Advantage I-75 Mainline Automated Clearance System

Final Evaluation Report

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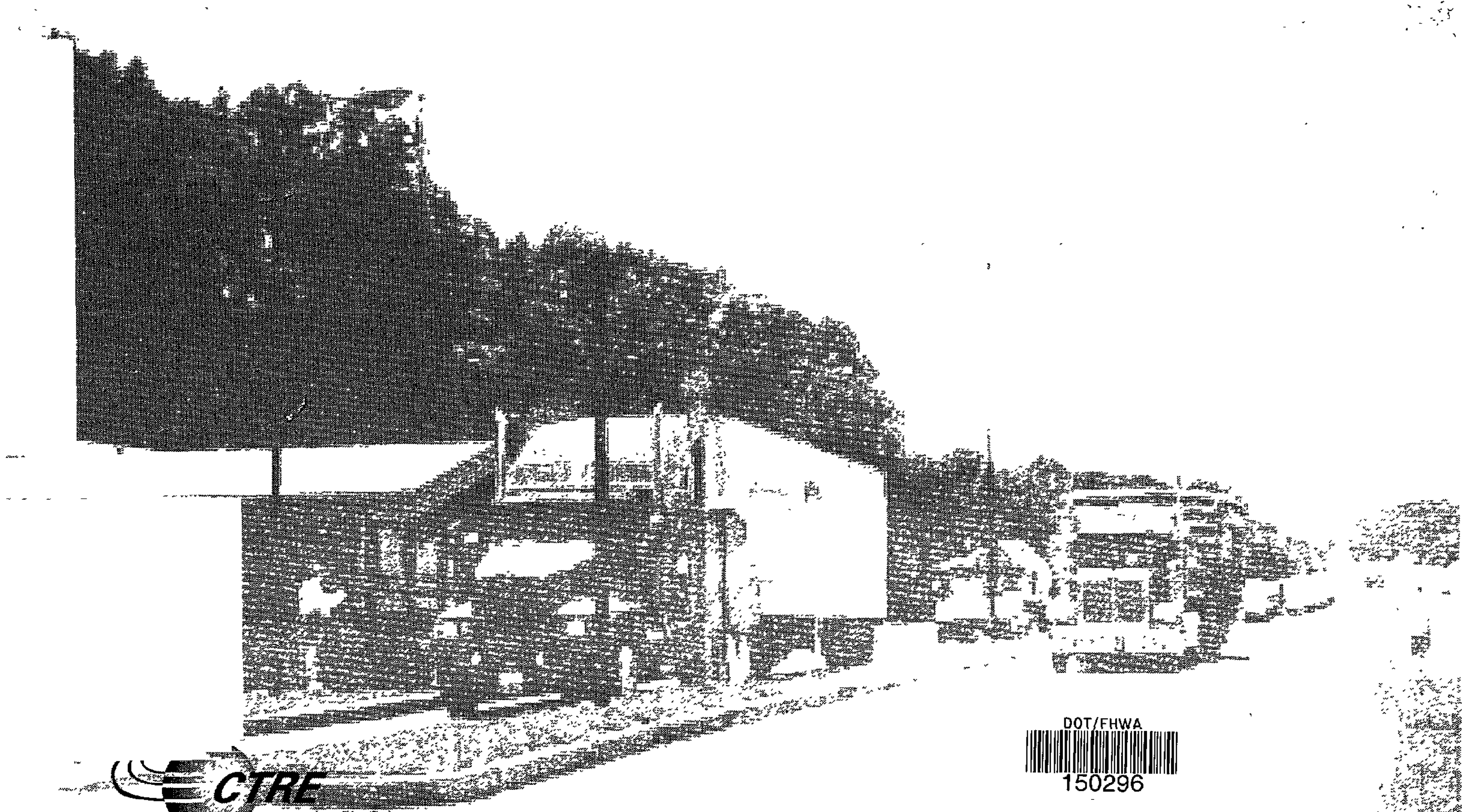
ADVANTAGE I-75
PROVING GROUND FOR ADVANCED TECHNOLOGY

U.S. Department of Transportation

Advantage I-75 Mainline Automated Clearance System

Final Evaluation Report

August 1998



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CTRE
Center for Transportation Research and Education

IOWA STATE UNIVERSITY

Advantage I-75 Mainline Automated Clearance System

Final Evaluation Report

Prepared for
The Advantage I-75 Evaluation Task Force

Submitted to
The Kentucky Transportation Center

Prepared by the
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August 1998

NOTICE

Advantage I-75 Mainline Automated Clearance Systems Evaluation Final Report

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Advantage I-75 Mainline Automated Clearance System

Final Report
Part 1 of 5: Executive Summary
Prepared for
The Advantage I-75 Evaluation Task Force

Submitted to
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University of Kentucky
Lexington, Kentucky

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EXECUTIVE SUMMARY

The Advantage I-75 Mainline Automated Clearance System Project (MACS) demonstrates and evaluates the feasibility of electronic clearance at weigh stations along the Interstate Highway 75 corridor. The test involves participants from government and industry. Government participants include the states of Michigan, Ohio, Kentucky, Tennessee, Georgia, Florida, the Province of Ontario, Canada, the Federal Highway Administration (FHWA), and Transport Canada. Industry participants included the American Trucking Associations, the National Private Truck Council, the Ontario Trucking Association, state trucking associations along the corridor, and individual motor carriers who travel along the corridor. The Kentucky Transportation Center at the University of Kentucky serves as the project's research and operations center on behalf of the lead state of Kentucky. The Center for Transportation Research and Education (CTRE) at Iowa State University serves as the evaluator of the project. The evaluation consists of four tests to determine the effectiveness of electronic clearance of commercial vehicles at weigh stations. These tests are a fuel consumption test, a weigh station throughput test, a simulation model, and an examination of jurisdictional issues. A report evaluating the Advantage I-75 MACS system prepared by the University of Kentucky, Kentucky Transportation Center with input from CTRE, is submitted separately.

The vision of the Advantage I-75 program was to incorporate existing technologies into an Intelligent Transportation System (ITS) operational setting that provides an initial step in the process of adapting the nation's highway system to accommodate the increased demands placed on it. The objective of the Advantage I-75 MACS operational test is to permit transponder-equipped trucks to travel any segment of the I-75 and Highway 401 corridor at mainline speeds while being cleared to bypass the weigh stations along the corridor.

PROJECT SCOPE

The scope of the Advantage I-75 MACS project, as identified by the partners were: (1) To increase industry and state productivity; (2) To improve highway safety; (3) To reduce congestion. The MACS project partners also identified a goal from inception to "utilize off-the-shelf technology as a tactic for getting the system up and operational quickly." Because of the far-reaching implications of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the MACS project partners incorporated these goals into the related project goal statements. ISTEA's broad goals are (1) To provide for a unified, interconnected transportation system, (2) To reduce energy consumption and air pollution while promoting economic development, and (3) Support the Nation's pre-eminent position in international commerce.

The evolution of electronic screening at weigh stations is an outgrowth of numerous efforts to streamline motor carrier regulatory enforcement and alleviate traffic congestion in and around weigh stations. The Advantage I-75 MACS system establishes the first step in creating "transparent borders" between states. Electronic screening at weigh stations proposes to change the ways in which state and federal

officials regulate commercial vehicle operations and to help make all concerned more efficient and productive.
As there are over 600 commercial vehicle inspection stations across the USA and the increasing emphasis on safety inspections for commercial vehicles, there are numerous occasions on which a commercial vehicle driver faces delays en route. Many of the nation's fixed inspection facilities were constructed 20 to 30 years ago. Consequently, the explosive growth in truck traffic has exceeded the station design specifications at many of these inspection stations. As truck arrivals exceed these stations' operational capacities, queues develop and drivers are delayed. Often, the backups require stations to close to avoid safety hazards on the mainline.

Background

The vision of the Advantage I-75 program is to incorporate existing electronic technologies into an ITS operational setting that provides an initial step in the process of adapting the nation's highway systems to accommodate the increased demands placed on it. This Operational Test entitled *Mainline Automated Clearance System* (MACS) was designed as the initial phase of the Advantage I-75 program. As previously stated, the objective of the Advantage I-75 MACS operational test is to permit compliant transponder-equipped trucks to travel any segment of the I-75 and Highway 401 corridor at mainline speeds while being cleared to bypass the weigh stations along the corridor.

Advantage I-75 goals identified by the partnership were: 1. To increase industry and state productivity; 2. To improve safety; and 3. To reduce congestion. The MACS project partners also stated from the project's inception to "utilize off-the-shelf technology as a tactic for getting the system up and operational quickly." Because of the far reaching implications of the Intermodal Surface Transportation Act of 1991 (ISTEA), the MACS project partners incorporated its into related project goal statements. ISTEA's broad goals provide for a unified, interconnected transportation system; to reduce energy consumption and air pollution while promoting economic development; and supporting the Nation's pre-eminent position in international commerce. As one part of a national effort to improve the transportation system, the Advantage I-75 MACS program meets these stated goals through improved procedures and systems used to verify commercial vehicle size, weight, and credentials.

Relationship to the National ITS Program

The national Intelligent Transportation System (ITS) program is designed to address these safety and productivity concerns by focusing advanced technology on commercial vehicle operations (CVO). One part of this overarching program is to enhance mainline electronic screening of CVO at the weigh stations. Presently, along the Interstate 75/Highway 401 corridor, there are approximately 4,500 trucks equipped with transponders to communicate with AVI (Automated Vehicle Identification) readers located near 29 weigh stations on the corridor. The AVI readers then identify the transponder-equipped trucks and their credentials. Those states with mainline weigh-in-motion (WIM) capabilities can also check compliance with size and weight regulations. When the information is read and verified, the trucks receive a signal, both visual and audible. The signal directs the operator to either by-pass the weigh station or to enter the station (for a random inspection). The elapsed time of this communication from the truck to the weigh station, back to the truck, is less than one second. Mainline electronically screening of commercial vehicles permits compliant vehicles to bypass the weigh station, consequently enforcement officials can better focus their resources on non-compliant commercial vehicle operations.

OVERVIEW OF PROJECT METHODOLOGY

To demonstrate and evaluate the feasibility of electronic clearance at weigh stations the basic test design was to install and operate a prototype system at selected weigh stations along the corridor. In addition to operating the system, studies were conducted to determine any fuel and time savings incurred by motor carriers operating with electronic clearance. The project methodology included these tasks:

- Motor Carrier Fuel Consumption Test
- Weigh Station Individual Evaluation Test
- Simulation Model
- Jurisdictional Issues Evaluation

Motor Carrier Fuel Consumption Test

This portion of the evaluation was to determine if mainline electronic clearance produces significant fuel savings for motor carriers. The test used to make this determination applied accepted Society of Automotive Engineers' (SAE) guidelines. The prescribed method directed one truck to stay on the mainline and a second truck to enter the weigh station. The second truck would then either stop or slow at the scale, depending on the design of the weigh station. The fuel used by each truck was then precisely measured to determine the fuel used by each vehicle. The difference in fuel used was the estimated savings of fuel attributable to a truck bypassing a weigh station.

Key Findings

The fundamental hypothesis tested was that reduction or elimination of stops at weigh stations by transponder-equipped truck will result in measurable fuel savings for that vehicle. While the fuel savings generated from a single stop were minimal, the accumulated benefit from reduced stops at a weigh station were significant. Fuel savings estimates were measured at five sets of weigh stations along the corridor. These five sets of weigh stations represent three main weigh station design types. They are: The static scale design type, the ramp weigh-in-motion (WIM) design type, and the high speed ramp WIM design type. The estimated fuel savings were different for each weigh station design type. The static scale design type provided the most substantial fuel savings of the three different designs. Bypasses at Knoxville, Tennessee and Findlay, Ohio, provided measurable savings of 0.16 (0.61 liters) and 0.18 gallons (0.68 liters) per vehicle per station bypassed respectively. The fuel savings accrued at the ramp WIM scales are less dramatic. The savings in Monroe, Michigan were estimated at 0.11 gallons (0.42 liters) per vehicle per station bypassed. The savings in Monroe County, Georgia, however, were estimated at 0.06 gallons (0.23 liters) per station. Finally, the savings accrued in Charlotte County, Florida, at the high speed ramp WIM, were 0.05 gallons (0.19 liters) per vehicle per station bypassed. A small study of fuel consumption in queues suggests that the fuel savings for static scales may be as much as twice the values given here when trucks are in stop-and-go driving conditions averaging 4 mph (6.4 kph). As this was a controlled experiment, the fuel savings gained from this exercise were nominal. The principal conclusion from the experiment, however, is that there are measurable fuel savings obtained by electronic clearance. The value of these savings, however, depends upon the number and nature of stations electronically cleared.

Weigh Station Individual Evaluation

Electronic screening at weigh stations proposes to change the ways in which state and federal officials regulate commercial vehicle operations and to help make all concerned more efficient and productive. By screening commercial vehicles electronically, and permitting compliant vehicles to bypass the weigh station, enforcement officials can better focus their resources on the non-compliant commercial vehicle operations. This evaluation assesses the effect of electronic clearance on the amount of travel time confronted by commercial motor vehicles at weigh stations, thus providing a measure of benefit to motor carriers. Benefits to state enforcement officials and the traveling public are assessed informally in this section, but more substantially in the simulation study discussed in a later report.

Data Collection

The purpose of this portion of the evaluation is to determine if mainline electronic clearance produces significant travel time savings for motor carriers. The data collection procedure used to make this determination was designed by Iowa State University. The prescribed method was to position recorders at the entrance point of the weigh station, at the static scale, and at the exit point of the weigh station. The recorders, equipped with stop watches, then recorded the time each truck crossed the specific point. Mainline speeds of commercial vehicles were also recorded. The difference in time between the commercial vehicle in the weigh station, and one on the mainline was the estimated time savings attributable to being electronically screened on the mainline.

Key Findings

The fundamental hypothesis tested was that reduction or elimination of stops at weigh stations by participant transponder-equipped vehicles will result in travel time savings for that truck. Travel time estimates were measured at 19 sets of weigh stations along the corridor. These 19 sets of stations represent the three main weigh station design types. They are the static scale design type, the ramp weigh-in-motion (WIM) design type, and the high-speed ramp WIM design type.

The estimated time savings were different for each weigh station design type. Travel time savings were most substantial at the static scale design types. At the static scales in Knoxville, Tennessee and Findlay, Ohio, vehicle bypasses provided measurable time savings, on average, of 4.86 minutes, and 2.22 minutes, per station respectively. Part of the time difference is the amount of truck traffic at each facility. Trucks entered the Knoxville, Tennessee weigh station at a rate of 450 trucks per hour, while the rate of arriving vehicles at the stations near Findlay, Ohio was 215 trucks per hour. The travel time savings between driving on the mainline and driving through the weigh-in-motion stations are smaller. Travel time savings at WIM stations such as those in Monroe, Michigan were estimated at 1.33 minutes per station. The time savings accrued in Charlotte County, Florida, at the high-speed ramp WIM, were

1.92 minutes per station cleared to bypass. The principal conclusion from this experiment is that there are measurable time savings obtained by electronic screening of commercial vehicles. As with the fuel savings, the time savings attributed to bypassing an individual station are minimal though, the accumulative value to bypassing several stations is significant. The value of these savings, however, depends on the number and nature of the stations being electronically screened.

Simulation Modeling

One of the tasks that the Center for Transportation Research and Education (CTRE) at Iowa State University was given for this program evaluation was to quantify the impact of electronic screening of commercial motor vehicles in terms of travel time savings for motor carriers and enhanced productivity of weigh stations. As part of that evaluation, CTRE developed a simulation model that provides visual animation of commercial vehicle traffic approaching, traveling through, and exiting a weigh station. The simulation provides a robust medium for evaluation as it can quantify the benefits of electronic screening under a variety of parameters and display the operation of the system using animation. The animation provides the audience a better understanding of the analysis of electronic screening on weigh station throughput.

This report examines the use of computer simulation of electronic screening at weigh stations on the I-75 corridor. For this portion of the evaluation of the Advantage I-75 MACS program, we developed computer simulation models for seven weigh stations along the I-75 corridor. The stations we modeled are in Halton, Ontario; Monroe, Michigan; Hancock, Ohio; Kenton, Kentucky; Knoxville, Tennessee; Lowndes, Georgia; and Punta Gorda, Florida. These stations were chosen by the Evaluation Task Force because they represent varying station design, commercial vehicle traffic flows, and topography.

The weigh station simulation design is based on the existing geometry and functionality of a given weigh station, yet is flexible enough to accommodate the potential modifications of the weigh station policy and procedure. The model allows the user to change the model's parameters to perform "what-if" scenarios.

The ability to change the model's parameters and simulate hypothetical scenarios is a powerful tool for decision-makers when considering performance of a given weigh station. One goal of the evaluation is to extrapolate the results of electronic screening into the future. By using simulation, performance measures such as transponder-equipped trucks, queue length, and unauthorized bypasses can be projected into the future. The model clearly illustrates the impact of these performance measures on weigh stations. Therefore, traffic planners and enforcement officials can see that electronic screening of commercial vehicles is a feasible option for increasing capacity without costly investments in expanding the physical infrastructure of a weigh station. Simulation is a process of modeling the operation of an actual system. Its purpose is to provide a better understanding of the behavior of actual systems and to evaluate the potential modifications of the system design. Computer simulation is a well known and powerful tool for testing the impact of changes in variables or parameters for systems where the effect of such changes cannot be determined analytically. One example in which simulation is useful is to evaluate traffic experiments which, for one reason or another, cannot be easily carried out and measured in the field. The MACS evaluation is an example of a complex system where observational studies aimed at estimating the MACS potential to reduce queues and unauthorized bypasses would be too costly or impossible to conduct. The model developed by CTRE and the Advantage I-75 MACS program vividly demonstrates the potential of computer simulation. Because of this potential, research is continuing in this area by CTRE and others in the field.

Key Findings

The evaluation of the Advantage I-75 MACS project has studied the effects of electronic screening on reducing travel time and fuel consumption for motor carriers and enhancing the productivity of weigh stations for enforcement officials. The results of the simulation model show that as participation in electronic screening grows, participant trucks, enforcement officials, and even non-participant trucks benefit by a more efficient system.

Jurisdictional Issues

The purpose of this report is to document the jurisdictional issues encountered in the implementation of electronic screening technologies for commercial vehicle operations in the participant states and provinces. The report also documents whether or not states will continue using MACS or an enhanced version of electronic screening, and motor carriers' reactions to using the MACS version of electronic screening.

The jurisdictional issues portion of the Advantage I-75 MACS evaluation examined several items including interstate, intrastate, and regional issues with regard to the implementation of electronic clearance systems. As part of the evaluation, agency staff members and motor carriers were interviewed and surveyed to obtain their views and opinions of the processes leading to electronic screening. The examination then set out to determine whether or not the states and province in the project planned to continue with electronic screening, or an enhanced form of MACS.

As a primary goal, the Advantage I-75 MACS operational test was to demonstrate and evaluate the jurisdictional issues involving electronically screening commercial vehicles at weigh stations. This evaluation of jurisdictional issues among the Advantage I-75 MACS partnership was designed to provide states and motor carriers with information to support decisions about continuing or discontinuing electronic screening or an enhanced form of electronic clearance and verification.

Key Findings

The research into the jurisdictional issues was guided by meeting three objectives: (1) To determine whether or not states, along with Province of Ontario, will continue to offer electronic screening of motor vehicles; (2) To determine whether or not motor carriers will continue to participate in Advantage I-75 MACS after the operational test is completed; and (3) To record all significant jurisdictional issues addressed during the operational test and document the resolution to issues addressed.

The first objective of the evaluation was met, as the states in the partnership, along with the Province of Ontario, have agreed to continue to offer mainline electronic screening. The second objective of the evaluation was also met as our findings conclude that there is support from the industry to continue with electronic screening of commercial vehicles. Finally, the third objective was met by documenting the issues encountered in the operational test. These issues were the following: (1) In order to facilitate the implementation of the system, technical standards and information sharing must be agreed to early on in the project; and (2) There must be "buy-in" from upper management in order to succeed.

System Evaluation

The purpose of this portion of the evaluation was to compare the performance of the as-built MACS system during the operational test to the performance levels specified in the Functional Requirements Document (FRD). The system evaluation is a cooperative effort including the team from the Center for Transportation Research and Education (CTRE) and the operations and support staff from the Kentucky Transportation Center (KTC). The system evaluation report was prepared by the Kentucky Transportation Center and will be submitted separately by KTC.

EVALUATION CONCLUSIONS

The Advantage I-75 MACS Project has demonstrated that both states and motor carriers expect to reap benefits from mainline electronic screening of commercial vehicles at weigh stations. The fuel consumption tests demonstrated that there are measurable fuel savings generated from mainline electronic screening. The savings, however, are dependent upon the number and nature of stations electronically cleared. The weigh station tests measured the effect of mainline electronic screening on the amount of travel time confronted by commercial motor vehicles at weigh stations, thus providing a measure of benefit to motor carriers. The principal conclusion from this experiment was that there are measurable time savings obtained by mainline electronic screening. The value of these savings, again however, depends on the number and nature of the stations being electronically cleared. Another part of the evaluation was to develop a computer simulation model. The model that CTRE developed provides visual animation of commercial vehicle traffic approaching, traveling through, and exiting a weigh station. The evaluation of the Advantage I-75 MACS project studied the effects of mainline electronic screening on reducing travel time and fuel consumption for motor carriers and enhancing the productivity of weigh stations for enforcement officials. The results of the simulation model show that as participation in electronic screening grows, participant trucks, enforcement officials, and even non-participant trucks benefit by a more efficient system.

