencies gained from electronic screening, some additional insight may be gained by examining the time and fuel savings discussed earlier, within the operational context of a given carrier. It is possible that enhancements in logistical flexibility and efficiency would result in certain circumstances.

At the public level, CVO roadside systems have long held the promise of enhancing the efficiency of roadside enforcement efforts. One of the more common scenarios involves the use of technology as a force multiplier. If technology can be used to effectively perform certain tasks associated with enforcement, then enforcement officials can better focus their efforts on removing unsafe vehicles and drivers from the road.

The WI/MN and ID OOS systems were both conceived as a means to provide a force multiplier for ensuring compliance with OOS orders. Both were intended to provide an efficient and accurate means of identifying OOS vehicles and enforcing related regulations. Of the two tests, only the WI/MN effort is complete.

The WI/MN system utilized LPR technology to assist Motor Carrier Safety Assistance Program (MCSAP) inspectors by screening vehicles for open OOS orders as they passed through a weigh station. The system would poll the Wisconsin Motor Carrier Enforcement System (MCES) database for information on current OOS orders, and provide the results to the inspectors at the station.

Because inspectors currently check the MCES database only when a vehicle has been selected for inspection, the ability of the WI/MN system to screen a substantial portion (36 percent to 44 percent) of the vehicles passing through a station, effectively multiplied the capabilities of the staff at the station. While this represents an improvement in screening for OOS orders, a number of technical and operational issues remain unresolved. The two most significant of which are the frequency of correct license plate reads by the LPR system, which ranged from 50 percent to 60 percent during the test, and the detection and screening of vehicles and drivers avoiding the weigh stations, or passing by when they're closed.

Operational efficiency improvements can also take the form of reductions in the costs associated with performing administrative functions. While this topic is discussed in detail in the CVO Administrative Processes Cross-cutting report, the ability of roadside systems to enhance those efficiencies bears highlighting here.

The AMASCOT system utilized GPS for accurate reporting of apportioned mileage data. By providing an automated means to capture the mileage accrued in each state, the system effectively simplified two labor-intensive steps in the preparation of quarterly International Fuel Tax Agreement (IFTA) reports. The manual recording of mileage by jurisdiction by the driver and the reconciliation of driver's logs with the IFTA reporting requirements were automated.

A case study approach was used to assess the system benefits. Based on current processes, state agencies responsible for IFTA indicated potential benefits falling into two categories—Processing Benefits, and Auditing Benefits. Information regarding current state processes was gathered, and based on the defined system model, agency representatives were asked to estimate potential impacts to processing and auditing activities.

State agency processing staff in the three participating states generally concurred, in varying degrees, that the automated mileage data collection and filing system would result in increased reporting accuracy, reduced data entry, more efficient data storage and retrieval, and less time spent resolving inaccuracies.

"State agency processing staff generally concurred, in varying degrees, that the automated mileage data collection and filing system (AMASCOT) would result in increased reporting accuracy, reduced data entry, more efficient data storage and retrieval, and less time spent resolving inaccuracies."

Auditing staff in the three states also cited additional likely benefits: the ability to audit the electronic data using specially developed audit software, improved ease of querying information, decrease in the time required to perform audits, improved data accessibility resulting in greater audit efficiency, and increased reporting accuracy.

While general agreement exists regarding the types of potential benefits, the assignment of specific values for each is problematic. The magnitude of the benefits would depend on the level of implementation among carriers and service agents.

Among responding carries, service agents and leasing companies that acknowledged that the system offered potential impacts, there was general agreement that the cost of compliance with IRP and IFTA requirements would be reduced through savings in data entry, paperwork, and a reduction in data errors and the associated reconciliation. While these respondents estimated benefits on the order of 33 to 50 percent, they felt strongly that a system like AMASCOT would be too costly as a stand-alone system. It was generally felt that it could be combined with other CVO ITS offerings and become a viable service.

Improved Safety

The actual determination of the safety benefits of any given implementation continues to represent a significant challenge. This is most often due to the limited duration of system operation and evaluation of operational tests. Nonetheless, analysis of currently available information allows for some interim conclusions.

As mentioned earlier, the speed with which responders are able to assess the nature and severity of a HazMat incident directly impacts

> **A system like Tranzit *Xpress* has the potential to reduce the time required:**
>
> - for the first responder to reach the incident site
> - for the cargo recognition and identification by the first responder
> - for the cargo notification of HazMat team and/or emergency management agency
> - for secondary responders to reach the site with proper equipment
> - for containment and stabilization

upon the effectiveness of the response. Survey responses provided by first responders and motor carriers indicate a system like that implemented in the Tranzit *Xpress* FOT has the potential to significantly enhance the safety of motorists and residents in the event of a HazMat incident by reducing the time required to make decisions and deploy the appropriate response.

While these results are subjective in nature, responders and carriers alike considered the TXS an improvement compared to existing systems. These findings are a clear indication of the potential ability of the system to enhance safety.

The Downhill Truck Speed Warning (DTSW) System, and the DSIS component of Oregon Green Light both offer potential improvements in safety by providing commercial vehicle drivers with safe speed advisories on downgrades. Because the evaluation of these systems is not complete, it is uncertain whether significant safety impacts will result from their implementation.

Cost Savings

While none of the operational test evaluations cited in this study offered direct evidence of the ability of any system to promote cost savings, a

> **Over the course of a year, a carrier with 1,000 trucks could realize over $35,000 in fuel cost savings alone from the use of electronic screening like that deployed in Advantage I-75**

number of inferences can be made based on the results reported by some evaluations. For example, the fuel savings reported in the Advantage I-75 (up to 0.18 gallons saved per station by-passed) can be directly translated into cost savings. Assuming an estimated diesel fuel price of $1.15 per gallon, carriers can save as much as $.20 per by-pass. Extrapolating this result to a fleet of 1,000 vehicles (assuming 85 percent of the fleet is operational in a given day), each by-passing just one station per day, would result in daily savings of $170. Over the course of a year, this same carrier could realize over $35,000 in fuel cost savings alone.

Additionally, several studies have shown that vehicles experience greater wear and tear with a greater number of stops and starts. Any system that effectively employs the concept of electronic screening can reasonably be expected to provide some wear and tear reduction benefits to the commercial vehicle operators by reducing the number of stops, and stop and go movement in queues.

USER RESPONSE

User response can be characterized as the degree to which the levels of functionality, utility, and value provided by a given system are acceptable to its intended users. Each of the FOT evaluations discussed in this report either has, or will, offer insights into user response. Some responses are based on actual system use, while others are based on "concept" systems—hypothetical systems with capabilities and functions similar to those actually implemented.

To facilitate this discussion, the FOTs are segregated into categories here according to the primary service being addressed: *Electronic Screening, HazMat Incident Response, Administrative Processes and Vehicle Safety*.

Electronic Screening

While user acceptance assessment was not a specific focus of either the HELP/Crescent or Advantage I-75 evaluation, some conclusions can be drawn about the responses of system users. Perhaps the best endorsement of any system or service can be found in the level of support generated among its potential user community. Since electronic screening systems were first deployed under the HELP/Crescent FOT, the use of such systems has grown significantly. Eleven states currently either have, or intend to implement the HELP PrePass system. In addition, five states and one Canadian province have chosen to continue to offer the services available under the Advantage CVO (formerly Advantage I-75) program. An increasing percentage of motor carriers also support the implementation of such systems.

> **"Eleven states currently either have, or intend to implement the HELP PrePass system. In addition, five states and one Canadian province have chosen to continue to offer the services available under Advantage CVO."**

Users of electronic screening systems at international borders have also indicated a positive level of acceptance of such systems. This is in spite of the inability of any of these systems to demonstrate significant, measurable benefits during the border FOTs. At the time of this report, specific results are not available.

HazMat Incident Response

The user response to the TXS was highlighted by perhaps the single most important user acceptance indicator—users were in agreement that it represented an improvement over current systems for storing and disseminating information necessary for incident response.

> **"Half of the First Responders indicated they would like to use a system like Tranzit *XPress*."**

Existing emergency response information sources are considered to be generally good but not outstanding, which is why multiple sources of information are required to confirm cargo contents. The proposed system was considered to be generally better as an information source in almost all areas. However, users felt that it would be most useful as a supplement to existing methods, rather than as a replacement.

As with the electronic screening systems described previously, the overall perceptions users have of the TXS might be best summed up in their intention to use the system. Half of the first responders indicated they would like to use a system like Tranzit *XPress*. In contrast, motor carrier response to Tranzit *XPress* was not as favorable—only 3 of 28 participants indicated they would like to use Tranzit *XPress*.