For motor carriers, the benefits in fuel and time savings are dependent upon the number, the design, and the level of traffic at each of the weigh stations encountered en route. For states, the benefits are dependent on the cost avoidance of building new weigh stations by installing mainline electronic screening systems in the existing weigh stations. As more motor carriers implement electronic screening, states reap greater benefits without additional costs.

Future ITS projects should seriously consider the methods developed by Advantage I-75 MACS. This method includes a lead agency to facilitate the project and lead representatives from each jurisdiction in close contact with the lead agency to enhance communication. While there were issues that caused minor delays in the project because of uncertainties, with few exceptions, the parties made the commitment to work together to complete the goals and objectives for the project satisfactorily. The lessons learned from this project will serve others well in future ITS projects.

Advantage I-75 Mainline Automated Clearance System

Final Report
Part 2 of 5: Motor Carrier Fuel Consumption Individual Evaluation Report

Prepared for
The Advantage I-75 Evaluation Task Force

Submitted to
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Lexington, Kentucky

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Introduction

With over 600 commercial vehicle inspection stations across the USA and the increasing emphasis on safety inspections for commercial vehicles, there are numerous occasions on which a commercial vehicle driver faces delays en route. Many of the nation's fixed inspection facilities were constructed 20 to 30 years ago. Consequently, the explosive growth in truck traffic has exceeded the station design specifications at many of these inspection stations. As truck arrivals exceed these stations' operational capacities, queues develop and drivers are delayed. Often, the backups require stations to close to avoid safety risks.

The national Intelligent Transportation System (ITS) program is designed to address these safety and productivity concerns along with focusing advanced technology on commercial vehicle operations (CVO). One part of this overarching program is to enhance mainline electronic clearance of CVO at the weigh stations. Presently, along the Interstate 75/Highway 401 corridor, there are approximately 4,500 trucks equipped with transponders to communicate with AVI (Automated Vehicle Identification) readers located near the 29 weigh stations on the corridor. The AVI readers then identify the transponder equipped trucks and their credentials. Weigh stations equipped with mainline weigh-in-motion (WIM) scales can also verify compliance with truck size and weight regulations. When the information is read and verified, the trucks receive a signal, both visual and audible. The signal directs the operator to either by-pass the weigh station or to enter the station (for a random inspection). The elapsed time of this communication from the truck to the weigh station, back to the truck, is less than one second. By electronically screening commercial vehicles on the mainline, thereby permitting compliant vehicles to bypass the weigh station, enforcement officials can better focus their resources on non-compliant commercial vehicle operations. This specific test was to evaluate the effect of electronic clearance on motor carrier fuel consumption along the Interstate 75/Highway 401 corridor.

Project Scope

The purpose of this part of the evaluation is to determine if mainline electronic clearance produces significant fuel savings for motor carriers. The test used to make this determination applied accepted Society of Automotive Engineers' (SAE) guidelines. The prescribed method directed one truck to stay on the mainline and a second truck to enter the weigh station. The second truck would then either stop or slow at the scale, depending on the design of the weigh station. The fuel used by each truck was then precisely measured to determine the fuel used by each vehicle. The difference in fuel used was the estimated savings of fuel attributable to a truck bypassing a weigh station.

Summary of Findings

The fundamental hypothesis tested was that reduction or elimination of stops at weigh stations by transponder equipped truck will result in measurable fuel savings for each transponder equipped vehicle. Fuel savings estimates were measured at five sets of weigh stations along the corridor. These five sets of weigh stations represent the three main weigh station design types. They are: The static scale design type, the ramp weigh-in-motion (WIM) design type, and the high speed ramp WIM design type. The estimated fuel savings were different for each weigh station design type. The static scale design type provided the most substantial fuel savings. Bypasses at Knoxville, Tennessee and Findlay, Ohio, provided measurable savings of 0.16 (0.61 liters) and 0.18 gallons (0.69 liters) per vehicle per station bypassed respectively. The fuel savings accrued at the ramp WIM scales are less dramatic. The savings in Monroe, Michigan were estimated at 0.11 gallons (0.42 liters) per vehicle per station bypassed. The savings in Monroe, County, Georgia, however, were estimated at 0.06 gallons (0.23 liters) per station. Finally, the savings accrued in Charlotte County, Florida, at the high speed ramp WIM, were 0.05 gallons (0.19 liters) per vehicle per station bypassed. A small study of fuel consumption in queues suggests that the fuel savings for static scales may be as much as twice the values given here when trucks are in stop-and-go driving conditions averaging 4 mph (6.4 kph). As this was a controlled experiment, the fuel savings realized were minimal savings. The principal conclusion, however, is that there are measurable fuel savings obtained by electronic clearance. The value of these savings, however, depends upon the number and nature of stations electronically cleared.

PURPOSE OF THE TEST

The purpose of this test was to evaluate the effect the Advantage I-75 Mainline Automated Clearance System (MACS) has on the fuel consumption of participant motor carriers.

The detailed data collected as part of the Motor Carrier Fuel Consumption Individual Evaluation Test were used to provide data on fuel usage of heavy trucks at weigh stations.

EVALUATION TEST DESCRIPTION

On the basis of the results of the previous evaluation activities and pilot studies, this test was designed to determine the potential fuel savings attributable to electronic clearance of weigh stations at selected sites along the Advantage I-75 corridor.

This test was based upon applying accepted fuel consumption test procedures to determine the differences in fuel consumption between two nearly identical commercial vehicles under defined scenarios (scripts) in the vicinity of selected weigh stations on the I-75 corridor. The scripts were designed such that one of the trucks simulated electronic clearance by driving past the weigh station at mainline speeds while the other truck simulated routine weigh station processing by driving through and stopping or slowing (as the weigh station design dictated) at the weigh station. At the selected test sites, the two trucks were equipped with special 15-gallon (56.775 liter) fuel tanks and given specific instructions concerning speed and route for a loop of interstate highway containing two weigh stations (one each direction). The trucks used in this test were nearly identical in specifications, equipped with identical loads and used the same drivers throughout the test procedure. Also, the trucks began their test runs within one minute of each other to control as much variability in fuel consumption as possible. The fuel consumption was measured according to the procedures defined in the SAE Type II Fuel Consumption Test (SAE J1321). This test was conducted under controlled conditions. Thus, the tests were run with the weigh stations closed, in order to control the variability in fuel consumption associated with queues.

Hypothesis Tested

Hypothesis One: "Reduction or elimination of stops at weigh stations by participant transponder equipped trucks will result in measurable energy (fuel) savings for each equipped truck." (Detailed Evaluation Plan, May 10, 1996.)

Recap of Test Procedures

The fuel consumption test was based upon the Society of Automotive Engineers Recommended Practice (SAE Type II Fuel Consumption Test). This experiment was performed to determine if the reduction or elimination of stops at weigh stations by trucks equipped with transponders results in measurable fuel savings for each participant truck. One truck, termed the control truck, always bypassed the weigh station. The other truck, termed the test truck, alternated between control runs in which the weigh station was bypassed, and experimental (or test) runs in which the weigh station was entered. At each of the test sites, the baseline fuel consumption difference between the two trucks was measured (when both trucks bypassed the weigh station.) Then the experimental fuel consumption difference was measured between the two trucks (when one truck bypasses the weigh station and one stops or slows at the weigh station.) This procedure includes two forms of control. First, during each run the control truck and test truck encountered almost identical conditions, therefore any observed differences were due to experimental or vehicle differences. Second, the use of baseline runs provided estimates of the fuel consumption differences due to vehicle variances (tire tread, engine performance, etc.) The baseline runs, therefore, provided a control for the experimental runs.

It should also be noted that Mr. Claude Travis of Claude Travis & Associates was instrumental in developing these test procedures. Mr. Travis played a key role in the Pilot Tests and provided much needed expertise and advice throughout the evaluation procedure.

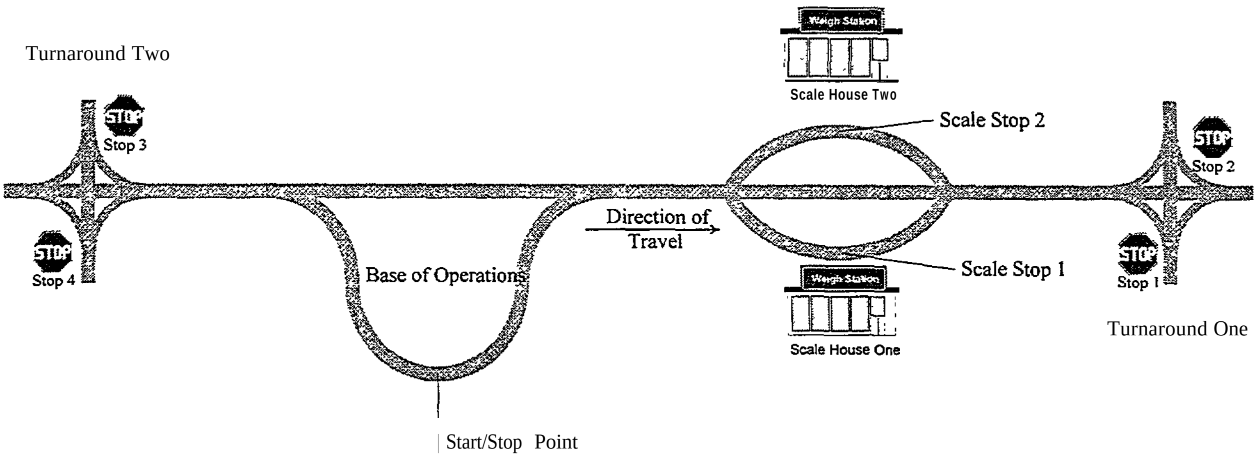
Scenarios of Fuel Consumption Tests

The following describes the scenarios, scripts and procedures for performing the Fuel Consumption Tests. These are the scenarios as described in the Detailed Evaluation Plan, submitted on May 10, 1996.

As previously stated, two identically equipped trucks, one termed the control truck and one termed the test truck, complete test runs on defined loops of the interstate highway following defined scripts. The defined interstate highway loops, illustrated in Figure One, consist of two weigh stations, two turnaround points, and one base of operations. The trucks complete the appropriate number of baseline runs whereby both of the trucks follow the control script. These runs are used to establish baseline fuel consumption differences between the two trucks. The trucks then complete the appropriate number of test runs whereby one truck follows the control truck script and the other truck follows the test truck script. The trucks were dispatched on the runs within 30 seconds of each other, so that they would be running in identical conditions. The number of baseline runs and test runs is dependent upon weigh station design. (Detailed Evaluation Plan, pp. 22 - 23, May 10, 1996).

The drivers complete each test run according to the following scripts. Separate scripts are provided for the control truck and the test truck. The route of a typical test run is provided in Figure 1.

Figure 1: Typical Test Route



Scriptfor the Control Truck

1. Upon entering the truck cab, close the vent window and side window, reset the cumulative stop timer to zero, release the parking brakes (hold the vehicle in place using the foot brake pedal), and wait for the start signal from the data collection team leader.
2. When the data collection team leader signals the start of the run, start the engine, exit the base of operations, and begin the test run.
3. Accelerate to 60 miles per hour (mph) (97 kilometers per hour [kph]), enter the mainline and engage the cruise control.
4. Bypass Weigh Station One and proceed to the exit designated as turnaround one.
5. Come to a complete stop at the base of the turnaround one exit ramp (see stop point one) and depress the start button of the cumulative stop timer.
6. Turn left, pull away from stop point one when traffic permits, and depress the stop button of the cumulative stop timer.
7. After crossing over the interstate highway, come to a complete stop at a point opposite the top of the interstate entrance ramp (see stop point two), and depress the start button of the cumulative stop timer.
8. Turn left onto the interstate exit ramp when traffic permits and depress the stop button of the cumulative stop timer.

9. Accelerate to 60 mph (97 kph), re-enter the interstate highway, and engage the cruise control.
10. Bypass Weigh Station Two, and proceed to the exit ramp designated as turnaround two.
11. Come to a complete stop at the base of the turnaround two exit ramp (see stop point three) and depress the start button of the cumulative stop timer.
12. Turn left, pull away from stop point three when traffic permits, and depress the stop button of the cumulative stop timer.
13. After crossing over the interstate highway, come to a complete stop at a point opposite the top of the interstate entrance ramp (see stop point two) and depress the start button of the cumulative stop timer.
14. Turn left onto the interstate exit ramp when traffic permits and depress the stop button of the cumulative stop timer.
15. Accelerate to 60 mph (97 kph), re-enter the interstate highway, engage the cruise control, and proceed to the exit ramp at the base of operations.
16. Upon arriving at the base of operations start/stop point set the parking brake and put the transmission in neutral.
17. Observe the cumulative stop timer and idle the engine for the period of time necessary to equal 60 seconds total stop time. For example, if the cumulative stop timer indicated 27 seconds, the engine would be idled for 33 seconds to equal 60 seconds total stop time.

Script for the Test Truck

1. Upon entering the truck cab, close the vent window and side window, reset the cumulative stop timer to zero, release the parking brakes (hold the vehicle in place using the foot brake pedal), and wait for the start signal from the data collection team leader.
2. When the data collection team leader signals run start, start the engine, exit the base of operations, and begin the test run.
3. Accelerate to 60 miles per hour (97 kph), enter the mainline, and engage the cruise control.
4. Instruct the run observer, seated in the passenger seat to notify Weigh Station One at a point 4 miles (6.4 km) upstream from the weigh station entrance ramp.
5. Slow to the designated weigh station approach speed at the beginning of the weigh station entrance ramp and continue to the static scale.
6. Come to a complete stop for 15 seconds at the static scale (do ***not engage the cumulative stop timer).***
7. Pull away from the static scale, and re-enter the mainline.
8. Accelerate to 60 mph (97 kph), engage the cruise control, and proceed to the exit ramp designated as turnaround one.
9. Come to a complete stop at the base of the turnaround one exit ramp (see stop point one) and depress the start button of the cumulative stop timer.
10. Turn left, pull away from stop point one when traffic permits, and depress the stop button of the cumulative stop timer.
11. After crossing over the interstate highway, come to a complete stop at a point opposite the top of the interstate entrance ramp (see stop point two) and depress the start button of the cumulative stop timer.

12. Turn left onto the interstate exit ramp when traffic permits and depress the stop button of the cumulative stop timer.
13. Accelerate to 60 mph (97 kph), re-enter the interstate highway and engage the cruise control.
14. Instruct the run observer, seated in the passenger seat, to notify Weigh Station Two at a point 4 miles (6.4 km) upstream from the weigh station entrance ramp.
15. Slow to the designated weigh station approach speed at the beginning of the weigh station entrance ramp and continue to the static scale.
16. Come to a complete stop for 15 seconds at the static scale ***(do not engage the cumulative stop timer).***
17. Pull away from the static scale, and re-enter the mainline.
18. Accelerate to 60 mph (97 kph), engage the cruise control and proceed to the exit ramp designated as turnaround two.
19. Come to a complete stop at the base of the turnaround two exit ramp (see stop point three) and depress the start button of the cumulative stop timer.
20. Turn left, pull away from stop point three when traffic permits, and depress the stop button of the cumulative stop timer.
21. After crossing over the interstate highway, come to a complete stop at a point opposite the top of the interstate entrance ramp (see stop point two) and depress the start button of the cumulative stop timer.
22. Turn left onto the interstate exit ramp when traffic permits and depress the stop button of the cumulative stop timer.
23. Accelerate to 60 mph (97 kph), re-enter the interstate highway, engage the cruise control, and proceed to the exit ramp at the base of operations.
24. Upon arriving at the base of operations start/stop point set the parking brake and put the transmission in neutral.
25. Observe the cumulative stop timer and idle the engine for the period of time necessary to equal 60 seconds total stop time. For example, if the cumulative stop timer indicated 27 seconds, the engine would be idled for 33 seconds to equal 60 seconds total stop time.

Procedures

The following paragraphs provide a discussion of the setup procedure for the test trucks and the base of operations. Following that, the test run procedure provides a discussion of the data collection team procedure for each of the test runs.

Setup

Upon arriving at the selected test location, the test trucks must be equipped with the appropriate fuel lines and fuel tanks, and the base of operation must be set up.

- Test Truck Fuel Lines: First, the trucks must be equipped to accept the portable fuel tanks and quick disconnect fuel lines. This is completed by installing quick-connect fittings on the fuel draw and fuel return lines. Secondary fuel draw and fuel return lines with in-line fuel coolers are then run from the engine to the location where the portable fuel tank will be mounted. The quick connect fittings will allow the truck to be fueled by either the portable 15 gallon (56.775 liters) fuel tanks (during the test runs) or the existing 150 (567.75 liters) gallon fuel tanks (traveling to and from lodging facilities).

- Test Truck Fuel Tanks: Second, the portable fuel tanks are installed in a location that allows quick access and secure mounting. These tanks are held in place with cargo securement straps. Generally, the fuel tanks can be mounted on the deck plates behind the truck's sleeper cab. These deck plates are typically used by drivers when coupling or uncoupling trailers and would provide adequate support for the 150-pound (68.1 kilograms) portable fuel tanks. Using the experience gained in Pilot Study One, six hours should be an adequate time period to equip the two trucks (test truck and control truck). It should be noted that the truck setup procedure needs only to be done once at each test location.

Figure 2: Placement of Portable Tanks

- Test Truck Fan Hubs: The automatic fan hubs are disabled by disconnecting the positive power lead to the air solenoid. This eliminates variability in fuel consumption that is attributable to the engagement and disengagement of the fan hub. It should be noted that engine operating temperatures will be closely monitored. Should operating temperatures approach manufacturers recommended maximums, test runs will be suspended or the fan hubs will be set to constant run (always engaged).

- Base of Operations: The base of operations is a site located on the test route that provides an adequate safe working area at each test location. This working area is used for installing and removing the portable fuel tanks before and after each test run and fueling and weighing an extra set of tanks while the trucks complete test runs. As part of the setup activities, the scales used to weigh the fuel tanks must be set up and leveled at a location that is shielded from wind and rain. The recommended method is to use an enclosed 6 foot x 12 foot (1.82 m x 3.66 m) trailer with a sturdy floor that can be detached from a towing vehicle and leveled. This trailer would house the scale used for weighing the tanks and a one-day fuel supply.

4 Other Setup Activities: The base of operations was well marked with orange-safety cones and warning signs during setup. For tests scheduled during nighttime hours, the base used auxiliary lighting utilizing a portable generator with a light stand.

Test Runs: The data collection team procedure for each test run is detailed in the following paragraphs:

1. The portable fuel tanks are filled, weighed, with the weights recorded on the data collection sheet (one sheet per run), and loaded on the trucks. The odometer reading for each truck is also recorded on the appropriate location on the data collection sheet at this time.
2. The drivers go to their trucks, close the vent windows and side windows, release the parking brakes, hold the vehicle in position with the foot brake pedal, and wait for the start signal.
3. The data collection team leader signals the control truck to start the engine and begin the test run according to the prescribed script.
4. The data recording person notes the control truck start time (HH:MM:SS) on the data collection sheet.
5. Between 30 and 45 seconds after the control truck begins its run, the data collection team leader signals the test truck to start the engine and begin the test run according to the script.
6. The data recording person notes the test truck start time (HH:MM:SS) on the appropriate data collection sheet.
7. A member of the data collection team observes and records the wind speed and direction and temperature within one minute after the test truck has departed the base of operations.
8. The extra set of tanks are weighed (empty weight from previous run), filled, and re-weighed (loaded weight for next run) while the control truck and test truck complete their test runs.
9. As the trucks approach the base of operations after completion of their test runs, the data collection team positions themselves to direct traffic This is necessary to prevent unplanned stops or starts for the test truck and control truck as they re-enter the base of operations.
10. The data recording person notes the engine stop time (HH:MM:SS) when each truck has been parked and the engine has been shut down.
11. The data recording person then interviews the drivers and notes any significant deviation from the defined script (unplanned stops or starts or other factors that might skew the fuel consumption).

12. The fuel tanks are changed (empty tank replaced with full tank) and the trucks are readied for the next run.
13. The drivers go to their trucks and ready for the next test run (ideally within five-seven minutes).
14. After the test trucks have departed the base of operations on the next test run, the data collection team leader computes the fuel consumed and notes the T/C ratio' for the previous run.