Administrative Processes

The AMASCOT system evaluation specifically assessed IFTA staff receptivity to implement electronic mileage data collection and electronic filing. Though results varied somewhat across the three states participating in the FOT, processing staff were generally receptive to the automatic mileage data collection for automatic reporting and electronic filing of IFTA reports.

"Because auditors have indicated a willingness to accept the validity and accuracy of the information provided by a system like AMASCOT, it has demonstrated the potential to offer a viable alternative to the current, labor-intensive processes associated with fuel tax administration."

They were also optimistic that all applied benefits were likely to occur. However, processing staff in one state indicated there was an underlying concern about job security.

Perhaps more importantly, auditing staff was highly receptive to the AMASCOT concept. They were also optimistic that the device would be acceptable among the auditing community, and believed that an electronic mileage data collection and filing system will improve accuracy, provide cost savings to motor carriers, and provide the opportunity to conduct more audits. This is significant since the endorsement of auditors is a critically important prerequisite for the deployment of such a system. Because auditors have indicated a willingness to accept the validity and accuracy of the information provided by a system like AMASCOT, it has demonstrated the potential to offer a viable alternative to the current, labor-intensive processes associated with fuel tax administration.

Carrier response regarding system function and potential benefit was generally favorable. All agreed that the concept system had the potential to reduce the costs associated with data entry and reconciliation of records with the state auditors. However, with the exception of only the largest carrier, none felt the concept system, as described, would be considered for implementation. Instead, they felt it should either offer additional functionality, like the ability to produce electronic driver logs and reconcile fuel purchases with mileage records, or be offered as an add-on to a fleet management system.

Vehicle Safety

By definition, downhill speed advisory systems function under the premise that at least a portion of the advisories offered to commercial vehicle drivers will be heeded. Such a result is not only an indication of user response, it is also a direct measure of such systems' effectiveness. When they become available, results form the Oregon Green Light and DTSW FOT evaluations should shed light on these topics.

TECHNICAL LESSONS LEARNED

Most CVO FOTs did not, or will not develop any new technology for freight transportation. A possible exception would be in the area of LPR and vehicle imaging technologies. However, many tests introduced new technical configurations and system integration concepts. Several of the test evaluations specifically addressed technical performance of the system or its components.

GPS

In general, GPS is a widely used and accepted product, available to consumers in the form of Commercial Off-The-Shelf Technologies (COTS). Its reliability, accuracy, and other performance measures are well documented. However, two of the FOTs did demonstrate that GPS could be adapted and configured to meet different CVO needs.

Tranzit *XPress* was not a fully functioning system, but was developed sufficiently to demonstrate it in a laboratory setting. The project included installation of GPS on a small fleet of trucks as part of the system development process. The testing of the system demonstrated the ability to locate a test vehicle from the operation center and place its location on a map visualization product. Its accuracy was sufficient to provide emergency responders with assistance in locating the vehicle without delay. The system demonstrated its location accuracy to be between 50 to 150 feet of actual vehicle location–a result typical of most COTS GPS products.

The AMASCOT project used GPS to determine when a vehicle crossed a state border and to assign a recognizable place name to the latitude-longitude location reading recorded by the system. The accuracy was sufficient to satisfy the requirements of IRP and IFTA auditors in fulfilling mileage recording requirements. Actual state border crossing locations were determined within 75 feet.

In-Vehicle Systems

The problems that arose during the implementation of in-vehicle equipment for the Tranzit *Xpress* FOT were generally attributed to the field testing being conducted before all the technical problems were solved. Many of the problems could be attributed to the complexities of system and data integration.

The single biggest technical lesson learned was the appreciation gained for the difficult and complex problem of remote interrogation of the vehicle electronics. The Tranzit *XPress* concept holds that a first responder could remotely query the master vehicle transponder for cargo information and the master tag would broadcast the contents. Shipment data would be transmitted on an emergency radio frequency in a synthesized voice and in a data stream. This concept was successfully demonstrated using a Ka band radar gun to stimulate the vehicle electronics and a police radio to receive the information. All the following issues require resolution:

- Finding or developing a query device which most first responders have or could acquire cost effectively,
- Finding or developing query and receiving devices with sufficient range to be useable from a safe distance from the vehicle, up to quarter mile,
- Avoiding unintended broadcast of shipment information over emergency or other frequencies due to inadvertent stimulation of the vehicle electronics,
- Assuring cargo content information security from access by those not authorized, and
- Identifying a means or device for first responders to receive the information in an easily decipherable manner, either audibly or electronically.