PLANNING AND SCHEDULING

The test schedule was contingent upon close coordination with all test participants. The following tables list the names, organizations, addresses, and telephone numbers for each of the participants involved in the test:

Table 1: Test Participant Contacts by Project Role

Role	Key Contact	Address	Phone/Fax
Evaluation Manager	Mr. Bill McCall	Center for Transportation Research and Education 2625 N. Loop Drive Suite 2 100 Ames, Iowa 50010-8615	(515) 294-9501 (5 15) 294-0467
Evaluation Coordinators	Mr. James York, Mr. Dennis Kroeger	Center for Transportation Research and Education 2625 N. Loop Drive Suite 2 100 Ames, Iowa 50010-8615	(515) 294-8103 (5 15) 294-0467
Data Collection Team	Mr. Ed Powe	Entrepreneurial Development Institute (EDJ) Kentucky State University 415 Hathaway Hall Frankfort KY 40601	(502) 227-6172 (502 227-6763
Motor Carrier	Mr. Richard Honeycutt	Collins and Aikman Corporation PO. Box 521 New London NC 28 127	(704) 985-1202 (704) 985-1216

Scheduling commitments were made with participants approximately six weeks prior to commencement of actual testing. Events such as the 1996 Summer Olympics in Atlanta, Georgia and highway construction projects caused changes in the original schedule. We

[1] The T/C ratio is defined as the ratio of test truck fuel consumption (pounds of fuel consumed) to control truck fuel consumption (pounds of fuel consumed). This ratio is computed in the field to verify that test run consistency meets defined SAE standards for data collection. A detailed description of the field data and required field data reduction method is provided in Appendix One pp. 48-49 of the Evaluation Recommendations. ***Detailed Evaluation Plan Part One: Evaluation Recommendations. The*** Iowa Transportation Center. October 18, 1995.

proceeded with the tests in other locations and returned to the Georgia test site following the conclusion of those special events.

Test Locations

With regard to the information learned from Pilot Study One, the goal of the site selection was to choose the most favorable and the least favorable topographical conditions for each of the weigh station design types that exist on the Advantage I-75 corridor. Thus, weigh stations were chosen for their terrain as well as their design and proximity to each other at that location. (See pp. 20-21 of the Detailed Test Plan, submitted May 10, 1996, for a more detailed discussion of site selection.)

The following table lists the test sites that were selected for the tests, and the contact person for that weigh station.

Table 2: Weigh Station Contacts by Test Location

Test Location	Key Contact	Address	Phone/Fax
Monroe, MI	Lt. Thomas Kenney	Michigan State Police 12075 South Telegraph Road Erie MI 48133	3 13-848-4684 3 13-848-3603
Findlay, OH	Sgt. Jim Bennett	Ohio Highway Patrol 3201 North Main Avenue Findlay OH 45840	419-423-1414 419-423-9179
Knoxville, TN	Capt. Richard Sayne	Tennessee Dept. of Public Safety 7601 Kingston Pike Knoxville TN 3 79 19	615-966-5071 615-671-1293
Monroe, Co. GA	Capt. Cliff Tackett	Georgia Dept. of Transportation 935 E. Confederate Ave Atlanta, GA 303 16-253 1	912-994-1278
Charlotte, Co. FL	Maj. Bill Mickler	Florida Department of Transportation 605 Suwarmee Street Mail Station 99 Tallahassee FL 32399-0450	904-488-7920 904-22 1-6627

Generally the above named officials were notified in writing and by telephone approximately one month in advance of commencing the fuel consumption tests. The tests were scheduled and conducted in the following order:

1. Findlay, Ohio
2. Monroe, Michigan
3. Knoxville, Tennessee
4. Charlotte County, Florida
5. Monroe County, Georgia

Test Duration

The duration of the tests was dependent upon weigh station design type. The Findlay, Ohio and Knoxville, Tennessee locations are static scale design. All trucks are directed to the scale and there is no bypass lane. The Monroe, Michigan and Monroe County, Georgia locations are Ramp Weigh-In-Motion (WIM) design, consisting of a static scale and a bypass lane. The weigh station in Charlotte County, Florida contains a higher speed ramp WIM design. The weigh station is equipped with a bypass lane that permits speeds of 45 miles per hour (72 kph), and two scales for weighing trucks. As described in the Detailed Evaluation Test Plan, weigh station types vary in expected fuel savings and in variability from run-to-run. On the basis of the Pilot Study data, tests including 60 runs (30 control runs and 30 test runs) were recommended for the static scales; 100 runs for ramp WIM scales; and 140 runs for the high speed ramp WIM scales. These sample sizes were reduced by half when the studies were carried out because:

- The time required to perform the tests with the original sample sizes was found to be excessive;
- The recommended sample sizes were found to be conservative, once the data collection began.

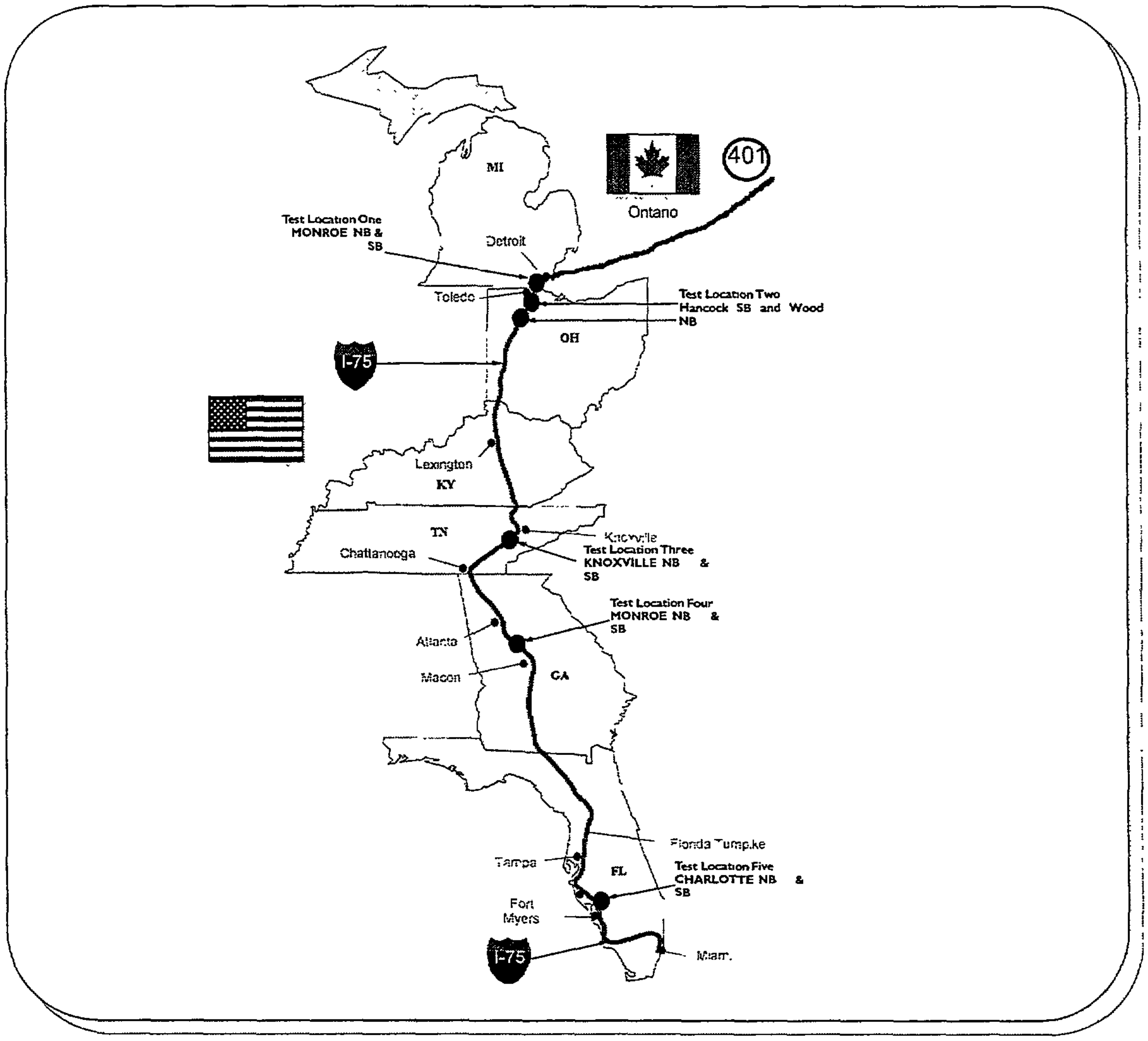
Table 3 lists the test location, scale design and duration of the tests.

Table 3: Test Location, Design Type and Test Duration

Test Location	Design Type	[Duration (in Days)	Total Test Runs
Monroe, MI	Ramp WIM	7 Days	50
Findlay, OH	Static Scale	5 Days	30
Knoxville, TN	Static Scale	5 Days	30
Monroe Co., GA	Ramp WIM	7 Days	50
Charlotte Co., FL	High Speed Ramp WIM	9 Days	70

In addition to the tests described above, we carried out additional runs at Charlotte County, Florida to determine the effect of queue length/traffic speed on fuel savings. These runs were conducted using the large parking areas behind the Charlotte County weigh stations where the trucks made repeated stops at measured intervals to simulate queue traffic.

Figure 3: Map of Test Locations



Actual fuel consumption testing began in July 1996. Preparations, however, were being made since immediately after the Pilot Studies concluded in September 1995. Data collection, analysis, and report preparation proceeded through 1996 and 1997, and will be completed at the end of the MACS operational test in March 1998. A test schedule recap is provided below:

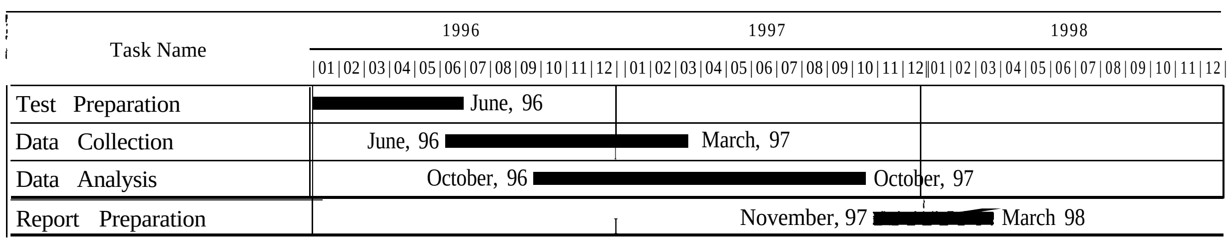
- Test Preparation: September 1995 - June 1996
- Data Collection: June 1996 - March 1997
- Data Analysis: October 1996 - October 1997
- Final Report Preparation: November 1997 - March 1998

Data collection extended beyond the original schedule set forth on May 10, 1996 due to scheduling conflicts. The original schedule stated that fuel consumption testing would begin on or about June 8, 1996 and would be completed on or about August 21, 1996. This target schedule was not met for a number of reasons, including:

- The weigh stations in Georgia closed for a month during the Olympic Games in Atlanta, Georgia. The closures of the weigh stations were done to minimize traffic delays incurred by the huge number of visitors to the Atlanta area. Thus, we could not run the tests at the Monroe County location during July.
- Following the closure of the weigh stations for the Olympic Games, the weigh stations in Georgia closed for construction improvements and the implementation of the Advantage I-75 systems, such as the AVI equipment and mainline WIM scale. The construction improvements at the Monroe County weigh station were not completed until January 1997. The tests were completed at our first scheduled opportunity.
- The tests in Charlotte County, Florida were postponed for two weeks, because in-service training was scheduled for the days that we originally planned for the fuel consumption tests.

A Gantt Chart illustrating the above schedule is provided in Figure 4.

Figure 4: Evaluation Test Schedule



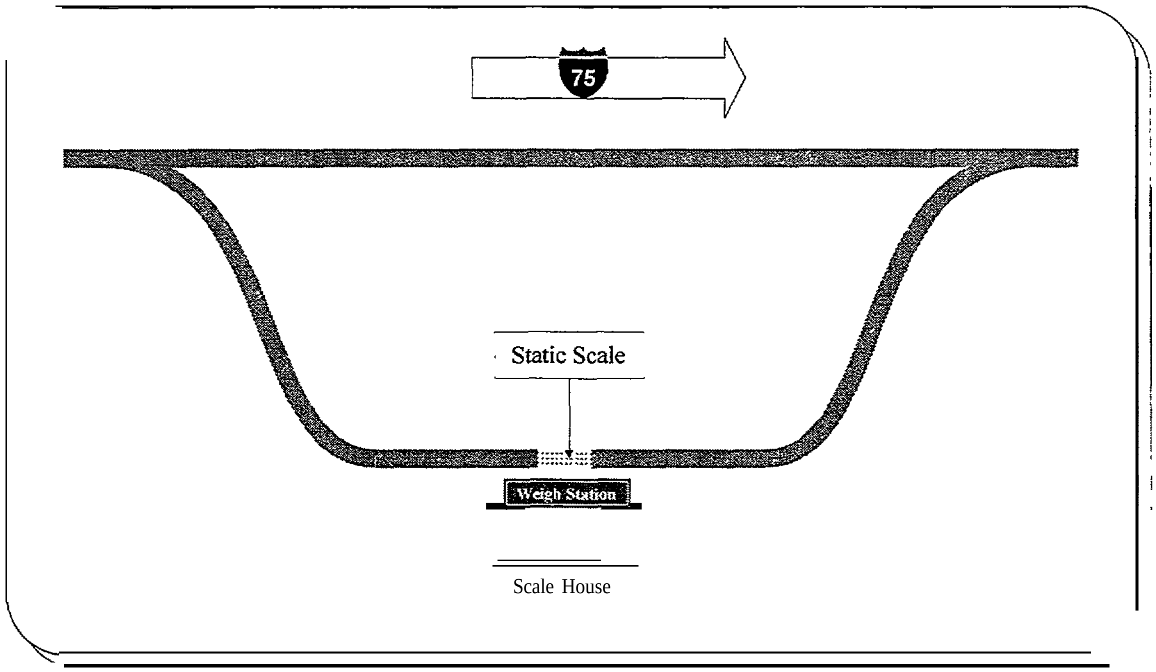
WEIGH STATION DESIGN

There were three basic weigh station design types used for the fuel consumption experiment. These design types were: The static scale design, the ramp weigh-in-motion (WIM) design, and the high-speed ramp WIM design. These are the most common design types encountered by participants. During the early phases of the test, the task force decided that the most efficient and least efficient design types be used for the experiment in order to determine a proper range of fuel consumption. To that end, the task force chose the static scale design types at the locations in Ohio and Tennessee. The ramp WIM design was chosen at the locations in Michigan and Georgia. Finally, the task force picked the high-speed ramp WIM design in Charlotte County, Florida. To recap the site location decisions, these sites were picked based upon their topographical layouts, varying traffic volumes, and efficiency in design. The static scales at the Ohio location have flat terrain and contain moderate traffic volume. Conversely, the static scales near Knoxville, Tennessee are hilly with very heavy vehicle traffic. The ramp WIM design near Monroe, Michigan is laid out on flat terrain, with heavy traffic. Meanwhile, the scale layout in Monroe County, Georgia is hilly with a moderate amount of traffic. The high-speed ramp WIM design in Charlotte County, Florida is probably the most efficient design layout of the group. It is on flat terrain with a light to moderate traffic volume. This design was termed “high-speed” ramp WIM because the design allows trucks to use the bypass lane at speeds of up to 45 mph (72 kph), which is considerably higher than bypass lanes at other facilities.

Because no two weigh station designs are identical, the contrasting design types and locations were chosen by the Evaluation Task Force in order to capture as broad a range of fuel consumption differences as feasible. Thus, the test results will show expected fuel savings at the various weigh station deign types that are located on level terrain, rough terrain, heavy traffic, and light traffic.

The following figures illustrate the differing design types. Please be aware that these are not actual scale blueprints, but representations used to illustrate the differences in the weigh station configurations.

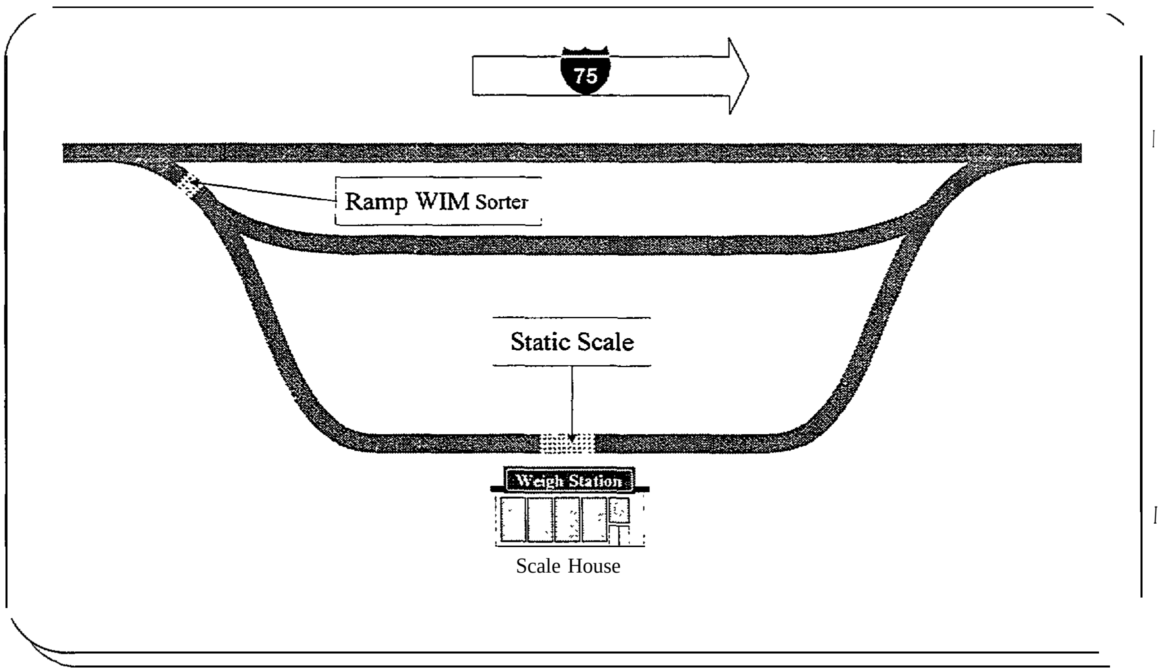
Figure 5: Weigh Station Design Type One, Single Static Scale



Note: Schematic Representation - NOT to Scale

This illustration depicts the type of weigh station layout at the locations in Knoxville, Tennessee and in Findlay, Ohio. The stations use a single static scale that does not allow the use of a bypass lane. All trucks that enter the station are directed to the scale.

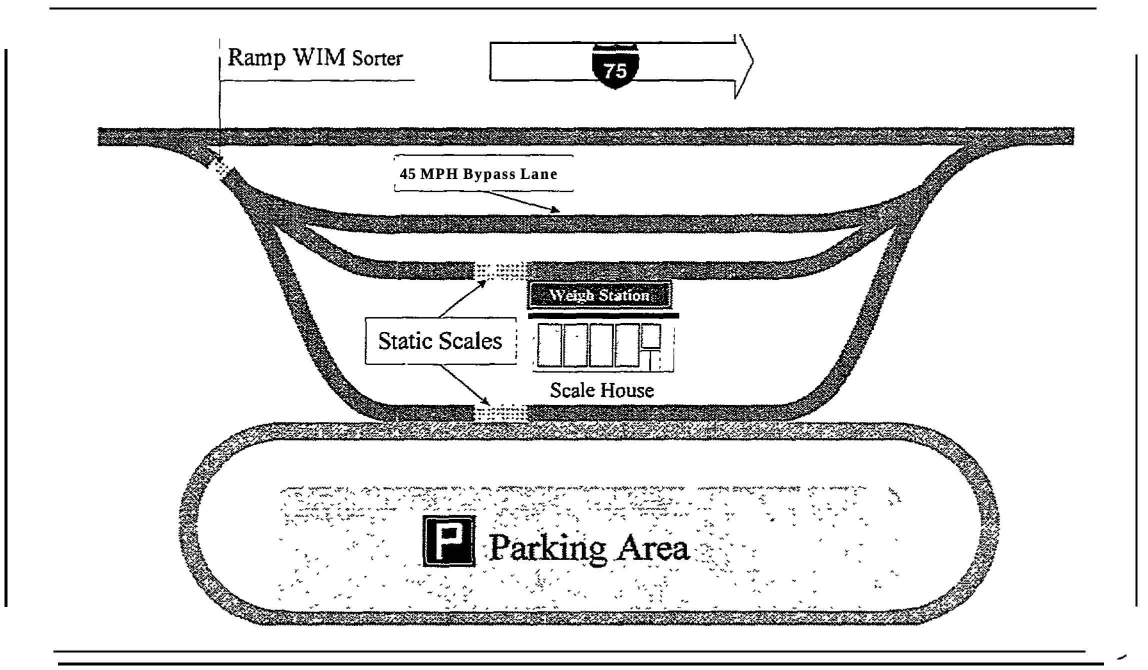
Figure 6: Weigh Station Design Type Two, Ramp WIM, Single Bypass Lane



Note: Schematic Representation - NOT to Scale

This illustration depicts the design used at the locations near Monroe, Michigan and Monroe County, Georgia. This design uses a ramp WIM sorter that permits the use of a bypass lane to sort compliant trucks from those that require a static weight. Trucks are directed to the bypass lane if they weigh under the weigh-in-motion (WIM) threshold weight and no other defects or violations are initially discovered; other trucks are directed to the static scale. For example, State of Georgia regulations requires all over-dimension trucks to report to the static scale for a check. Thus, those trucks requiring an oversize or overweight permit must stop at the static scale in Georgia.

Figure 7: Weigh Station Design Type Three, High-Speed Ramp WIM, Two Static Scales



Note: Schematic Representation - NOT to Scale

This is the weigh station design located in Charlotte County, Florida. This design again uses a ramp WIM sorter that directs compliant trucks to the bypass lane and other trucks to the static scale. This weigh station design also contains two static scales for greater efficiency. The bypass lane allows trucks to bypass the static scale at speeds of 45 mph (72 kph). (That speed is generally 10 mph (16 kph) faster than other stations along the corridor.)

TEST SUMMARIES

The same equipment and drivers were used throughout the tests, to maintain continuity and uniformity of testing procedures. Two five axle tractor/trailer units from Collins & Aikman Products Co. of New London, North Carolina were used, along with the same drivers. The drivers, Mr. Leon Cox and Mr. Grady Wood, have over 60 years of commercial driving experience between them. Their experience proved to be a great asset during the tests.

In an attempt to obtain "real-world" results as closely as possible, standard issue equipment was used for these fuel consumption tests. The only modification made to the vehicles was the addition of the portable fuel tanks, utilized for the precise measurement of the fuel usage. Prior to the first set of tests in Ohio, the tractors were equipped with "quick-connect" fittings by the motor carrier, permitting the easy installation and subsequent removal of the portable fuel tanks and fuel coolers. No other alterations were made to the tractors or trailers. The following lists the specifications of the equipment:

1. 1993 Freightliner Conventional Model D 120 64ST
2. 400 hp Detroit 60 Series 12.7 Liter engine, equipped with DDECII electronic engine management system
3. Eaton Roadranger 10 speed transmission
4. 2 10" wheelbase
5. 11 x 22.5 low profile radial tires
6. 48' x 102" enclosed Great Dane trailers
7. Air ride suspension system

FINDLAY, OHIO

The fuel consumption tests began on August 3, 1996 at the weigh stations near Findlay, Ohio in Hancock and Wood Counties. The Hancock County weigh station is located on the Southbound side of I-75 and the Wood County weigh station is located on the Northbound side of the interstate. To reiterate, the reason for selecting this set of weigh stations, was that these weigh stations are set on flat terrain with moderate traffic levels and there are stations on either side of the interstate. This selection provided an effective contrast to Knoxville, Tennessee that has a hilly terrain and heavy traffic levels.

The static scale design required a minimum of 60 runs, in the original plan: 30 in the "control" condition and 30 in the "test" condition. After completing 12 runs in the control condition and 26 runs in the test condition it was determined that additional runs were not required since existing results provided results at the desired level of accuracy. As a result of this experience sample sizes were reduced for all weigh station designs. To review our experimental design, two trucks drove repeated highway circuits under two different scenarios. To recap the scenarios, the "control"' condition is where both trucks remain on the freeway for the experiment to establish the baseline fuel consumption difference between the trucks. The "test" condition is where one truck, termed the test truck, enters the weigh station to simulate the processing of a given vehicle. The other truck, termed the control truck, remains on the freeway and does not enter the weigh station. The fuel consumption difference between a truck entering and slowing (or stopping) at a given weigh station and one that is able to remain on the freeway is measured. This difference in fuel consumed, after allowing for the baseline differences between the trucks, is the estimated fuel savings attributable to bypassing a weigh station.

Base of Operations

The base of operations for this was a rest area on the southbound leg of the route. During most of the testing the rest area was near full capacity. Because the tests were conducted during the day, testing began at 9:00 AM. Beginning at this hour allowed for the morning rush hour traffic to clear, and for travelers to vacate parking spaces in the rest area. Each morning members of the crew secured three parking spaces at the north end of the rest area (two spaces for the tractor-trailers and one space for the van and equipment trailer.) Securing the first three parking spaces permitted the trucks to enter the rest area unimpeded by other traffic. After refueling the trucks, members of the crew would go out into the rest area and halt traffic until the test trucks had entered the freeway. Stopping traffic in the rest area permitted the trucks to accelerate smoothly and maintain consistent run times.

Figure Eight: Control Truck Entering Base of Operations

Test Route

The test route for this set of tests was a 37 mile (59.5 kilometers) loop, with the north boundary at Exit 179 and the south boundary at Exit 161. The north exit was US. Highway 6, a 4-lane divided highway, with little traffic during the day. The turnaround point on the south exit was a county road with very little traffic.

Traffic

Over the course of the tests in Ohio, the traffic volume varied. Mostly, the traffic was light to moderate. During runs four through seven, however, the drivers described heavy car traffic, which caused the drivers to slow down to 55 mph (88.5 kph) for about 2 miles (3.2 km). Fortunately, the heavy car traffic did not affect the test results. Later in the test, however, the drivers encountered heavy truck traffic. When this situation occurred, the drivers experienced heavy turbulence from the trucks passing the test vehicles. This turbulence caused wider than normal variance in the test results.

Test Conditions

To recap this portion of the Motor Carrier Fuel Consumption Test, the topography at this location in Ohio is flat with wide open spaces. The weather cooperated throughout the test, with no adverse impact on the proceedings. For the four days of testing the temperature averaged in the mid-80°F (26°C) with little to moderate winds.

For this test, 30,472 lb. (13,834 kg) of freight was obtained from a local warehouse for each truck. Adding the freight to the truck made the gross weight (the weight of the vehicle plus the weight of the freight) of each of the trucks 65,000 lb. (29,510 kg). The evaluation task force determined this gross weight "target" to be the approximate average weight of commercial vehicles operating on the highways. (Please refer to Appendix page 40 for copies of the bills of lading and scale receipts for the actual, certified weight used for the tests.)

MONROE, MICHIGAN

The second round of testing took place at the weigh stations near Monroe, Michigan beginning on August 20, 1996. These stations are located between Detroit, Michigan and Toledo, Ohio, about 35 miles (56 km) south of Detroit. These scales are the ramp WIM (weigh-in-motion) design type, with a weigh-in-motion scale in the entrance ramp and a single static scale for stationary weighing of vehicles and inspection purposes. These are the same weigh stations used in the Pilot Studies in the Summer of 1995.

Base of Operations

The base of operations was an interstate rest area and welcome center on the northbound end of the route. The rest area was continuously full and traffic levels were heavy with both car and truck traffic, requiring testing during nighttime hours. This alleviated some of the traffic congestion on the highway, but the rest area remained filled with trucks and drivers resting before making their rounds the next day.

Three parking spaces were secured at the south end of the rest area prior to each day's testing. Again, securing these spaces permitted the test vehicles to enter the rest area smoothly and park next to the van and equipment trailer for refueling. As was done in the previous set of tests, when the trucks left the rest area, members of the crew halted traffic temporarily to allow the test trucks to enter the highway unimpeded from the other vehicles, in order to maintain consistent run times.

Test Route

The north "border" of the test route was moved north one exit from the Pilot Study, because of the opening of a Pilot Travel Plaza at the exit and the addition of stop lights. The turnaround point was moved north on Interstate 275, Milemarker 2. Moving from I-75 to I-275 was a smooth transition as the highway provided a merge lane to the I-275 Loop at highway speeds. There was no slowdown required until the designated turnaround point at Milemarker 2.

The southbound border of the test route remained Exit 5 of I-75, the Temperance Road exit. This is not a heavily traveled road and there are no stoplights to hinder the vehicles' process.

Moving the north border of the test loop did not extend the test loop too far. The loop was a 34 mile (55 km) round trip, well within the parameters of the test procedures.

Traffic

This stretch of Interstate 75 was streaming with so much traffic that the tests were conducted at night. Nighttime testing was performed in order to maintain consistency in the test results and to alleviate the amount of turbulence caused by other trucks moving around the test vehicles. Even so, at times the test trucks would still encounter "packs" of trucks that would surround them for a period of time. Administering the tests at night, however, lessened the impact of the heavy traffic volume.

Test Conditions

The tests at Monroe, Michigan represent one of the contrasting ramp WIM design types. The topography at this location was flat with wide open spaces. The weather also cooperated during this set of tests. Because these tests were run during nighttime hours, the temperatures were cooler than were experienced in Ohio. The temperatures averaged in the low 70's F (21 °C) and winds remained calm. The mild weather had little or no adverse impact on the research.

For this test 30,920 lb (14,038 kg) of freight was obtained from a local warehouse for each truck. By obtaining approximately the same amount of freight for this set of tests (within 500 lb (227 kg) from the previous set of tests), it was anticipated that the test results would remain consistent. (Refer to Appendix page 40 for copies of bills of lading and certified scale receipts.)

The revised design ramp WIM station required a minimum of 50 runs, 25 in the "control" condition and 25 in the "test" condition. The duration of the testing was seven days, including the placement and subsequent removal of the test equipment on the trucks. This specific set of tests consisted of 48 total runs, 23 in the control condition and 25 in the test condition. A broken water pump on the control truck forced cessation of the testing after the 48th run. It was the next day before repairs were completed. A review of the data collected determined that the preliminary results were within the parameters established by the Evaluation Task Force. Therefore, the team did not return to the field to complete two more runs.

KNOXVILLE, TENNESSEE

The third round of testing took place at the weigh stations near Knoxville, Tennessee beginning on September 17, 1996. These stations are located about 15 miles (24 km) west of Knoxville, near the junction of Interstates 40 and 75. These static scales are set in hilly terrain with a heavy volume. (At peak operating times, an average 430 trucks per hour enter or bypass the weigh station.) There is a long, steep grade approaching the eastbound scale. This steep hill, coupled with heavy traffic, made this location a natural contrast to the scales in Ohio. As with those scales in Ohio, there is no ramp weigh-in-motion scale to sort traffic at this location. These are the same weigh stations used for the Pilot Studies in the summer of 1995.

Due to the heavy volume of truck traffic, the policies and practices at the weigh stations have been modified by Tennessee Motor Vehicle Enforcement officials. Changes in weigh station procedures were made to reduce the risks of accidents on the interstate. Generally, it is required that all trucks approaching the weigh stations enter the stations. However, if there is a queue of vehicles on the entrance ramp that extends to the interstate, then the next vehicle (or vehicles) can bypass the weigh station without repercussions. This practice of allowing commercial vehicles to continue past the weigh station when the queue is full prohibits vehicles from lining up onto the interstate, which would cause a severe safety hazard.

Base of Operations

A base of operations was established at an undeveloped rest area west of the weigh stations. The use of this facility worked well because there was little traffic around the area. Additionally, this rest area had no toilet or snack food facilities, which probably contributed to the lack of traffic interference in the immediate area. Due to the heavy traffic around the weigh station, however, the tests were conducted at night, to diminish the turbulence caused by the traffic. Each night the parking area was secured for the trucks and testing equipment. As cars and trucks still utilized the area, crew members were dispatched to stop traffic temporarily to allow the test trucks to enter the freeway unimpeded from other traffic.

Test Route

The east border of the test route was moved two exits east from the one used in the Pilot Studies, because of continued road construction to the airport. The turnaround point was moved to Milemarker 375 on Interstate 75/40 near Knoxville. The overpass road did have a metered stoplight. The stoplight, however, did not cause any extended delays, due to a low traffic volume on that road and the time of night that the tests were conducted. The westbound turnaround point remained Milemarker 356 on Interstate 40. This is not a heavily traveled road, and there are no stop lights to hinder the test vehicles' progress.

By moving the east exit of the test route, the loop extended about three more miles, making a 41 mile (66 km) round trip. The length of the trip is well within the parameters of the test procedures.

Traffic

Like Monroe, Michigan, this stretch of Interstate 75 is heavily traveled. The large traffic volume caused the tests to be performed at night in an attempt to diminish the impact of traffic on the test, both in terms of turbulence and possible speed variations. By running the tests at night there was a definite reduction in the amount of automobile traffic. The amount of truck traffic, however, appeared to remain constant. There were times when after the closure of the weigh station was requested to allow the test truck to enter the scale, that the control truck was then in the middle of a "pack" of trucks. While this truck traffic did not adversely affect the overall test, it is noteworthy that the traffic volume of commercial vehicles did not seem to decrease appreciably during the nighttime hours.

Test Conditions

The Knoxville, Tennessee weigh stations were chosen because of the hilly terrain and high traffic volume. This site provided a sharp contrast to the character of the static scales utilized in Ohio, which were located on flat terrain, with a lower traffic volume. By using these contrasting sites, it was hoped to capture a broad range of fuel consumption differences along the I-75 corridor.

The weather did not adversely impact our testing procedures. The weather was cool but humid during the three nights of testing. There was fog during one night of testing. It was not, however, thick enough to suspend testing. The temperature averaged the mid-60's F (16°C) and winds remained calm.

For this test, 31,600 lb (14,364 kg) of freight was acquired for each truck. The gross weight of each truck was virtually identical; within 120 lb (55 kg) of the other. The control truck's gross weight was 65,400 lb (29,692 kg) and the test truck's gross weight was 65,520 lb (29,746 kg) (Refer to Appendix page 37 for copies of bills of lading and certified scale receipts.)

The revised design for the static scale station required a minimum of 30 runs, 15 in the "control" condition and 15 in the "test" condition. This set of tests completed 30 total runs, 15 in each condition.

CHARLOTTE COUNTY, FLORIDA

The fourth round of testing was conducted at the weigh stations in Charlotte County, Florida, near the city of Punta Gorda. The testing began on October 2, 1996, and lasted through October 9, 1996. These weigh stations are located about six miles south of the intersection of US 17 and Interstate 75. These scales are termed "high-speed" ramp WIM, because the scale is equipped with a ramp WIM sorter and a bypass lane with a posted speed limit of 45 mph (72 kph). This bypass lane speed is considerably higher than other bypass lanes, hence the term "high-speed ramp WIM." Along with the bypass lane, there are two static scales, one on each side of the scale house, and a large parking lot for inspection purposes. This particular set of scales was not used in the Pilot Studies, although a similar design layout, near Marion, Florida, was included in the Pilot Studies in 1995.

Base of Operations

The base of operations for this set of tests was the shoulder of the road on the south side of the test route. The nearest rest area was not acceptable because there was no direct access to it. The rest area on North Jones Loop Road is about l/4 mile (0.4 km) off the interstate, and the trucks would have to maneuver around a long circular drive to get to the parking area. Thus, a wide shoulder area on Tuckers Grade Road was utilized for the base of operations. Tuckers' Grade Road is a four lane, divided road, that provided an adequate set-up area. The shoulder proved to be satisfactory, as there was little traffic on this road to interfere with the test procedures. There was also plenty of territory for the trucks to make their turns into the base area. The Florida DOT also supplied the crew with warning flags that were posted alongside the road, to warn any oncoming motorists that a crew was working along the shoulder of the roadway.

As with previous tests, after refueling the trucks, crew members were sent to designated positions to hold back any oncoming traffic and send the trucks on the test route.

Test Route

The north border of the test route was Exit 34. There was very little traffic on this end of the test route. The south border, as stated, was Exit 27, Tuckers' Grade Road. This was a 47 mile (76 km) route. Again, there was little traffic and no traffic signals to interfere with the operations. Given the length of the route, the crew was fortunate to complete 10 runs a day, and remain within the drivers' hours of service limits.

Traffic

Truck traffic was not a hindrance at this location. There was a moderate amount of automobile traffic, however, not enough to cause major problems.

Test Conditions

The tests at the Florida location were conducted at the efficient "high-speed ramp WIM" design. It was a wide open, flat area. There was the Peace River bridge to cross each run, however. The bridge was probably 3/4 mile (1.2 km) long. There were cross winds that the trucks encountered going across the bridge. Temperatures were warm, in the mid-80's F (27 ° C). There were moderately gusty winds throughout the testing. On the seventh day of testing, Tropical Storm Josephine came ashore north of the test location. While the area did not bear the brunt of the storm, there were strong winds and rain in the area. The turbulent weather conditions forced a delay in testing on two occasions, to allow for the storm to dissipate. However, there was sustained precipitation throughout the day.

For this test 30,240 lb (13,729 kg) of freight was procured for each truck. Again, the gross weight of each was virtually identical, within 80 lb (36 kg). The gross weight of the control truck was 64,840 lb (29,437 kg). The test truck's gross weight was 64,740 lb (29,392 kg). (Refer to Appendix page 40 for copies of bills of lading and certified scale receipts.)

The revised design for the high speed ramp WIM station required a minimum of 70 runs, 35 in each condition. The larger number of runs is a consequence of the smaller fuel savings expected in this type of station. This test completed 70 runs, 35 in each condition.

MONROE COUNTY, GEORGIA

The fifth and final round of testing was conducted at the weigh stations in Monroe County, Georgia, near the city of Forsyth, about 60 miles (96 km) south of Atlanta, Georgia. These scales are the ramp weigh-in-motion (WIM) design type, similar to those in Monroe, Michigan. These scales provide a substantial contrast to the weigh stations in Michigan, as these scales sit on top of a hill. There is a long, gradual incline approaching the static scale at both northbound and southbound weigh stations, in contrast to the scales in Michigan, which sit on flat terrain. Testing began on February 25, 1997 and concluded on March 1, 1997.

Base of Operations

A rest area at the south end of the test route provided the crew with a base of operations. The rest area was continually full and traffic volumes were heavier than anticipated with both automobiles and trucks.

The crew was fortunate each day to secure three parking spaces; keeping the parking spots secured also proved to be a challenge. On several occasions, even after cones were placed in the spots to reserve the space, people would park in those spaces. Crew members frequently asked people to move their vehicles, so the test trucks would have a place to park. As with the other tests, after refueling the tanks, the crew was dispatched to hold back traffic to allow the trucks to enter the freeway without interference.

Test Route

The north end of the test route was Exit 65, High Falls Road. The south end was Exit 58, Bolingbrooke Road. Neither road was heavily traveled and there were no traffic signals to hinder their progress. Utilizing these two exits produced a 41 mile (66 km) test route.

Traffic

This area of Interstate 75 had an ample amount of traffic, both in trucks and automobiles. There was heavier than normal tourist traffic, due to a motorcycle rally in Daytona, Florida the following weekend. Even without the tourist traffic, the test trucks encountered several slowdowns during the runs, due to heavier than expected truck traffic.

Test Conditions

The rolling terrain at this set of weigh stations provided a sharp contrast to the area surrounding the weigh stations in Monroe, Michigan. The test route contained several hills, including long slopes approaching the southbound weigh station and the rest area. The weather also cooperated during the tests. The temperature was moderate, in the 70's F, (21° C). We did, however, encounter light rain during two of the days of testing.

For these tests, 30,240 lb (13,729 kg) of bricks were acquired. The acquisition of this freight produced a gross weight of 65,280 lb (29,637 kg) for the control truck and 65,520 lb (29,746 kg) for the test truck. Again, the gross weights of the vehicles were very similar, a difference of only 240 lb (109 kg). (Refer to Appendix page 40 for copies of bills of lading and certified scale receipts.)

The revised design for the ramp WIM station required 50 runs to be performed 25 in the control condition and 25 in the test condition. This test completed 50 runs, 25 in each condition, carried out over a period of five days.

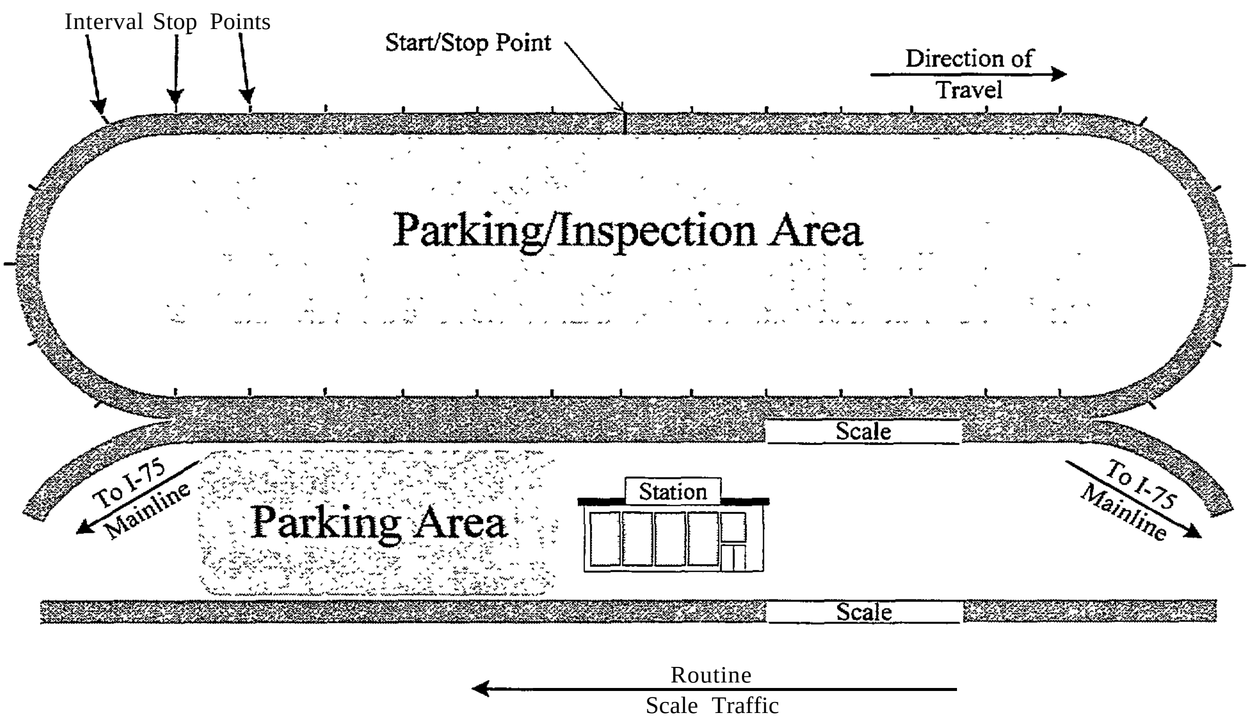
WEIGH STATION QUEUE FUEL CONSUMPTION TESTS

Separate fuel consumption tests were conducted at the Charlotte County, Florida weigh stations to gather data for estimating the effect of weigh station queues on fuel consumption. The tests were conducted using similar procedures to those used for to the fuel consumption tests at the weigh stations. Some procedures were adjusted to account for the fact that we now had drivers starting and stopping at various intervals. The description of the test procedures went as follows:

Scenarios

Two identically equipped trucks, one termed the control truck, the other termed the test truck complete test runs of defined loops, as illustrated in Figure Nine. These tests were conducted in the large parking and inspection area at the Charlotte County, Florida weigh station. The trucks completed five baseline runs whereby both trucks follow the control truck script. The control truck script established the baseline fuel consumption differences between the two trucks. The trucks then completed five experimental runs in which the test truck stopped each 200 feet, (61 m), and the control truck again followed the control script. The last set of five runs had the test tuck stop each 100 feet (30.5 m).