Perhaps the most significant development to come from the electronic screening FOTs regarding in-vehicle systems is the increased emphasis placed on ensuring transponder interoperability. Significant effort has been expended to develop and deploy transponders that can be used in a variety of AVI applications. Nowhere is this more evident than in the border crossing FOTs. At both the Peace Bridge and Ambassador Bridge, systems have been implemented that allow for the use of transponders for electronic screening for customs and immigration at any international border crossing in the United States, and the collection of tolls on the bridge, and with other existing toll systems.

Cellular Communication

Cellular phone communication technology as a means to transmit data was successfully demonstrated in Transit *XPress*. It was used to transmit vehicle location information to the operations center and to transmit cargo information from the operation center to the vehicle and the on-board systems. Cell phones are a common commodity with well understood limitations and features that offer the opportunity for further exploitation as needed in CVO applications.

LPR/Vehicle Imaging

LPR continues to demonstrate its limitations as clearly as its usefulness. During the course of the WI/MN OOS FOT, several hundreds of reads were attempted with limited success. Of 3,460 attempted reads, 1,413 were successful in correctly interpreting the license plate information, for a success rate of 40.8 percent. Unsuccessful reads fall into two categories: "no reads" and "bad reads." Reasons cited for "no reads" included missing, damaged, or dirty license plates. No reads accounted for 27 percent of the unsuccessful attempts. "Bad reads" were attributed to misinterpretation of the license data, often caused by different styles and colors of various state plates. "Bad reads" accounted for 32 percent of the unsuccessful reads. Excluding unreadable plates, the success rate was 56 percent.

As has traditionally been the case with LPR systems, successful reads seemed to vary by the origin of the license plate and tuning of the system to capture specific plate types improved the success rates. However, with such a large portion of the vehicles having unreadable plates, LPR is clearly a system that has limited usefulness in its current state.

The ID OOS project was originally intending to use video vehicle imaging system to capture the image of a truck as it entered and again as it left the inspection area. Comparison of images was to allow the system to determine when a certain vehicle left the inspection area. The system was never fully functional and has been deleted from the FOT. One of the problems encountered stems from differences in viewing angles that cause a rectangle perceived by the entrance video system to be perceived by the exit video system as a parallelogram.

WIM

WIM systems have been deployed throughout the world in various configurations. Given the trade-off that must be considered regarding accuracy, cost, and durability, implementing authorities have been wrestling with the issue of which type to deploy.

The Crescent project used and tested WIM extensively at many locations. Several different manufacturers and scale configurations were included in testing. Typically, axle weights were recorded with an accuracy of 3 percent with a standard deviation of 10 percent. The high standard deviation compared to the accuracy indicates that the scales were calibrated fairly well, but that random inaccuracy was significant. The pavement conditions around the WIM are important in reducing wheel hop, a significant component of random error.

Total vehicle weight was similarly recorded accurately but with relatively high standard deviations. For vehicles over 10,000 pounds (lbs.), mainline WIM scales were accurate to 5 percent ± 10.1percent while weigh station scales were accurate to 2 percent ± 7.4 percent. Mainline scales had speeds over 40 MPH and weigh station scales had speed between 20 and 40 MPH. For vehicles under 10,000 pounds, percent differences become misleading and less relevant. Therefore, accuracy is best stated in terms of absolute values. With this in mind, mainline WIM scales were accurate to 600 lbs. ± 100 pounds, while weigh station scales were accurate to 200 pounds ± 900 pounds.

Significant advances and refinements in WIM technology and installation techniques have occurred since the Crescent project testing was done in 1993. Since then, WIM has become a relatively well proven and reliable means of data collection, perfectly suited to many CVO applications.

AVI

In general, AVI systems have developed into a commonly accepted tool, in extensive use worldwide in the form of ETC and commercial vehicle electronic screening systems. It is also used extensively in the rail and maritime industries to track freight containers. The extent of its use indicates there is little need to continue to explore its capabilities.

Testing conducted during the Crescent project supports this premise. Testing the reliability (percent of accurate reads) of the AVI system was carried out under a variety of speed, placement, radio interference, and environmental conditions. In virtually all cases the AVI system performed with 100 percent accuracy.

Perhaps the most significant remaining technical challenge is configuring an AVI system that can effectively screen vehicles in the tight confines typical of some border crossing compounds. Results from the IBEX FOT indicate that the utility of transponders for border crossing applications is directly related to the ability of system implementation contractors to configure systems tailored to the unique attributes of a given compound. The placement and tuning of readers and antennae is critical in ensuring transponders are read at the appropriate time.

Results from the IBEX test have illustrated an unacceptable success rate of approximately 60 percent. Many factors contributed to this relatively poor performance, the foremost of which was the basic design of the port in which the system operated. In a facility designed for manual operation, multiple readers were placed in close proximity to each other in a non-linear arrangement. The trucks passing through were often routed such that transponders passed through the footprint of a single antennae several times, confusing the system.

AVC

Automatically classifying a vehicle involves two steps: measuring a vehicle's length, number of axles, axle spacing, and axle weights, and assigning a class based on an algorithm which interprets those measurements. Four FOTs discussed in this report employ or employed AVC. Three of these tests have not yet published data—Oregon Green Light, Ambassador Bridge, and the DTSW System.

The Crescent project tested AVC extensively at several locations. The mean accuracy of wheel base measurements ranged from –1.2 percent to +2.2 percent. For individual axle spacing over eight feet, the mean percentage difference ranged from -1.8 percent ± .9 percent to +2.1 percent ± .9 percent. For individual axle spacing under eight feet the AVC systems had mean absolute differences ranging from –0.2 ft. ± 0.1 ft. to +0.1 ft. ± 0.2 ft. These values indicated that the AVC was performing well within the required Crescent System specifications.

The classification of a vehicle based only on axle number, spacing, and weight measurements is less accurate. An algorithm is used which interprets the physical measurements and assigns the vehicle to a class, based on FHWA Scheme F classification schedule. The classification system is visual based and the algorithm does not have the benefit of a visual interpretation of the vehicles.

Absolute classification accuracy measured by the Crescent system installations ranged from 46 percent to 84 percent with a mean of 68 percent. However, by screening some vehicle classes, such as passenger cars, motorcycles, and light trucks, and considering consistent classification errors which may be addressed by modifying the algorithm the accuracy improved, ranging from 64 percent to 94 percent with a mean of 83 percent.

As has been the case with AVI, advances and refinements in AVC technology and installation techniques have occurred since the Crescent project testing was completed. Since then, AVC has become an increasingly proven and reliable means of vehicle classification.

INSTITUTIONAL CHALLENGES AND RESOLUTIONS

ITS projects in the CVO arena have uncovered numerous institutional challenges. The most significant issues and challenges pertain to the government and carrier administrative aspects of CVO, and are addressed under the separate cross-cutting report 'Commercial Vehicle Operations Administrative Processes.' However, some issues specific to the implementation of CVO roadside systems have been identified. Specifically, these issues can be broadly categorized into four general areas: *carrier participation, privacy and enforcement concerns, jurisdictional issues,* and *standards*.

Carrier Participation

The ultimate success of many CVO systems will be proportional to the percent of carriers that elect to participate in their deployment. For instance, if a HazMat incident occurs involving a non participating rail or motor carrier, then incident response systems requiring enrollment will not be of use to the first responders. Likewise, border crossing and weigh station by-pass projects also depend on carrier participation. A significant investment is required of government agencies in these systems, an investment that will provide substantial benefits only if a large portion of the motor carrier population chooses to participate.

The greatest challenge appears to remain one of enlisting the support and participation of the smaller or less sophisticated carriers—those carriers who are not currently automated or have limited automation in record keeping and fleet and cargo management. Larger, more technologically advanced, and perhaps more profitable, carriers have traditionally been the first to adopt new technologies. Not only are these firms more likely to possess the necessary capital to invest in such systems, carriers with larger fleets are also more likely to accrue significant returns on their technology investments.

Over time, the net effect of this issue should diminish, at least in the case of electronic screening systems. Because larger, more successful carriers are more likely to keep their fleets well-maintained and properly credentialed, and since more states are implementing advanced CVO systems, it is likely that the portion of the carrier population that participates will grow substantially. The end result will be that the vehicles belonging to less sophisticated carriers should become more likely to be targeted for CVO roadside enforcement.

In any case, at the root of the issue is the need for carriers to recognize the benefits they will realize through the use of such systems. If a carrier can justify the expense of participation in terms of improved profitability, then the competitive forces at work in the commercial freight market will serve as sufficient incentive to enroll.