Figure 9: Weigh Station Queue Fuel Consumption Tests



Scripts

The drivers completed each test run according to the following scripts. Separate scripts are provided for the control truck and the test truck.

Script for the Control Truck

1. Upon entering the truck cab, close the vent window and side window, reset the cumulative stop timer to zero, release the parking brakes (hold the vehicle in place using the foot brake pedal), and wait for the start signal from the data collection team leader.
2. When the data collection team leader signals the start of the run, start the engine, depart from the start/stop point, and accelerate to 15 miles per hour (24 kph).
3. Maintain a speed of 15 miles per hour (24 kph), complete two loops of the parking area access road, and return to the start/stop point.
4. Upon arriving at the start/stop point put the transmission in neutral, set the parking brake, and immediately shut down the engine.

Script for the Test Truck

1. Upon entering the truck cab, close the vent window and side window, reset the cumulative stop timer to zero, release the parking brakes (hold the vehicle in place using the foot brake pedal), and wait for the start signal from the data collection team leader.
2. When the data collection team leader signals run start, start the engine, depart the start top point and accelerate to 5 miles per hour (8 kph). (This was an average in-queue speed observed during Pilot Study Two's weigh station throughput timing tests.)
3. Come to a complete stop at the first interval stop point and remain stopped for a period of 15 seconds.
4. Depart the first interval start/stop point and accelerate to 5 miles per hour (8 kph).
5. Come to a complete stop at the next interval stop point and remain stopped for a period or 15 seconds.
6. Repeat steps 5 and 6 for each interval stop point, complete two loops of the parking area access road, and return to the start stop point.
7. Upon arriving at the start/stop point put the transmission in neutral, set the parking brake, and immediately shut down the engine.

Std. $Dev._e$= the standard deviation of the observed fuel consumption differences between the control truck and the test truck during the experimental runs

SEMean = the standard error of the sample mean (this is equal to the standard deviation divided by the square root of the number of runs; it is a measure of the variability of our sample mean measurement).

N_b= number of baseline runs

N_e= number of experimental runs

The fuel consumption values are provided in Table Four for the tests of various weigh stations. The table lists the difference in fuel consumption between the two trucks during the baseline runs (in which both trucks bypass the weigh station) and the experimental runs (in which one truck bypasses while the other pulls into weigh station). The difference between M_b and M_e is a measure of fuel savings due to trucks bypassing weigh stations. M_e, the difference between the fuel consumption of a truck bypassing the station and one pulling into the station, is not an accurate measure of the savings in fuel because the observed differences on the experimental runs could be due to variations between the test truck and control truck rather than bypassing the station. This is why we use baseline runs to establish the relative fuel consumption of the two trucks at the time of each test. To elaborate:

Notice that at most locations the control truck (which always bypasses the station) uses more fuel than the test truck (which pulls into the station) during the experimental runs. For example, at the Findlay, Ohio station, the control truck used 0.05 gallons more bypassing the station than the test truck uses when it stops at the static scale. We use the baseline runs to establish the relative fuel consumption of the two trucks at the time of each test. At Findlay, Ohio, when both trucks bypass the weigh station the control truck consumes 0.23 gallons more fuel than the test truck. It is the difference between these two values, 0.23 - 0.05 = 0.18, that represents the fuel savings. By stopping at the static scale the test truck has consumed additional fuel so that the two trucks are nearly the same in terms of fuel consumed.

The use of baseline and experimental runs would not be necessary if it were possible to use truly identical trucks. For truly identical trucks the mean difference for the baseline runs (M_b) would be zero. For this evaluation the mean difference for the baseline runs was positive, the vehicle used as the control truck always consumed more fuel than the test truck during the baseline runs. This can be due to minor variations in engine performance, tire tread, or any number of other possible factors. Since it is not possible to control all of these factors the baseline runs provide the best means of obtaining accurate estimates of fuel savings.

Table Five illustrates the estimated fuel savings per weigh station bypass.

Table 5: Estimated Fuel Savings Per Weigh Station

Location	Weigh Station Type	Estimated Fuel Savings in Gallons (Liters)	95% Confidence Interval in Gallons (Liters)
Monroe MI	Ramp WIM	0.11 (0.42)	0.085, 0.134 (0.322, 0.507)
Findlay OH	Static Scale	0.18 (0.68)	0.151, 0.207 (0.572, 0.783)
Knoxville TN	Static Scale	0.16 (0.61)	0.134, 0.194 (0.507, 0.734)
Monroe Co. GA	Ramp WIM	0.06 (0.22)	0.026, 0.097 (0.098, 0.367)
Charlotte Co. FL	High Speed Ramp WIM	0.05 (0.19)	0.037, 0.067 (0.140, 0.254)

The two sample pooled-t-statistic-based methods are used for drawing conclusions. To be specific, the runs are viewed as a sample from the population of interest (i.e., the savings that would be observed in a much bigger experiment involving more trucks). The observed difference between M_b and M_e is an estimate of the fuel savings expected. A 95% confidence interval provides a range of plausible values for the expected fuel savings. The formula used to provide the interval is:

$$\text{Confidence Interval} = (M_b - M_e) \pm t* \ S\left(\sqrt{\tfrac{1}{N_b} + \tfrac{1}{N_e}}\right)$$

where S is a pooled (combined) estimate of variability that uses both the experimental and baseline runs and the $t*$ value is a number that can be obtained from the tables to insure the 95% confidence statement is accurate (the $t*$ value is generally about 2.0). More details about this procedure can be found in a variety of statistics texts including The Basic Practice of Statistics by D.S. Moore, W.H. Freeman and Co., 1994. The pooled procedures require that S_b and S_e be approximately the same. They are almost identical at four of the five sites. The difference is more substantial in Charlotte County, Florida, but still within the range for which pooled procedures can be applied.

The width of the confidence interval is determined mainly by the standard error of the baseline and experimental means. Although the standard deviations are large, indicating substantial run-to-run variability, the standard errors are much smaller because they account for the sample size. Sample sizes were chosen with the goal of obtaining confidence intervals that are sufficiently narrow for the present purpose.

An alternative method of expressing the value of fuel savings attributable to electronic clearance is in percentage of fuel saved. The following table expresses the fuel savings terms of gallons saved per clearance. These values are expressed as a percentage of the fuel required to complete l/2 of the loop, i.e. per one station. Table 6 includes an expanded version of the data that led to these conclusions along with notes about computing fuel savings as a percentage. The numbers range from 1.53% to 6.65%.

Table 6: Fuel Savings As a Percentage

Station	Type of Run	Number of Runs	Mean Fuel Used - Control Truck Gal. (Ltr.)	Mean Fuel Used - Test Truck Gal. (Ltr.)	Mean Difference Between Control and Test Truck Gal. (Ltr.)	Savings (%)
Findlay OH (Static Scale)	Baseline	12	2.82	2.59	0.23	
	Experimental	26	2.79	2.74	0.05	6.65%
Knoxville TN (Static Scale)	Baseline	15	2.98	2.8	0.18	
	Experimental	15	2.95	2.94	0.01	5.69%
Monroe MI (Ramp WIM)	Baseline	23	2.62	2.49	0.13	
	Experimental	25	2.57	2.55	0.23	4.33%
Monroe GA (Ramp WIM)	Baseline	25	3.4	3.39	0.02	
	Experimental	25	3.44	3.49	-0.45	1.80%
Charlotte FL (High Speed (Ramp WIM)	Baseline	35	3.42	3.25	0.17	
	Experimental	34	3.52	3.41	0.12	1.53%

The percentage of fuel saved is derived by taking the fuel consumed by both trucks per l/2 loop (one station) and dividing by the mean amount of fuel used by the test truck on that half loop. For example, at Findlay, Ohio the typical savings are calculated by subtracting the experimental fuel used from the baseline fuel used, then dividing by the typical fuel used per half loop. Therefore, fuel savings expressed as a percentage is: 0.18/2.69 = 6.65%.

At the Knoxville, Tennessee site, the typical fuel consumption is 2.8765 gallons. The fuel savings is then 0.1638/2.8765 = 5.69%.

At Monroe, Michigan the typical fuel consumption is 2.5295 gallons. The fuel savings as a percentage is then calculated as (savings/consumption) 0.1096/2.5295 = 4.33%.

At the Monroe County, Georgia site, the typical fuel consumption is 3.414 gallons. The fuel savings as a percentage is then calculated (savings/consumption) 0.0616/3.4 14 = 1.80%.

At the Charlotte County, Florida location the typical fuel consumption is 3.3875 gallons. The fuel savings as a percentage is then calculated (savings/consumption) 0.0519/3.3875 = 1.53%.

Results of Weigh Station Queue Tests

These weigh station queue tests were designed to provide some insight into the fuel consumption of commercial vehicles which make repeated starts and stops. These tests were to simulate, as closely as possible, a full weigh station queue. As stated earlier, the test truck made repeated stops at 100 ft. (30.5 m) and 200 ft. (61 m) intervals. During these queue tests the trucks were loaded with 35,000 lb. (15,890 kg) of freight to better simulate actual operations through a given weigh station.

The methods for data analysis and reduction of the weigh station queue tests are the same as for the highway speed versions with one modification. Results are recorded as fuel saved per mile rather than per weigh station since no weigh station bypasses are involved in this test.

Table Seven shows the results for three sets of runs: baseline runs in which both trucks complete a one-mile loop at about 15 mph with no stops, Experimental Condition I (200 ft., 61 m) in which the test truck stops every 200 feet (6 1 m) for 15 seconds, and Experimental Condition II (100 ft., 30.5 m) in which the test truck stops every 100 feet (30.5 m) for 15 seconds.

The control truck averaged about 13.1 mph (2 1.1 kph) during its 15 runs. We report the mean difference between the two trucks in gallons saved per mile along with the run-to-run standard deviation and the standard error of the mean. Here, as before, the baseline mean would be zero if it were possible to use identical trucks. The observed difference suggests that the control truck consumes more fuel at 13.1 mph (21.1 kph) than the test truck on the baseline run. In the two experimental conditions the test truck consumes considerably more fuel. The standard deviations of the Baseline and Experimental I runs are extremely similar, however, the Experimental II runs were much more variable. Perhaps the constant stopping and starting made these runs more susceptible to environmental factors. Given the small number of runs we have treated the standard deviations as equal.

Table 7 summarizes the results of the weigh station queue test.

Table 7: Baseline and Experimental Results For Weigh Station Queue Test

Run Type	**Approx. stops** ft. (m)	**Approx. Speed in** mph (kph)	**Number of Runs**	**Mean** in Gal. (Ltr.)	**Standard Dev.** in Gal. (Ltr.)	**SE Mean** in Gal. (Ltr.)
Baseline	None	13.1 (21.1)	5	0.0697 (0.263)	0.0124 (0.047)	0.0055 (0.021)
Experimental I	200' (61 m)	3.8 (6.1)	5	-0.1897 (-0.718)	0.0127 (0.048)	0.0057 (0.022)
Experimental II	100' (30.5 m)	2.3 (3.7)	5	-0.2960 (-1.120)	0.0233 (0.088)	0.0104 (0.039)

To further explain the Weigh Station Queue Test Results, we go to Table 8. The figures in Table Eight suggest that the stop-and-go driving conditions typical of weigh station queues may increase the expected fuel savings for commercial vehicles electronically cleared past static scales. Our earlier weigh station results suggest that a truck pulling into an empty weigh station, stopping at the scale, and accelerating back to highway speed will consume 0.16 to 0.18 gallons (0.61 to 0.68 liters) of fuel per station. The numbers here suggest that a queue moving roughly at 4 mph (6.4 kph) for a length 0.5 miles (0.8 km) would add another 0.13 gallon (0.49 liters) of fuel to the cost of stopping (0.26 gallons per mile for 0.5 miles) or (0.98 liters per kilometers for 0.8 km).

Table 8: Estimated Fuel Savings and Confidence Interval For Weigh Station Queue Tests
(relative to baseline)

Run Type	**Approx. Stops** in feet (m)	**Speed** in mph (kph)	**Cost of Stop/Go in gal/mi** (ltr/km)	**95% Confidence Interval** in gal. **(ltr.)**
Experimental I	200' (61m)	3.8 (6.1)	0.26 (0.98)	0.24, 0.28 (0.91, 1.06)
Experimental II	100 (30.5m)	2.3 (3.7)	0.37 (1.40)	0.34, 0.39 (1.29, 1.48)

SUMMARY AND FINDINGS

Table 5 (see page 34) provides the mean fuel savings in gallons (or liters) per weigh station bypassed and a 95% confidence interval for each site. All confidence intervals exclude the value zero which means that the fuel savings are "statistically significant." This statement is of limited value since it would seem evident that some fuel savings accrue to trucks that bypass weigh stations. A more important issue concerns the magnitude of savings.

The static scales provide the most dramatic savings with bypasses of Knox, Tennessee and Findlay, Ohio saving 0.16 and 0.18 gallons (0.61 and 0.68 liters) per station, respectively. The high-speed ramp WIM in Charlotte County, Florida performs as advertised with fuel savings of about 0.05 gallons (0.19 liters) per station bypassed. The savings accrued at the ramp WIM set of scales are between these two extremes. The savings in Monroe, Michigan were estimated at 0.11 gallons (0.42 liters) per station. The result from the Monroe County, Georgia station (0.06 gallons (0.19 liters) per station) is surprisingly low, even with the hilly terrain surrounding the Forsyth area. The confidence interval here is widest because there was a great deal of variability from run-to-run.

The estimated fuel savings per station bypassed is somewhat conservative since the experimental runs eliminated traffic within the weigh station. The weigh station queue tests provide some insight into the magnitude of the additional fuel savings due to queue traffic. It appears that the stop-and-go traffic, averaging 4 mph (6.4 kph) consumes an additional 0.26 gallons (0.98 liters) per mile (km) relative to the 15 mph (24 kph) constant travel. A queue moving at 2 mph (3 kph) consumes 0.37 gallons (1.4 liters) per mile (km) relative to the 15 mph (24 kph) constant travel through a given weigh station. The fuel consumption relative to mainline speed is probably a small amount more, but we did not measure this relationship directly. More testing is needed in the area of fuel consumption in queue relative to mainline speeds.

The value of electronic clearance, therefore, depends on the number and nature of stations passed. For example, in societal terms, suppose 100 trucks per hour were cleared to pass a static scale. The clearance of these trucks would mean savings of 16 gallons (6 1 liters) of fuel per hour (assuming no queue) for those 100 electronic clearances. Assuming a 0.5 mile (0.8 km) queue of stop-and-go traffic, would add another 13 gallons (49 liters) to the savings over those 100 clearances. If those trucks were cleared at a ramp Weigh-In-Motion (WIM) type scale, the fuel savings could range from 6 gallons (22.71 liters) to 11 gallons (41.64 liters) for those 100 trucks being cleared electronically.

Another method of expressing the value of electronic clearance is to state it in economic terms in relation to an individual truck or firm. Therefore, suppose a truck were cleared to bypass 100 static scale stations over a month period. With fuel at $1 .08/gallon[2] this could mean a fuel savings to the carrier of approximately $11 .00/month per truck. Thus, as a result of these experiments, we can state that there are measurable fuel savings attributable to electronic clearance at weigh stations.

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2 National Truck Stop (NTS) Average price. week of January 3-9, 1998.

PROVING GROUND FOR ADVANCED TECHNOLOGY

Advantage I-75 Mainline Automated Clearance System

Final Report
Part 3 of 5: Weigh Station Individual Evaluation Report
Prepared for
The Advantage I-75 EvaIuation Task Force

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Introduction

This document is the third of five evaluation reports for the Advantage I-75 Mainline Automated Clearance Systems (MACS) on the performance and productivity of weigh stations along the I-75/Highway 401 corridor between Ontario and Florida. The vision of the Advantage I-75 program is to incorporate existing technologies into an ITS operational setting that will provide an initial step in the process of adapting the nation's highway systems to accommodate the increased demands placed on it. A field operational test entitled *Mainline Automated Clearance* Systems (MACS) was designed and implemented for the Advantage I-75 program. The objective of the MACS operational test was to allow transponder-equipped trucks to travel any segment of the entire length of I-75 and Highway 401 at mainline speeds with no more than a single stop at a weigh station.

Project Scope

The purpose of this part of the evaluation is to determine if mainline electronic clearance produces significant travel time savings for motor carriers. The data collection procedure used to make this determination was designed by Iowa State University. The prescribed method was to position recorders at the entrance point of the weigh station, at the static scale, and at the exit point of the weigh station. The recorders, equipped with stop watches, then recorded the time each truck crossed the specific point. Mainline speeds were also recorded. The difference in time between the commercial vehicle in the weigh station, and one on the mainline was the estimated time savings attributable to being electronically screened on the mainline.

Findings

The fundamental hypothesis tested was that reduction or elimination of stops at weigh stations by participant transponder-equipped vehicles will result in travel time savings for that truck. Travel time estimates were measured at 19 sets of weigh stations along the corridor. These 19 sets of stations represent the three main weigh station design types. They are the static scale design type, the ramp weigh-in-motion (WIM) design type, and the high-speed ramp WIM design type.

The estimated time savings were different for each weigh station design type. Travel time savings were most substantial at the static scale design types. At the static scales in Knoxville, Tennessee and Findlay, Ohio, vehicle bypasses provided measurable time savings, on average, of 4.86 minutes, and 2.22 minutes, per station respectively. Part of the time difference is the amount of truck traffic at each facility. Trucks entered the Knoxville, Tennessee weigh station at a rate of 450 trucks per hour, while the rate of arriving vehicles at the stations near Findlay, Ohio was 2 15 trucks per hour. The travel time savings between driving on the mainline and driving through the weigh-in-motion stations are smaller. Travel time savings at WIM stations such as those in Monroe, Michigan were estimated at 1.33 minutes per station. The time savings accrued in Charlotte County, Florida, at the high-speed ramp WIM, were 1.92 minutes per station cleared to bypass. The principal conclusion from this experiment is that there are measurable time savings obtained by electronic clearance. The value of these savings, however, depends on the number and nature of the stations being electronically cleared.

PURPOSE OF EVALUATION

The purpose of the weigh station throughput evaluation is to determine the effect of the Advantage I-75 MACS project on travel time for commercial vehicles on the I-75 corridor. Specifically, the difference in time required by commercial vehicles traveling through Advantage I-75 MACS weigh stations and the time required by vehicles that are electronically cleared to bypass the same weigh stations was measured.

EVALUATION DESCRIPTION

The evaluation procedures, as described in the Weigh Station Individual Evaluation Test Plan, submitted to the Task Force on May 10, 1996, is based on the results of the previous evaluation activities and pilot studies. The test is designed to determine the potential time savings attributable to being cleared to pass weigh stations at selected sites along the Advantage I-75/Highway 40 1 corridor. Comparisons of travel times for vehicles electronically cleared to bypass selected weigh stations on the mainline and for vehicles routinely processed through the same weigh stations were established by collecting explicit vehicle throughput data during multiple time periods. The throughput data consisted of vehicle identification and arrival times collected at three locations within the weigh station for all vehicles entering the station during the prescribed time periods. The three locations were:

- Point One: Upstream base of the weigh station approach ramp (Point of Entry).
- Point Two: Static scale or primary monitoring facility at the center of the weigh station.
- Point Three: Downstream base of the weigh station departure ramp (Point of Exit).