Privacy and Enforcement Concerns

Related to carrier participation are enforcement and privacy issues. It has been evident in nearly all CVO operational tests that carrier participation has often been contingent upon the carriers not being subjected to extra or enhanced enforcement efforts or being at risk of having confidential information disclosed to auditors or competitors. If carriers perceive that participation will result in a detriment to their operations, in terms of enforcement or privacy, they are much less likely to participate.

For example, in TXS, the opportunity for enforcement agencies to monitor HazMat shipments presents itself. Enforcement and compliance with HazMat shipping regulations has traditionally been a difficult problem to solve. Those agencies responsible for enforcement were often quick to identify these projects as a potential means of aiding enforcement activities. The ability to inquire about the contents of a vehicle, whether at the vehicle or through some central data base or control center, could allow enforcement agencies to selectively target those vehicles or companies for inspection activities. Participating carriers raised the concern that these systems not be used to invite greater scrutiny upon them than non-users.

It is further possible that competing interests could gain some advantage by monitoring the cargo contents of the project participants. The ability to inquire about the contents of a vehicle without the knowledge or consent of the vehicle operator might be possible. For TXS, the potential exists for anyone with a remote query device and proper receiving equipment to access cargo information directly from the vehicles on-board electronic systems.

Carriers participating in electronic screening programs have long expressed concern over the use of transponder information for the purposes of enforcement. Resolving the time difference between successive transponder reads into speed would certainly be a simple way to monitor the speed limit compliance of a given vehicle. Transponder data also offers jurisdictions the opportunity to more closely scrutinize mileage reports for the purposes of fuel tax administration.

For the FOTs discussed in this report the participating enforcement agencies agreed that no enforcement activity would be undertaken. However, many issues of data security and enforcement have not been addressed on a permanent basis. The resolution of these issues is necessary for the successful deployment of CVO systems. Voluntary enrollment of motor carriers is essential to the success of these projects, and recruiting them will continue to be difficult until these issues are resolved.

Jurisdictional Issues

One of the problems many transportation policy efforts face is the fragmentation of jurisdictions. Usually, cooperation among transportation related agencies is excellent. However, ITS/CVO technologies and networks cross geographical and legislative boundaries, bringing together various levels of agencies and departments who are often unaccustomed (or averse) to working with each other. To varying degrees, some of the FOTs considered here experienced difficulties due to such inter-jurisdictional disagreements, resulting in less effective tests.

Typically, successful ITS projects are ones in which institutional barriers are adequately addressed. This usually results when all the appropriate stakeholders are included in the project from the earliest stages. Breaking down inter-jurisditional barriers may be accomplished by the formation of steering committees, working groups, and the like.

Steering committees are invaluable in the establishment of overall plans and the identification of resources and requirements. Working groups may help foster agreement on issues such as training needs and technology requirements. However, it is the unequivocal commitment of senior officials that has demonstrated the most significant impact.

For example, participating agencies in the Advantage I-75 test point to the unwavering support of key state leaders—often Governors—as the single most important factor in successfully addressing inter-jurisdictional and inter-agency issues. These long-term commitments, and the adoption of common requirements that were necessitated, provided a solid foundation for cooperative relationships.

Standards

The proliferation of CVO roadside systems has created the need for the identification and adoption of technology standards. This is especially true in the case of electronic screening systems.

Carriers have been particularly adamant that, to be of any real value, screening systems must offer some level of interoperability across state lines, and across regions of the country. During the development and implementation of the FOTs discussed in this report, carriers have repeatedly expressed the need for the adoption of standards, specifically regarding transponders.

As a result, significant strides have been made toward a "universal" standard for transponders. The HELP PrePass and Advantage CVO systems, both of which were spawned by FOTs, and the Multi-Jurisdictional Automated Pre-Clearance System (MAPS) being deployed throughout the Pacific Northwest, all use a common transponder format that is also consistent with that used at all six international border crossing FOT sites. Additionally, the Peace Bridge and Ambassador Bridge systems allow the same transponders to be used for toll collection. While specific terms are still under development, basic agreements are also being formulated to allow for the exchange of information across the different implementations (e.g., Advantage CVO and MAPS), which will further promote standardization of technologies.

Deployability

Many factors contribute to the overall deployability of a system or service. Aside form the ability to function properly, a system must represent a useful, affordable investment that meets the needs of its intended users, and the applicable regulatory requirements.