Two research assistants were positioned at each of the three locations and manually recorded the vehicle identification and arrival time for each arriving vehicle during the scheduled observation time period. Data were collected in 66 minute increments at the beginning of the tests. The six additional minutes of data were required to ensure that all measurements were obtained for each vehicle arriving at Point One during the first 60 minutes. On the basis of Pilot Study Two results, six minutes was an adequate time for approximately 99 percent of the arriving vehicles from Point One to Point Three. Later collection sessions gathered the data in two-hour increments. The use of two-hour periods proved to be more helpful for constructing a weigh station simulation program, which was required for other aspects of the evaluation.

The arrival time data at Points One, Two and Three were used to calculate the mean inter-arrival time and processing time at each of the weigh stations. The mean interarrival time is a measure of how frequently vehicles arrive at a specified point (e.g., Point One). For example, a mean inter-arrival time of 8.5 seconds at Point One, indicates that, on average, one vehicle is arriving at Point One every 8.5 seconds. Processing time is a measure of the time required for vehicles to be processed from the beginning point of the weigh station (Point One) to the ending point of the weigh station (Point Three). Travel time savings were established by subtracting the mainline travel time from Point One to Point Three at observed highway speeds from the weigh station processing time. The results of the evaluation are presented in a tabular listing of the typical travel time savings at each of the selected Advantage I-75 weigh stations. The nature and extent of vehicle inspections were determined by recording vehicle processing data for each vehicle arriving at the static scale or central processing point (e.g. Point Two) during the scheduled time periods. The data recorded are an identifier code used to designate pre-defined inspection scenarios and processing time. On the basis of the results of Pilot Study Two, the following three inspection scenarios were used for this test:

- Stop at Scale: Routine processing, in which the vehicle is immediately released to the mainline after the weight and credentials have been examined.
- Level One: Brief inspection, in which the vehicle is first directed to park on the scale (not pulled out of queue) for a brief credential check and then released to the mainline.
- Level Two: Detailed inspection, in which a vehicle is pulled out of queue and directed to park at a designated inspection and parking area for further inspection or credential check.

The data were recorded simultaneously with the identification and arrival time information by the research assistants stationed at Point Two.

For each selected test site, the inspection information is presented in a tabular format providing the number of vehicles entering the weigh station, the number of vehicles that stopped at the scale, and the number of Level One and Level Two inspections that occurred during the scheduled collection periods.

As the design of some of the weigh stations is such that not all the stations require that the vehicles entering the stations arrive at the static scale, (e.g. Ramp WIM and High-Speed Ramp WIM stations), the collected data are also useful in determining the probabilities of being directed to the static scale (Point Two) at these stations.

Hypothesis Tested

- "Reduction or elimination of stops at weigh stations by participant transponder-equipped trucks will result in travel time savings for those trucks."

Recap of Test Procedures

This test compared the travel time required for vehicles proceeding through the weigh station to that of vehicles bypassing the station at observed mainline speeds. We then calculated expected travel time savings resulting from electronic clearance at selected Advantage CVO MACS weigh stations. The data, referred to as throughput processing time data, were collected at scheduled one- and two-hour time periods that coincided with both peak and non-peak traffic conditions. The test output is listed in tabular format stating the mean and standard deviation of travel time savings, and intervals describing the travel time savings for 95% of the truck population for each of the selected test sites.

The evaluation also incorporated a survey of the nature and extent of existing inspection and credential monitoring conditions at selected Advantage CVO MACS weigh stations. The study documented the number and type of inspection and credential monitoring that occurred during the scheduled time periods. The results of this part of the study are listed in Table 5. The information provided is the number of inspections or credential verifications during the specified time periods.

Statistical Methods Used to Analyze the Data

The statistical methods used were consistent with the various aims of this data collection effort. The first part of the statistical analysis of the data was error checking and editing. The experience from the pilot studies proved accurate; approximately one-to-two percent of the data records contained data entry or recording errors. Some of these errors were easily discovered; for example, a truck recorded as having reached Point Three prior to reaching Point One.

The principal method of analysis was simply to record summaries of the data. To measure time savings the mean amount of time required for a truck to pass through the weigh station (based on a large sample) is reported. A smaller sample of speed measurements is used to assess the time required for trucks that bypass the weigh station to travel a similar distance. The difference between the two means is a measure of travel time savings. The median is an alternative measurement that is not affected by outlying errant values. In addition to reporting the mean savings, a measure of variability (the standard deviation) and an interval that describes the experiences of the middle 95 percent of the population of commercial vehicles (with others excluded as possible errors or evidence of unusual driving) is also reported. In addition, the recorded data will provide information about the frequency and duration of inspections under the current system. This information is most useful for others to assess the possible impact of electronic clearance on credential monitoring and other violations.

A second aim of the data collection was to provide data for building and validating simulation models. The tables described above were essential to that effort, but the simulation requires additional data about the probability distribution of various random phenomena (i.e., the interval between consecutive truck arrivals or the service time for an inspection or static weighing). Standard distributions like the exponential distribution for arrival times (or its generalized version, known as the gamma distribution) and normal distributions for processing times or speeds were also considered. The parameters of these distributions were chosen to match the observed mean and standard deviation of the data.

Evaluation Schedule

The evaluation schedule was contingent upon close coordination with the test participants and test location. The following tables list the contact names, addresses and telephone numbers for the key participants and research locations.

Key participants included the evaluation manager, evaluation coordinators, data collection team, and statistical analysis team. Table 1, provides the key contact, telephone numbers, fax numbers, and role of each key participant.

Table 1: Evaluation Participant Contacts by Project Role

Role	Key Contact	Address	Phone/Fax
Evaluation Manager	Mr. Bill McCall	Center for Transportation Research and Education 2625 N. Loop Drive Suite 2100 Ames, IA 50010-8615	(515) 294-9501 (515) 294-0467
Evaluation Coordinators	Mr. Dennis Kroeger	Center for Transportation Research and Education 2625 N. Loop Drive Suite 2100 Ames, IA 50010-8615	(515) 294-7164 (515) 294-0467
Data Collection Team	Mr. Ed Powe	Entrepreneurial Development Institute Kentucky State University 415 Hathaway Hall Frankfort, KY 40601	(502) 227-6172 (502) 227-6763
Statistical Analysis	Dr. Hal Stern	121 Snedecor Hall Iowa State University Ames, IA 50011-1210	(515) 294-5582 (515) 294-4040

Evaluation Locations

Because many weigh stations only operate during certain hours of the day, the evaluation was extremely dependent on close coordination with weigh station personnel. Table 2 provides the key contact names, addresses, telephone and fax numbers for each of the weigh stations included in the test. Every effort was made to contact the weigh station both by telephone and in writing approximately one month prior to commencement of the throughput data collection. The weigh station personnel were cooperative during the test procedures. Also, the data collection team made sure not to disturb the stations' operations while collecting the data.

Table 2: Weigh Station Contacts by Test Location

Test Location	Key Contact	Address	Phone/Fax
Halton, Ontario (Trafalgar North and South)	Mr. John Cowan	Ministry of Transportation 1182 North Shore Blvd. East P.O. Box 5020 Burlington ON, L7R-3Z9	(905) 637-4108 Ext. 252 (905) 637-4114
Middlesex, Ontario (Putnam North and South)	Ms. Kathie Costello	Ministry of Transportation 659 Exeter Road London, ON N6E- 1 L3	(5 19) 649-3004 (519) 649-3086
Essex, Ontario (Windsor North and South)	Mr. Duncan Calder	Ministry of Transportation 2740 Dougall Avenue Windsor, ON N8X-lT2	(5 19) 972-7349 (519) 973-1492
Monroe, MI (Erie East and West)	Lt. Thomas Kenney	Michigan State Police 300 Jones Avenue Monroe, MI 48161	(313) 242-3500 (3 13) 242-8928
Hancock/Wood, OH	Sgt. Jim Bennett	Ohio Highway Patrol 320 1 North Main Avenue Findlay, OH 45840	(419) 423-1414 (419) 423-9179
Kenton, KY	Lt. Jim Sutter	Kentucky Transportation Cabinet Motor Vehicle Enforcement: P.O. Box 109 Walton, KY 4 1094-0109	(606) 356-l 111 (606) 356-0862
Scott, KY (Georgetown)	Lt. William Carter	Kentucky Transportation Cabinet Motor Vehicle Enforcement P.O. Box 760 Georgetown, KY 40324	(502) 863-4559 (502) 863-2124
Knoxville, TN	Capt. Richard Sayne	Tennessee Dept. of Public Safety 760 1 Kingston Pike Knoxville, TN 37919	(615) 966-5071 (615) 671-1293
Monroe Co., GA (Forsyth)	Capt. Cliff Tackett	Georgia Dept. of Transportation 276 Memorial Drive Atlanta, GA 30303	(912) 994-1278 (912) 993-3017
Lowndes Co., GA (Valdosta)	Capt. Charles Purvis	Georgia Dept. of Transportation 276 Memorial Drive Atlanta, GA 30303	(912) 244-6863 (912) 245-433 1
Charlotte Co., FL (Punta Gorda)	Maj. Bill Mickler	Florida Dept. of Transportation 605 Suwannee Street Mail Station 99 Tallahassee, FL 32399-0450	904-488-7920 904-221-6627

The data collection schedule was originally designed to be in concert with the fuel consumption tests, and **to** be completed during the summer of 1996. The schedule was revised due to several factors:

- At the time of the data collection, the weigh stations at Halton and Middlesex, Ontario, due to staff constraints, were only operating 30 - 40% of the time.
- At Hancock, Ohio the weigh station building was undergoing renovation during June and July 1996, and was closed for 90 days due to the construction.
- The crews at the Monroe and Lowndes, Georgia stations were reassigned to Atlanta, Georgia for parts of July and August 1996 to assist with traffic control and security for the 1996 Summer Olympic Games.
- Following the Olympics, these stations then underwent construction improvements and were closed for periods of time during the fall. The data collection was delayed until December 1996.

Figure 1: Original Data Collection Schedule

Task Name	1996 01 | 02 | 0304 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |	1997 01 | 02 | 0304 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |	1998 01 | 02 | 0304 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
Evaluation Preparation	May 96 —June 96		
Data Collection	June 96 ——— Octc	ber 96	
Data Analysis	October 96	October 97	
Report Preparation		November 97	March 98

The data collection was originally scheduled to begin in mid-May 1996 and to have been completed within four months. The data collection was delayed, but was completed by mid-December 1996. Figure 2 shows the revised data collection schedule.

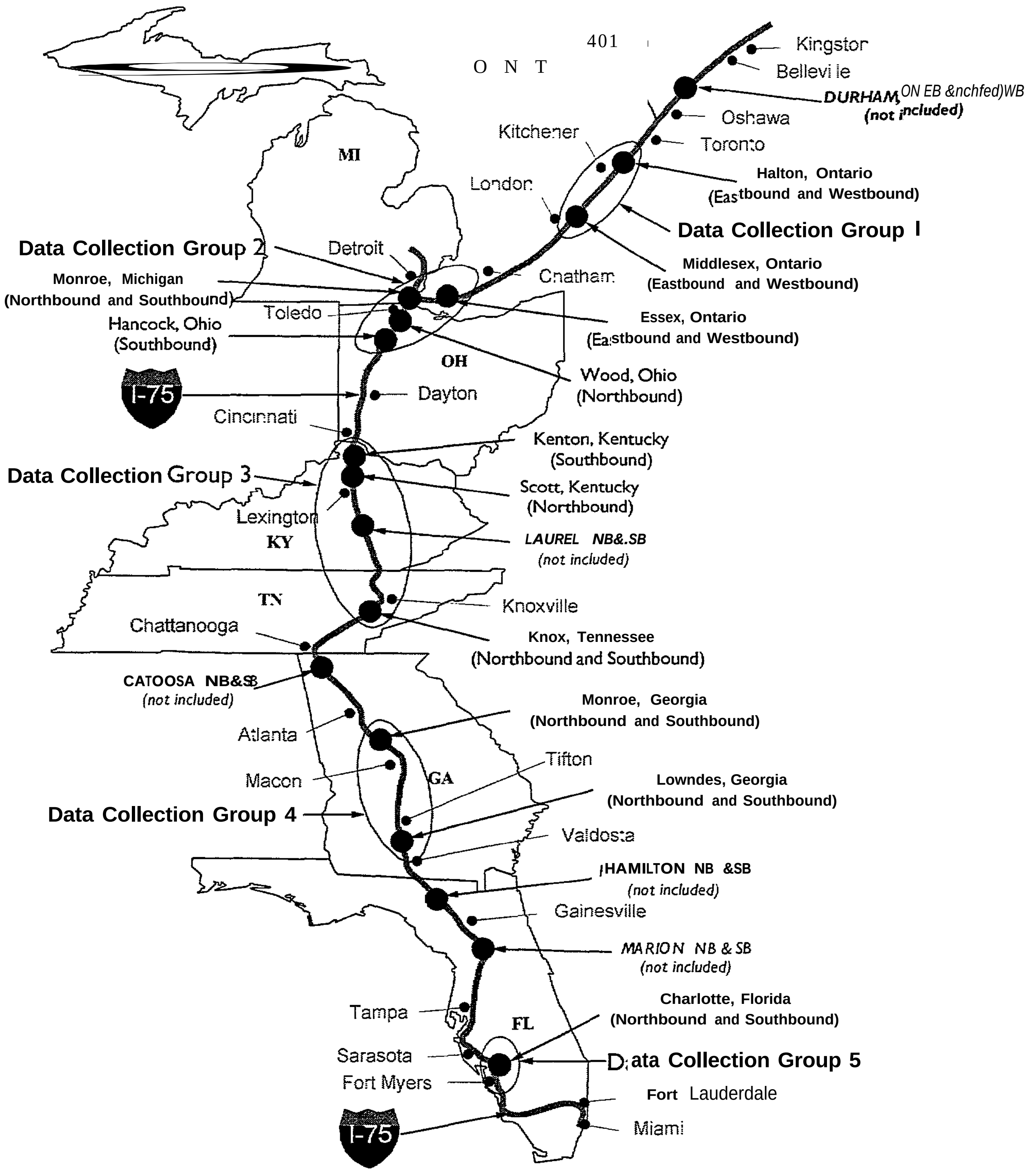
Figure 2: Actual Data Collection Schedule

Task Name	1996 01 | 02 | 0304 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |	1997 01 | 02 | 0304 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |	1998 01 | 02 | 0304 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
Evaluation Preparation	May 96 —June 96		
Data Collection	June 96	December 96	
Data Analysis	October 96	Octo	ber 97
Report Preparation		November 97	March 98

An overview of the data collection schedule:

- Test Preparation: May - June 1996
- Data Collection: June - December 1996
- Data Analysis: October 1996 - October 1997
- Final Report Preparation: November 1997 - March 1998

Figure 3: Data Collection Locations



As Figure 3 indicates, the data collection locations were grouped geographically into Data Collection Groups One through Five beginning with Data Collection Group One in Ontario, moving South to Group Two stations in Michigan and Ohio. Data Collection Group Three contained the stations in Kentucky and Tennessee. Data Collection Group Four included the stations in Georgia, and Data Collection Group Five included the stations in Florida.

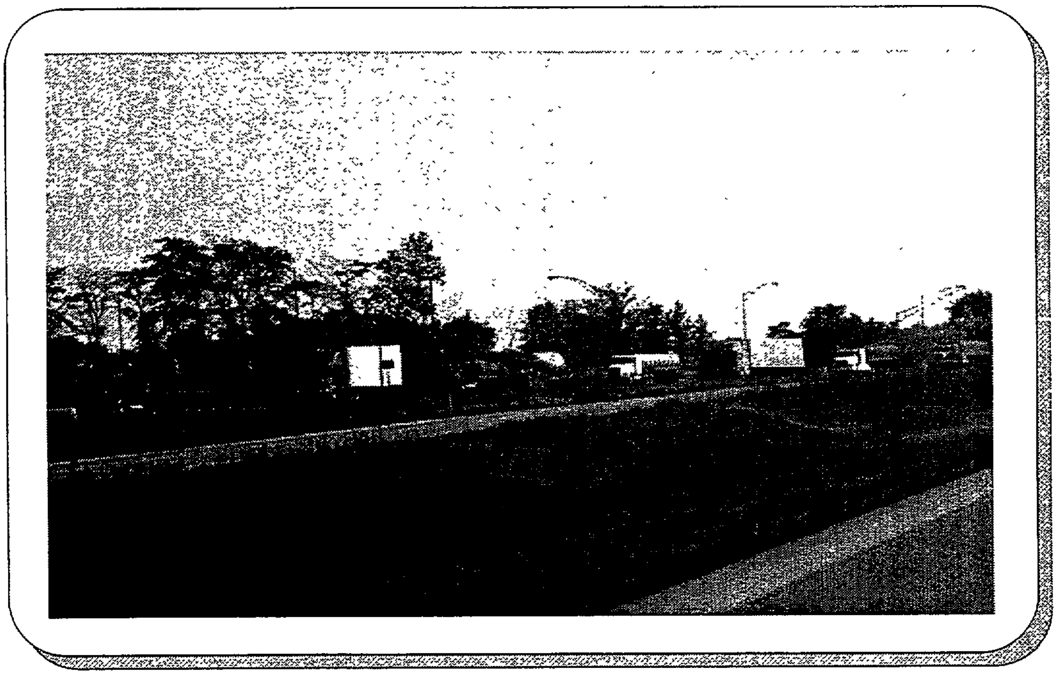


Figure 4: Weigh Station Queue at Findlay, Ohio

Figure 4 above, shows the arrival of trucks at the weigh station near Findlay, Ohio. The picture clearly illustrates the queue of trucks extending to the mainline highway.

The following table lists the weigh stations for which data were collected, and an indication of their peak hours of operations.

Table 3: Weigh Station Design Description

Station Name	Design Type	Peak Hours	Peak Queue Conditions
Halton, ON	Ramp WIM	7:00-9:00 AM East 9:00-l 1 :00 AM & 3:00-5:00 PM West	Frequently full queues resulting in manual closing as frequently as 6 times/hour during peak periods.
Middlesex, ON	Ramp WIM	7:00AM-3:00PM East 7:00-9:00 AM & 1:00-3:00 PM West	Frequently full queues resulting in automatic station closing as frequently as 3 times/hour during peak periods.
Essex,ON	Ramp WIM: East Static Scale: West	7:00AM-3:00PM East 7:00-l 0:00AM West	Frequently full queues resulting in automatic station closing as frequently as 6 times/hour during peak periods.
Monroe, MI	Ramp WIM	6:00-9:00 AM North 3:00-6:00 PM South	Frequently 2,000 ft queues during peak hours. No station closings.
Wood, OH	Static Scale	5:00-9:00 AM & 2:00-7:00 PM	Queue overflows onto mainline 5-7 times per hour during peaks. Manual station closing when notified by CB radio.
Hancock, OH	Static Scale	6:00-9:00 AM & 3:00-6:00 PM	Queue overflows onto mainline 7-9 times per hour during peaks. Queue monitored by TV camera. Manual station closing when queue fills.
Kenton, KY (southbound only)	Ramp WIM	9:00-l 1 :00 AM	Rarely full queues. No station closings.
Scott, KY (northbound only)	Ramp WIM	6:00-9:00 AM & 3:00-6:00 PM	Rarely full queues. Automatic station closing when queue fills.
Knox, TN	Static Scale	6:00AM-5:00 PM	Consistently full queues. Vehicles instructed to bypass when full. No station closings.
Monroe, GA	Ramp WIM	11:00 AM-4:00 PM	Seldom full queues. Manual station closing when full.
Lowndes, GA	Ramp WIM	7:00-l 1:00 PM South 9:00 AM-4:00 PM North	Seldom full queues. Manual station closing when full.
Charlotte, FL	High-Speed Ramp WIM	10:00 AM-5:00 PM	No full queues. No station closings.

Recap of Evaluation Procedures

A detailed description follows of the scenarios and procedures for the weigh station throughput evaluation.

Scenarios

While it is important to evaluate the effect of electronic clearance on weigh station performance, the task is complicated by the fact that the traffic conditions at every station are affected by a number of unique factors such as topography and traffic patterns. Additional complications include seasonal variation in traffic volume, special events traffic such as sporting events and conventions, and continuous road construction. With the enormous number of possible scenarios, a comprehensive design that would include data describing every possible traffic condition does not seem possible. Instead we opted to survey the stations during the summer months (when it was easiest to recruit data collection members and stay within the proposed evaluation time frarne) at both peak and non-peak travel times. Our aim was to provide information representative of the range of behavior seen at each station. Information about other scenarios (e.g., winter travel) can be obtained by simulation or extrapolation from the results obtained here.

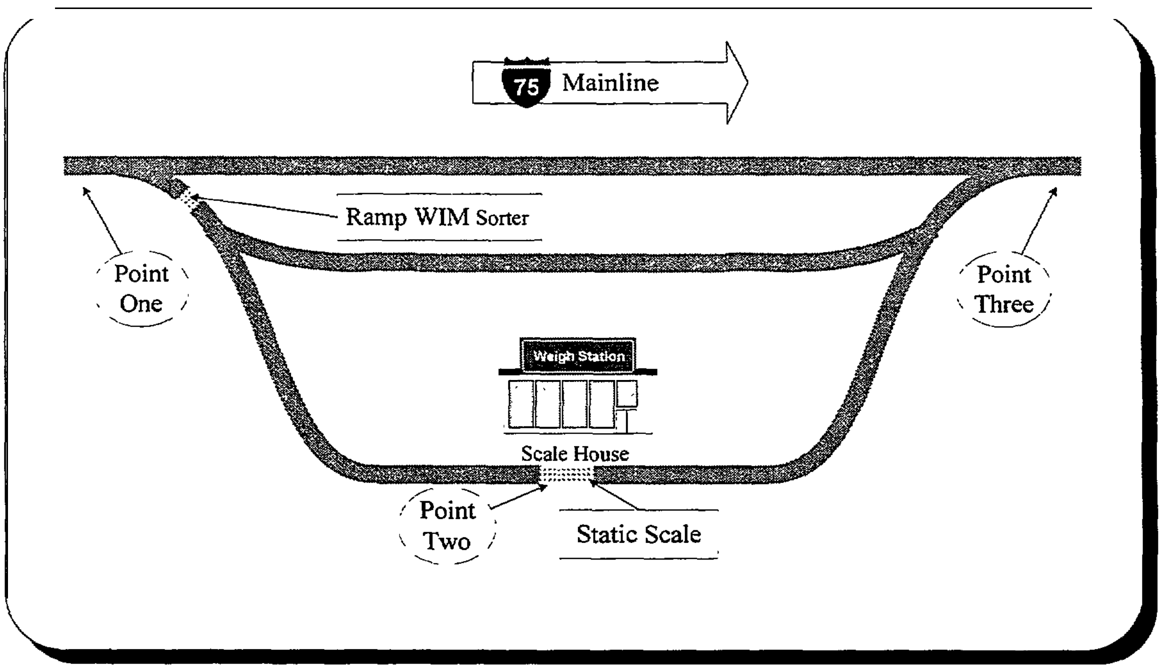


Figure 5: Weigh Station Data Collection Points

Throughput Data Collection Procedures

The procedures used for recording vehicle arrival time and unique vehicle identification information at each of the three data collection points shown in Figure 5 were identical for each selected collection site. (These are the procedures, as described in the Detailed Evaluation Plan, submitted on May 10, 1996).

- **Point One:** Point One was staffed by three individuals: one arrival observer, one arrival recorder, and one bypass observer/recorder. Prior to the start of the first scheduled one-hour data collection session, the data collection team leader locates and permanently marks the observation point (using a 1 "x2"x 18" pointed stake or fluorescent paint) at the location shown on the detailed weigh station site plan. (Site plans for each of the selected test sites are provided in Appendix Three.) The distance from Point One to Point Two was then measured using a surveyor's wheel and recorded on the site plan and in the right header of the first hour's Vehicle Arrival/Departure Identification Form. Just prior to the start of each scheduled session, the arrival recorder enters the information, such as site identification and weather information, in the header of page one of the Vehicle Arrival/Departure Identification Form.

As the session began, the arrival observer called out the unique truck identification (first four digits of the prorate plate and arrival time (MM:SS) to the recorder. For example, suppose that two closely spaced (say 100 feet apart) trucks arrive at Point One shortly after the session began. Now further suppose that the first truck, with prorate plate PR-4564, arrived at Point One at 2 minutes 14 seconds past the hour, and the second truck, with prorate plate RC-8742 arrived at Point One at 2 minutes 26 seconds past the hour. The arrival observer would announce the first truck as ***"PR45-02:14"*** and the second truck as ***"RC87--02:26.*** " The arrival recorder would record the first truck on the 2-minute line (i.e., third line from the top) on page one of the Truck Arrival/Departure Identification Form by noting PR45 on the ID line (gray-shaded) and 14 on the Sec. line (not shaded). The second truck would be recorded in the box immediately to the right of the first truck by noting RC87 on the ID line (gray shaded) and 26 on the time line (not shaded). Figure Six illustrates the above sample entries in an abbreviated version of the Vehicle Arrival/Departure Identification Form. Complete forms are included in the Appendix of the final report.

Figure 6: Abbreviated Vehicle Arrival/Departure Identification Form

Minute		Vehicle Identification and Arrival Time (Seconds)								
0	ID.									
	Sec.									
1	ID.									
	Sec.									
2	ID.	PR45	RC87							
	Sec.	14	26							
3	ID.									
	Sec.									

Using this system, the team can note the ID and arrival time of up to 10 trucks in any one-minute period.

On the basis of the results of Pilot Study Two, secondary vehicle identification procedures were established for those instances when the vehicle's prorate plate is not immediately conspicuous. Conditions encountered during this study indicated that the view of prorate plate is obstructed on approximately 10 percent of vehicles entering the weigh station because the plate is attached to the lower portion of the truck's front bumper on a pivoting bracket which is blown back, covered by an Oversize Vehicle sign, or otherwise not immediately visible. To ensure uniform identification of these vehicles at each of the data collection points, the following order of vehicle identification priority was established:

1. Vehicle prorate plate/identification tag (e.g., first four digits)
2. Vehicle cab color (e.g., blue, green, white, and etc.)
3. Vehicle make (e.g., Navistar, Ford, Kenworth, Peterbilt, and etc.)

We used this procedure to identify vehicles in order to reduce the possibility of erroneous or duplicate vehicle descriptions simultaneously residing in the throughput data set.

The bypass observer/recorder was located in the vicinity of Point One where the bypassing truck traffic can be safely observed. On the basis of the results of Pilot Study Two, the best location for this individual was approximately 200 feet downstream from Point One approximately 10 feet off the road shoulder. Just prior to the start of each session, this individual records the appropriate information in the header of the Truck Bypass Form (see page A-5). As the session commenced, this individual observed and recorded each commercial vehicle bypass event attributable to a queue overflow condition. As each bypass event occurred, this individual placed a dot on the appropriate minute line of the form using a ten-dot tally system. For example, if four vehicle bypasses were observed during minute six of the session, this individual placed four dots on line six of the form.

- **Point Two** Point Two was staffed by one or two individuals depending on the arrival rates and the arrival speed at the static scale. Generally the arrival speed at these sites was slow enough that one individual could both identify and record the required information.

Prior to the start of the first scheduled one-hour data collection session, the data collection team leader located and permanently marked Point 2 (using a 1" x2"x 18" pointed stake or fluorescent paint) at the location shown on the detailed weigh station site plan). (Site plans for each of the selected test sites are provided in Appendix Three.) The distance from Point Two to Point Three was measured using a surveyor's wheel and recorded on the site plan and in the header of the first hour's Vehicle Arrival/Departure Identification Form

Just subsequent to the start of each scheduled session, the individual assigned to this point enters the information, such as site identification and weather information, in the header of page one of the Arrival/Departure Identification Form.

Figure 7: Recording Data at Static Scale

The individual recorded the unique vehicle identification, arrival time (using the method described for Point One), as each truck arrived at the weigh station's static scale. The processing scenario is observed and recorded based on the key described below in Table 4.

Table 4: Recording Vehicle Processing Scenarios

Processing Scenario	Notation
Stop at scale: Static weigh and exit	None
Level One: Static weigh, credential check (while stopped on scale platform), and exit	A
Level Two: Static weigh, inspection, credential check, and exit	+

For example, if a truck is weighed on the static scale and released to return to the mainline, no additional notations are recorded. Suppose, however, that a truck with prorate plate CY-4911 arrived at the static scale at 15:23 past the hour and was stopped on the static scale by an enforcement officer, who walked out of the scale house and asked to see the driver's logbook. Upon examining the driver's logbook, the enforcement officer then released the truck to return to the mainline. This event is then recorded by noting "CY49" on the gray shaded ID line of the 15-minute segment line of page one of the Truck Arrival/Departure Form (i.e., 16 lines from the top), and noting "'23A" (the symbol A is noted for this processing scenario) on the time line (not shaded). If the truck had been instructed to park and bring the credentials into the weigh station and/or the vehicle was parked for inspection, the time line portion of the event would be noted as "23+" (the symbol + is used to denote trucks that are static weighed, credential checked, and inspected prior to being released to the mainline).

It should be noted that not all vehicles arriving at Point One will be observed at Point Two for those weigh stations designated as Ramp WIM or High-Speed Ramp WIM design types. Pilot Study Two revealed that the majority of vehicles (77-99 percent of the total vehicles) that enter these weigh stations are immediately directed back to the mainline on a static scale bypass lane. The observer(s) at Point Two at these stations were instructed to only note the vehicle arrival, identification, and processing scenario data for those vehicles that are directed to the static scale.

The process is repeated using pages one, two, and three of the form until the session ends at six minutes past the following hour.

- **Point Three:** As Figure Five illustrates, Point Three corresponds to the point where vehicles exit the weigh station and return to the mainline. However, the term "Vehicle Arrival" is still used at this point to maintain consistency in data terminology. This point is staffed by two individuals, one arrival observer and one arrival recorder. Prior to the start of the first scheduled one-hour session, the data collection team leader located and permanently marked the observation point (using a 1 "x2"x 18" pointed stake or fluorescent paint) at the location shown on the detailed weigh station site plan.

Just prior to the start of each scheduled session, the arrival recorder entered information, such as site identification and weather information, in the header of page one of the Vehicle Arrival/Departure Identification Form.

As each truck arrived, these individuals noted and recorded the unique vehicle identification and arrival time using the method previously described for Point One. This process continued for each arriving vehicle until completion of the session at six minutes past the following hour.

DATA REDUCTION AND ANALYSIS

Hypothesis and Expected Results

To evaluate the hypothesis that trucks being electronically cleared to bypass weigh stations save time, we measured time savings using the test procedures described earlier in this document. Our goal was to provide a measure of expected savings (time in seconds per weigh station bypassed) for different weigh station designs. One can formally test the hypothesis of no savings, but this is not of much interest here. Instead we focused on providing a valid estimate along with estimates of the possible variation due to a variety of uncontrolled factors.

Input Data

Data recorded for each truck observed included identification information, time at which the truck reached Point One (entry point), time at which the truck reached Point Two (static scale) if it did so, time at which the truck reached Point Three (exit point), and inspection information. Relatively few trucks were submitted to inspections that required extended time delays, so those trucks were omitted from analysis. Only trucks that submitted to a static weigh and/or credential check are described in Table 11. The information was entered into a computer database for further study.

METHODS

Data Editing

Real-time data collection efforts of this type are prone to a number of types of data errors. Errors may occur when recording data in the field (not appropriately identifying a truck, times recorded in the wrong line of the entry form, a truck being sent for an inspection but not reported as such, etc.), or when entering the data into the computer database. We ran some consistency checks to ensure, for example, that trucks arrived at Point One earlier than they arrived at Point Two and that trucks arrived at Point Two earlier than they arrived at Point Three. We also looked for instances in which one truck apparently passed a second when that is not possible (in a standard static scale setup for example.) Incorrect data records were corrected after examining the original forms. Even after editing, several unusual observations remain, e.g., trucks requiring 20 or 30 minutes to traverse a station with no evidence of an inspection or credential check, or trucks requiring fewer than 30 seconds to traverse a station, implying incredible speeds. Truck records with travel times below thirty seconds or above 900 seconds (15 minutes) were assumed to be in error and deleted from further analysis

Data Analysis

The analysis approach that we took used simple descriptive statistics to summarize the experience of the commercial vehicle operations. At each station we report:

N= the number of trucks observed arriving and departing the station inspection (after deleting the number of unusual observations);

Mean = the mean time required to travel from Point One to Point Three;

Std Dev. = the standard deviation of the travel times from Point One to Point Three;

Median = the median travel time from Point One to Point Three (recall the median is the value such that 50% of the trucks had shorter travel times and 50% of the trucks had longer travel times);

(2.5%, 97.5%) = interval describing travel times for the middle 95% of truck traffic (the fastest 2.5% of the trucks and the slowest 2.5% of the trucks are excluded).

All times are given in seconds.

The standard error of the mean is given in some tables. This quantity is computed as the standard deviation divided by the square root of the sample size (n). It is a measure of how accurately the sample mean here reflects the mean that would be observed over the course of a longer time period. This formula for the standard error assumes that the data are independent observations. Although this assumption is not valid because the experience of one truck certainly depends upon other (especially earlier arriving trucks) trucks, the standard errors still do provide some measure of variability. In addition we have computed for some tables the travel speeds that would be required for a truck traveling on the mainline to cover the distance from Point 1 to Point 3. Estimated time savings are the difference between the mean processing time for trucks that enter the station and the mainline travel time.

Some discussion about the measures used here is necessary. It is common to summarize data of this type by the mean and standard deviation. There are, however, several features of these measures that suggest the mean and standard deviation are of limited benefit here. First, as mentioned earlier, the data include outliers. The worst of these have been eliminated but it is likely that others remain. Second, the usual justification for summarizing data by the mean and standard deviation is that data often follow a bell-shaped symmetric (or normal) distribution. In this case the data do not appear to be symmetric since it is easy to obtain processing times much in excess of the mean but there is a limit on how fast a truck will be processed (approximately 30 seconds). For these two reasons we have included as alternatives the median and a 95% interval. The median is comparable to the mean. In these cases the median is generally lower than the mean because the mean is inflated by the few long processing times. It should be emphasized, however, that the mean and median are two different measures neither is incorrect and both are useful. The mean is useful because multiplying the mean by a number of trips will yield a realistic estimate of total processing time (this is the definition of the mean). The median is useful because it probably better represents the typical trip than the mean does. The 95% interval is just an empirical observation of the processing times of the middle 95% of trucks processed through the weigh station. It should be pointed out that this is not a confidence interval as it does not represent an estimate of the mean of some population.

RESULTS

The results of the evaluation are organized under three headings: Processing Times, Estimated Travel Time Savings, and Inspection Scenarios. Following the discussion of the evaluation results are the general conclusions of the evaluation.

Processing Times

The weigh station processing times are reported separately for weigh stations with different designs. For each station, the total number of trucks recorded (generally over six hours of observation) is given along with the numerical summaries of the distribution time of the elapsed time required to travel through the station. Specific summaries provided are the mean and median processing time, the standard deviation of the processing times, the standard error of the mean (a measure of accuracy associated with the mean), and the 2.5% and 97.5% point of the distribution of processing times. The last two quantities, viewed as an interval, describe the processing times experiences by the 95% of truck traffic through the weigh stations.

As described earlier, trucks with unusually large travel times (more than 900 seconds or 15 minutes) or unusually small travel times (less than 30 seconds) are omitted from analysis. In addition, the results provided do not include those trucks that were required to submit to an inspection (either Level 1 or Level 2) because the time required for an inspection is unpredictable. The number of inspections is relatively small so that we do not have enough inspections to draw reliable conclusions about the time required to perform an inspection.

There are considerable differences in the processing times at the various weigh stations. Naturally, static scales require more time than WIM scales. There is also variability due to a number of other conditions including the length of weigh station, topography of the station, and the vehicle arrival times.

Table 5 provides the results for four weigh stations with static scales. At these scales all trucks entering the weigh station are expected to stop at Point Two; data for a handful of trucks for which no Point Two arrival times was recorded are excluded from analysis. The Knoxville, Tennessee station stands out with a mean travel time of nearly five minutes; the typical travel times range from three minutes to seven minutes.

Table 5: Processing Times
Static Scales (Trucks Stop at Point 2)

Station	N	Mean	Std. Dev.	Median Point	SE Mean	2.5%	97.5%
Wood OH NB	1,246	136.8	39.4	133	1.12	79	216
Hancock OH SB	1,309	127.4	34	124	0.94	78	201
Knox TN NB	454	296.2	63	296	2.96	193	423
Knox TN SB	454	285.5	62.2	282	2.92	170	422

Tables 6 and 6A provide the results for seven weigh stations that are equipped with WIM scales and for which relatively few trucks were observed to stop at the static scale. Table 6 provides the results for all trucks at these stations and those that bypass the static scale whereas Table 6A excludes the trucks that stopped at the static scale. The results are similar because the number of trucks stopping at the static scale is small here, generally fewer than 60. As might be expected the means increase when the number of trucks that stop at the static scale are included, because their processing times are larger than for the trucks that bypass. The mean and standard deviation can be quite sensitive to inclusion of these static-scale stops. The median is much less sensitive. We view the results of Table 6A as being more representative for these stations because of the small number of static scale observations.

Table 6: Ramp WIM Station with FEW Stops at Static Scale (Point 2) All Trucks (Including stops at scale)

Station	N	Mean	Std. Dev.	Median Point	SE Mean	2.5%	97.5%
Monroe GA SB	1,377	103.9	40.9	95	1.11	71	194
Kenton KY SB	1,243	150.4	23.9	147	0.68	112	205
Lowndes GA NB	851	81.5	34.1	73	1.17	59	191
Lowndes GA SB	795	81	36.4	70	1.29	56	216
Monroe MI NB	1,960	77.9	9.6	77	0.22	64	103
Monroe MI SB	1,892	80.6	45.8	73	1.03	61	140
Scott KY NB	1,324	97.1	34.6	93	0.96	64	139

Table 6A: Ramp WIM Scales with Trucks NOT Stopping at Static Scales (Point 2)

Station	N	Mean	Std. Dev.	Median Point	SE Mean	2.5%	97.5%
Monroe GA SB	1,341	100.1	30	94	0.82	70	150
Kenton KY SB	1,210	149.9	23.6	147	0.68	111	203
Lowndes GA NB	816	77	18.4	72	0.64	59	135
Lowndes GA SB	737	72.6	17.2	69	0.63	56	125
Monroe MI NB	1,960	77.9	9.6	77	0.22	64	103
Monroe MI SB	1,861	75.6	18.8	73	0.44	61	111
Scott KY NB	1,285	95.3	21.4	93	0.59	63	136

Tables 7, 7A, and 7B provide results for eight weigh stations that are equipped with WIM scales for which a significant portion of the population was observed to stop at the static scale. It is noteworthy that Essex, Ontario (Westbound) is included in this last group even though it is identified as a static scale rather than a WIM scale. The reason for this is that the data collection effort observed a substantial number of vehicles that traveled through the station without stopping at the static scales (115 vehicles representing 15% of the traffic).

For these eight stations, Table 7 includes the results for all trucks. Table 7A includes only the trucks allowed to bypass the static scale, and Table 7B includes only the trucks stopped at the static scale. As one would expect the trucks required to stop at the static scale have longer processing times than those allowed to bypass the scale. On average it appears to add one or two minutes per station at the static scale.

Table 7: Ramp WIM Scales With Significant Stops at Static Scale (Point 2) (All Trucks)

Station	N	Mean	Std. Dev.	Median Point	SE Mean	2.5%	97.5%
Charlotte FL NB	786	94.8	40	79	1.43	64	197
Charlotte FL SB	791	128.5	68.3	109	2.43	60	271
Essex ON EB	1,054	148.7	56.7	137	1.75	80	280
Essex ON WB	786	147.7	70.3	137	2.51	56	295
Halton ON EB	553	163.9	119.8	126	5.09	54	528
Halton ON WB	841	141.5	108.8	85	3.75	54	457
Middlesex ON EB	1,890	114.7	40	107	0.92	80	207
Middlesex ON WB	1,725	117.2	41.7	109	1.01	82	199

Table 7A: Ramp WIM Scales with Trucks NOT Stopping at Static Scale (Point 2)

Station	N	Mean	Std. Dev.	Median Point	SE Mean	2.5%	97.5%
Charlotte FL NB	631	77.9	12.9	76	0.51	63	106
Charlotte FL SB	647	114.1	55.5	77	2.18	59	205
Essex ON EB	89	101.1	33.1	97	3.51	62	195
Essex ON WB	115	101.7	51.5	86	0.21	34	222
Halton ON EB	332	103.4	70.2	79	3.85	50	275
Halton ON WB	531	83	49.9	72	2.17	51	268
Middlesex ON EB	1,684	106.4	20.7	104	0.51	80	140
Middlesex ON WB	1,557	111.9	35.8	108	0.91	82	156

Table 7B: Ramp WIM Scales of Trucks Stopping at Static Scale (Point 2)

Station	N	Mean	Std. Dev.	Median Point	SE Mean	2.5%	97.5%
Charlotte FL NB	155	163.6	39	157	3.13	117	290
Charlotte FL SB	144	193.3	81.7	161	6.81	111	454
Essex ON EB	965	153.1	56.4	142	1.82	88	286
Essex ON WB	671	155.6	70.1	145	2.71	68	327
Halton ON EB	221	254.9	121.5	227	8.17	95	586
Halton ON WB	310	241.6	109.5	222	6.22	101	523
Middlesex ON EB	206	182.7	77.5	168	5.4	116	394
Middlesex ON WB	168	166.1	57.6	158	4.44	107	518

Estimated Travel Time Savings

Tables 8, 9, and 10 provide a comparison of the observed processing times with an estimate of the time required for trucks that bypass the given station on the mainline highway. The mainline travel time is computed based on the average speed observed for trucks on the mainline in the vicinity of the weigh station. Average time savings per trip ranges from 1.5 - 5 minutes for static scales. For ramp WIM stations the average savings for a truck remaining on the mainline is 30 - 90 seconds against a truck on the WIM-bypass lane, and about 2 - 4 minutes against a truck which is directed to the static scale from a ramp WIM sorter.