Electronic Screening Systems

Due to the fact that several different electronic screening systems are being deployed all across the country, it is quite clear that they represent a highly deployable system. Furthermore, the level of carrier and state participation in each of the three major systems indicates that the determination of which approach should be taken is a function of the specific needs of the implementing state, with input from the carriers based there.

The deployability of currently available electronic screening systems in international border crossing environments is less certain. The difficulties experienced in the IBEX effort have not yet been demonstrated at other sites, but the use of such systems has not yet gained the full support of the United States Customs Service. Of significant concern is the ability of current AVI systems to meet the performance and reliability requirements. Results from other tests may offer some measure of reassurance, but to what degree is unclear at this time.

HazMat Incident Response Systems

Perhaps the most significant factor in the deployability of systems such as Tranzit *Xpress* is the segregation of costs and benefits. A significant portion of the costs of implementation rests on the carriers, while most of the benefits are likely to accrue to the public sector, and potentially, the general public. This represents a dilemma unique among the systems deployed in the FOTs discussed in this report. Convincing carriers to invest in such systems is likely to remain a significant challenge. Unless the implementation of such a system becomes mandatory—an extremely unlikely occurrence—some incentive may be required to enlist the support of the carrier community.

These concerns are in addition to those that can only be addressed through a more practical demonstration of the technical capabilities of the system. The limited conditions under which the system functionality was explored during the FOT constrained the evaluation to a degree that prevented a full assessment.

OOS Verification Systems

While it is generally acknowledged that current commercial vehicle OOS levels—which average approximately 30 percent across the United States—are unacceptably high, substantially less is known about the severity of the problem of OOS runners. Nevertheless, the consequences of allowing a vehicle or driver to return to the road prior to rectification of the problems that caused the OOS order are certainly unacceptable.

The OOS systems described in this report, however, have not yet demonstrated an effective approach to address this issue. The use of LPR to screen vehicles, as in the WI/MN FOT, offers some additional level of capabilities. Unfortunately, successful read rates continue to remain low, thanks largely to variations in license plate design, location and condition. As a result, such systems remain suboptimal.

Downhill Speed Advisory Systems

The nature of the system design, and the relative affordability of the components used, make downhill speed advisory systems such as DTSW readily deployable. However, the demonstration of the effectiveness of such systems in reducing vehicle speeds, and the likelihood of accidents, has not been completed.

Automated Mileage Reporting Systems

In contrast to the downhill speed advisory systems, an automated mileage reporting system has been proven effective, but is likely to be too expensive to be deployable as a stand-alone system. The cost to implement a system such as AMASCOT were estimated to range from $400 per truck for large carriers, to as much as $1,500 per truck for small carriers. As discussed earlier, potential carrier users indicated an unwillingness to purchase such systems unless they were bundled with other fleet management systems.

SUMMARY

CVO Roadside components of CVO FOTs have been successful in demonstrating a number of potential benefits of deploying and integrating roadside technologies for various CVO applications. The application of electronic, sensor and information technology to CVO as part of the FOT program has demonstrated the potential benefits available from the large-scale deployment of these technologies. These benefits include reduction in costs through reduced fuel usage, greater operational efficiency, better response to incidents, and better handling of HazMat incidents. Also, time savings have been effected through elimination of stops. Some of these benefits have been clearly documented, other benefits have yet to be quantified.

The issues regarding large-scale deployment of roadside technologies and systems discussed in this report are typical of CVO. Acceptance and participation by motor carriers and public agencies remains critical to successful deployment and use. Successful integration of these technologies to provide synergistic and optimal results is also of paramount importance. Cooperation between jurisdictions and involved public entities will be required for the successful deployment of full-scale systems.

Many of the technologies themselves have been technically proven in other applications and other spheres of industry. The actual configuration and design of applications using these technologies will determine their further success within the CVO arena. GPS, DSRC, WIM, AVC, wireless communications, and VMS have all been extensively tested and proven by themselves and in combination, in several applications related to transportation and other industries. Their success in the CVO area will depend on a combination of applications design, systems integration, resolution of institutional and jurisdictional issues and cost.

More experience and knowledge needs to be gathered regarding these technologies and deployment issues. In the interim, the FOTs discussed in this cross-cutting report have provided valuable insight and a comfortable basis for the deployment of CVO roadside technologies on a larger scale.

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