There is quite a bit of variability in each case due to the different designs and traffic patterns at each station. In Table Eight it can be seen that among the static scales, the stations in Hancock and Wood Counties in Ohio require less time than the Knoxville, Tennessee station. Tables Nine and Ten show that among the ramp WIM stations, Monroe, Michigan, Lowndes County, Georgia, and Charlotte County, Florida tend to allow the fastest travel times. The station in Halton, Ontario generally requires more time.

Table 8: Estimated Travel Time Savings Attributable to Electronic Clearance at Static Scale Type Weigh Stations

Station	N	Mean Processing Time (Sec.)	Std. Dev (Sec.)	Mainline Travel Time (Sec.)[1]	Estimated Time Savings (Sec.)
Wood OH NB	1,246	137.5	44.68	31.82	105.7
Hancock OH SB	1,312	128.04	39.45	31.86	96.18
Knox TN NB	454	295.68	70.15	37.76	257.92
Knox TN SB	457	287.09	75.38	37.76	249.33
Essex, ON WB	794	150.17	81.59	15.92	134.25

[1] Ohio speed limits for commercial vehicles is 55 mph (88 kph). Other states are 65 mph (105 kph).

Table 9: Estimated Travel Time Savings Attributable to Electronic Clearance at Ramp WIM Type Weigh Stations

Station	N	Mean Processing Time (Sec.)	Std. Dev. (Sec.)	Mainline Travel Time (Sec.)[1]	Estimated Time Savings (Sec.)
Halton ON EB	567	173.93	142.47	31.92	142.01
Halton ON WB	845	150.84	158.31	30.99	119.85
Middlesex ON EB	1,895	116.13	56.79	50.35	65.78
Middlesex ON WB	1,734	118.63	48.43	47.68	70.95
Essex ON EB	1,055	149.27	58.43	31.37	117.9
Monroe MI NB	1,990	78.33	30.24	42.01	36.32
Monroe MI SB	1,892	81.35	48.72	30.99	50.36
Scott KY NB	1,351	96.53	43.93	26.93	69.6
Kenton KY SB	992	162.06	160.17	51.48	110.58
Monroe GA SB	1,392	104.32	51.5	32.89	71.43
Lowndes GA NB	873	85.48	63.5	33.18	52.3
Lowndes GA SB	814	88.73	83.04	33.18	55.55

[1] Michigan speed limit for commercial vehicles is 55 mph. Other states' limits are 65 mph.

Table 10: Estimated Travel Time Savings Attributable to Electronic Clearance at High Speed Ramp WIM Type Weigh Stations

Station	N	Mean Processing Time (Sec.)	Std. Dev. (Sec.)	Mainline Travel Time (Sec.)	Estimated Time Savings (Sec.)
Charlotte FL NB	800	97.59	49.06	47.94	49.65
Charlotte FL SB	799	132.85	82.55	47.98	84.87

Processing Scenarios

As described earlier, part of the data collected for each truck was a record of the type of processing it received. For each truck we record whether it stopped at the static scale, whether it received a Level One inspection, and whether it received a Level Two inspection. For the purposes of this report, and to be consistent with the individual test plan, Level One inspections are walk-around inspections. The Level Two inspections are full vehicle inspections. The data are recorded in Table 11 as vehicle counts and in Table 12 as percentages.

Table 11: Weigh Station Processing Scenarios

Location	N - Number of Trucks Through W.S.	Stop at Scale- Number (%)	Level One Inspections Number (%)	Level Two Inspections- Number (%)
Group One				
Halton, ON EB	609	260	18	0
Halton, ON WI3	909	384	4	8
Middlesex, ON EB	1,954	236	3	4
Middlesex, ON WB	1,793	202	6	6
Group Two				
Essex, ON EB	1,075	984	2	5
Essex, ON WB	813	693	4	2
Monroe, MI NB	1,997	5	3	4
Monroe, MI SB	1,904	34	1	3
Wood, OH NB	1,263	1,242	1	10
Hancock, OH SB	1,318	1,313	1	4
Group Three				
Kenton, KY SB	1,332	41	8	6
Scott, KY NB	1,361	44	1	2
Knoxville, TN NB	472	454	6	6
Knoxville, TN SB	461	456	0	0
Group Four				
Monroe, GA SB	1,410	32	0	11
Lowndes, GA NB	884	34	0	15
Lowndes, GA SB	821	58	5	13
Group Five				
Charlotte, FL NB	812	146	12	1
Charlotte, FL SB	815	144	9	2

Table 12: Percentage of Credential Checks and Vehicle Inspections at Weigh Stations on 175 Corridor

Weigh Station	% Stop at Scale	% Credential Check	% Inspection
Group One			
Halton ON EB	42.69	2.96	0
Halton ON WB	42.2	0.44	0.89
Middlesex ON EB	12.08	0.15	0.2
Middlesex ON WB	11.27	0.33	0.33
Group Two			
Essex ON EB	91.53	0.19	0.47
Essex ON WB	85.24	0.49	0.25
Monroe MI NB	0.25	0.15	0.2
Monroe MI SB	1.79	0.05	0.16
Wood OH NB	98.33	0.08	0.79
Group Three			
Kenton KY SB	3.01	0.6	0.45
Scott KY NB	3.23	0.07	0.15
Knox TN NB	96.16	1.27	1.27
Knox TN SB	98.48	0	0
Group Four			
Monroe GA SB	2.27	0	1.06
Lowndes GA NB	3.85	0	1.69
Lowndes GA SB	7.06	0.61	1.58
Group Five			
Charlotte FL NB	17.98	1.48	0.12
Charlotte FL SB	17.67	1.1	0.25

The data were collected during the summer of 1996 and reflect vehicle inspections and credential checks based on zero percent transponder usage (transponders were only available on a limited basis at that time). Note that the observed counts or percentages may reflect variations in enforcement strategies or truck populations. Here we briefly describe the processes that seem to be followed at the different stations. At the static scale stations, enforcement officials screen the vehicles as they approach the scales. The officer can then direct the vehicle to the inspection area if an inspection is required. At those sites with Ramp Weigh-In-Motion capabilities, the ramp WIM is set at a certain threshold, 72,000 lb. for example. At that point, vehicles that exceed 72,000 lb. are directed to the static scale to be weighed, and given a cursory examination. The fact that the vehicle is directed to the static scale does not mean that the vehicle will automatically be inspected . It only means that a static weight of the vehicles is required. A visual check of the vehicle is performed while it is being weighed. An inspection is possible, if vehicle defects are found during the cursory examination. Because the observed counts or percentages are merely a "snapshot" of station behavior at a particular point in time, they should be viewed for informational purposes only rather than as a formal evaluation of any specific hypothesis.

CONCLUSIONS

On the basis of our survey findings, numerous factors affect the measurement of travel time savings attributable to electronic clearance of commercial vehicles at weigh stations. The nature and amount of traffic, for example, around each weigh station plays a role in the amount of travel time saved (or expended) at each weigh station. For example, it will take vehicles longer to travel through weigh stations equipped with only static scales and no bypass lanes, than through those stations equipped with Ramp Weigh-in-Motion (WIM) scales and bypass lanes to sort compliant vehicles. There **is** little doubt that mainline electronic clearance of commercial vehicle can play a major role in increasing the productivity of the weigh station, as well as the motor carriers.

To illustrate, suppose a transponder-equipped truck was driven from Detroit, Michigan to Naples, Florida. If that truck were cleared to pass each of the southbound weigh stations, a total of 12 minutes, on average, could be saved by electronic clearance of that vehicle. This is valuable time that can be used by the carrier to make deliveries, and the weigh station personnel can focus their resources on other vehicles that were screened on the mainline.

Summarizing the information from this evaluation is difficult because the time savings that accrue to a particular company or vehicle depend on the number and type of weigh stations encountered. A commercial vehicle that frequently passes the weigh station near Knoxville, Tennessee can save up to five minutes per trip through electronic clearance. A couple of useful summaries are that a vehicle can save approximately 1.5 - 5 minutes for every static scale weigh station by using electronic clearance. Furthermore, approximately 0.5 - 1.5 minutes can be saved for every ramp WIM weigh station that a truck is electronically cleared to pass. An alternative summary can be obtained by considering a single trip over the length of the corridor (approximately 3,200 miles) and evaluating the total time saved. When this is done it appears that a truck can save 0.5 seconds for every mile traveled. A heavily used truck that travels 12,000 miles per month (144,000 miles per year) can save nearly two hours per month (100 minutes) by using electronic clearance. An extra two hours of truck time per month is worth approximately $96.00 per truck per month (assuming 50 miles per hour and $1.20 cost per mile. This does not include the fuel savings which are described in a separate evaluation). The evaluation suggests that electronic clearance offers significant benefits for both the motor carriers (time savings) and state officials (more efficient enforcement). While there is no “cookbook” answer for how much time will be saved or how much more efficient enforcement might become, **this** report takes the first step in determining systematically and comprehensively what the costs and benefits are. Therefore, this report states that there are measurable time savings attributable **to** electronic clearance of commercial vehicles at weigh stations. States and motor carrier officials can then use this information as part of their decision making process in determining **how** best to **utilize** electronic clearance at weigh stations.

ADVANTAGE I-75

PROVING GROUND FOR ADVANCED TECHNOLOGY

Advantage I-75 Mainline Automated Clearance System

Final Report
Fart 4 of 5: Simulation Modeling Individual Evaluation Report
Prepared for
The Advantage I-75 Evaluation Task Force

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EXECUTIVE SUMMARY

The following is the fourth of five evaluation reports for the Advantage I-75 MACS electronic screening project. The vision of the Advantage I-75 program is to incorporate existing technologies into an ITS operational setting that will provide an initial step in the process of adapting the nation's highway systems to accommodate the increased demands placed on it. A field operational test entitled *Mainline Automated Clearance Systems* (MACS) was designed and implemented for the then-termed Advantage I-75 MACS program. The objective of the Advantage I-75 MACS operational test was to allow transponder-equipped trucks to travel any segment of the entire length of I-75 and Highway 401 at mainline speeds with no more than a single stop at a weigh station.

PURPOSE OF THE EVALUATION

The purpose of this portion of the evaluation was to develop a reliable computer simulation model to assess the effect that the Advantage I-75 Mainline Clearance Operational Test (MACS) has on weigh station queue length and the number of unauthorized (queue-based) bypasses resulting from weigh station overcrowding.

INTRODUCTION

As the evaluator of the Advantage I-75 MACS Operational Test, we were given the task of quantifying the impact of electronic screening in terms of travel time savings for motor carriers and enhanced productivity of the weigh station. To conduct our evaluation, we developed a simulation model that provides for visual animation of traffic operations approaching, through, and after a weigh station. The simulation provides a robust medium for evaluation as it can quantify the benefits of electronic screening under a variety of operating policy alternatives and display the operation of the system under each alternative using high fidelity animation. The animation allows a broad audience to better understand the analysis and the effect of electronic screening on weigh station throughput.

The simulation model consists of two modules, a weigh station and a mainline module. The weigh station module examines the number of trucks forced to bypass a weigh station due to a full queue (unauthorized bypasses) and determines the travel time saved by allowing compliant trucks to be screened electronically at mainline speed. The mainline module measures the reduction in fuel consumption and potentially other benefits such as improvement in traffic efficiency due to fewer merges and diverge activities in the vicinity of the weigh station. The mainline module and its integration with the weigh station module is not examined in this project.

The weigh station simulation module is a microscopic, stochastic model with a powerful animation capability. The simulation module is built in Arena simulation language (1). The “Pack and Go” feature of Arena enables the end-users to view the model’s animation and outputs using Arena Viewer software. The Arena Viewer software, runs the “packed” model on any Personal Computer running Windows 95.

This report documents the application of the weigh station simulation model. The report illustrates the use of the model through a case study of the Knoxville, Tennessee northbound weigh station. This is a weigh station with a high volume of truck traffic (i.e., 440 trucks per hour), The collected field data at this site indicates that more than two thirds of trucks on the mainline are currently bypassing the weigh station due to a full queue at the weigh station (unauthorized bypasses). It also shows that under the weigh station’s existing operation the average static scale total delay is 290 seconds per truck.

Although only one weigh station is used in the case study illustration, we have used the simulation to analyze electronic screening for the other selected weigh stations along the I-75 corridor. Table 1 includes the locations and types of the simulated weigh stations. Each state is provided with the Arena Viewer software, the “packed” model of the state’s selected weigh station, and a user manual.

Table 1. Selected Weigh Stations Along I-75 Corridor

Weigh Station	Design Type
Knoxville, TN (northbound)	Static scale
Hancock, OH (southbound)	Static scale
Halton, ON (eastbound)	Ramp WIM
Monroe, MI (northbound)	Ramp WIM
Kenton, KY (southbound)	Ramp WIM
Lowndes, GA (southbound)	Ramp WIM
Charlotte, FL (southbound)	High-speed ramp WIM

WEIGH STATION SIMULATION MODEL

The weigh station model design is based on the existing geometry and functionality of a given weigh station, yet is flexible enough to accommodate the potential modifications of the weigh station policy and procedure. Given an option to change the model’s parameters, a “what-if’ analysis can be done.

The weigh station module is specifically designed to simulate traffic operations in and around a weigh station facility. It simulates truck movement through a weigh station, the weighing of the trucks, and inspection. One of the most important parts of this module is the inclusion of the decision-making logic that **is** associated with the electronic screening system’s assignment of bypass or pull-in flags to the approaching trucks. The electronic screening decision making logic for this study is based on the Advantage I-75 functional requirements document (2). Figure 1 presents an overview of the electronic screening bypass and pull-in logic.

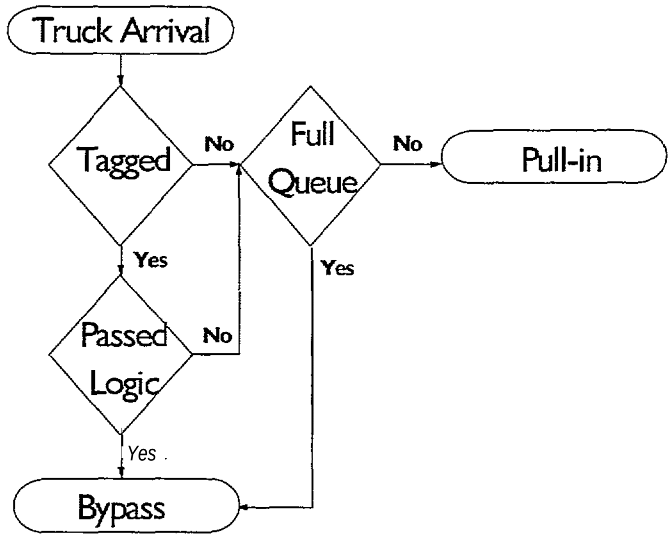

Figure 1. Electronic Screening System Bypass/Pull-in Logic

The model generates each entity (a truck), according to an exponential distribution in the simulation and attributes the entity with vehicle characteristics. For example, if the user decides to test the implication of having ten percent of the population of trucks equipped with transponders, the program randomly allocates transponders to ten percent of the entities. Other attributes are assigned following a discrete or continuous probability function. These attributes could include such vehicle characteristics as classification, axle spacing, and axle weights. When electronic screening is deployed in a network or a corridor of weigh stations: the simulation also has the ability to take into account information regarding the vehicle which was written to the transponder during prior interrogation (e.g., the transponder might contain the weight when it was weighed at a static scale upstream earlier in the day).

The decision making engine is triggered when a transponder-equipped truck passes the Advance AVI reader site located on the mainline. The transponder data (prior information written to the transponder) as well as WIM data (e.g., axle weights and spacing), which initially were assigned to each truck, are recorded by the roadside reader. If a truck successfully satisfies all the conditions stated in the logic, it is awarded a bypass flag. If not, it must enter the upcoming weigh station (pull-in). All trucks that are not assigned a transponder must also enter the weigh station.

The allowable weight criteria and the bridge formula are the two main components of the decision-making processor. Given a truck's axle weights and spacing information from the WIM, these components determine the truck's compliance with weight regulations.

The logic used by the simulation have been verified and the results of the simulation have been validated by comparing the travel time collected in the field to those generated by the simulation without the availability of electronic screening. The validation procedure will be described in more detail later in the report.

Input and Output Data

The weigh station simulation module is built based on actual truck traffic patterns and geometry data collected at weigh station sites or obtained from local agencies. The default input data, therefore, presents the existing conditions of a weigh station. Table 2 shows the default input data that reflects the field observations at the Knoxville weigh station. The model, however, provides the users the opportunity to modify the default parameters to examine different scenarios. Figure 2 presents an example of parameters that can be modified prior to a simulation run at the Knoxville static scale weigh station. Appendix I includes the input data for the other simulated weigh stations.

Table 2. Knoxville Simulation Input Parameters

Parameters	Morning	Noon	Afternoon
Traffic volume (vph)	1866	1559	**2134**
Truck percentage	16	**25**	**20**
Safety inspection rate (%)	1	1	1
Average safety inspection time (mm)	15	15	15

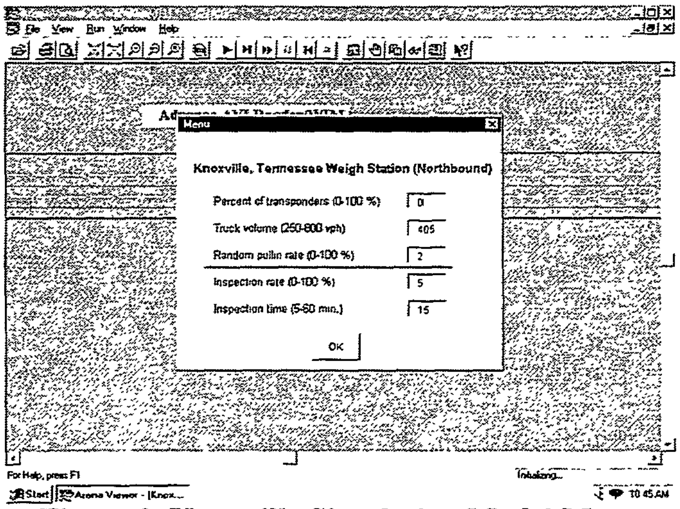

Figure 2. Knoxville Simulation Model Menu

The static scale weighing duration is not listed among the changeable parameters. The weighing times are randomly generated according to a statistical distribution, which may not be modified by the users. Field data provides no good statistical distribution for the safety inspection duration since only a small number of the weighed trucks (less than 3 percent) are being sent for the safety inspection.

The output provides the principle performance attributes. This includes the number of unauthorized bypasses and trucks' travel times (time spent being weighed and in line at the scale). Other output parameters include the queue length, the average time in the system, and total number of trucks processed per hour. Figure 3 shows a summary of the results during a simulation run of the Knoxville weigh station.

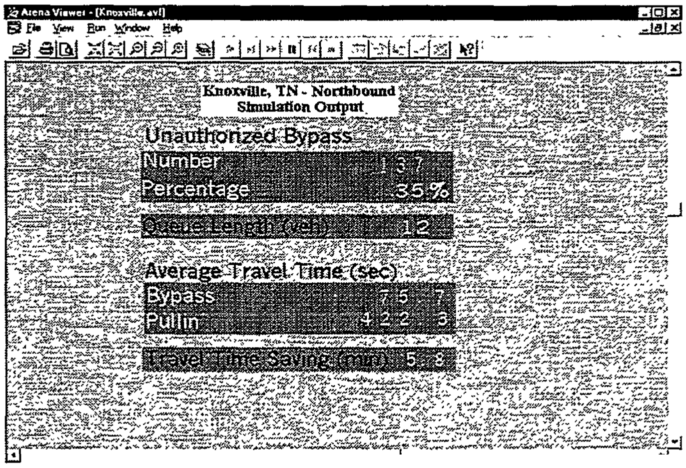

Figure 3. Knoxville Simulation Sample Output

Model Validation

The model may provide results, which are not identical to the observed system. The purpose of model validation is to determine if the model replicates the actual system at an acceptable level of confidence (3). The simulation results are compared to the real system to validate the weigh station simulation module.

The resemblance of the functionality of traffic movements through an unsignalized intersection and static scale at weigh stations led to the validation data collection method suggested for delay study at unsignalized intersections. In this method, total delay at unsignalized intersections is defined as "....the total elapsed time from when a vehicle joins the queue until the vehicle departs from the stopped position at the head of the queue (4)." Using the same concept, total delay at weigh stations' static scales is measured using a plate-reading method.

The data collection crew consists of two individuals who record arrival times and plate numbers of trucks joining the queue (point 1) another individual who records the arrival and departure times and plate numbers of trucks at the static scale (point 2), and two other individual who record the departure time and plate number of trucks leaving the weigh station (point 3). The number of unauthorized bypasses is concurrently collected by another individual positioned at point one.

Having the truck arrival times at the these points, the static scale total delay (i.e., delay from points one to two; d_{12}) and the travel time from the static scale to the exit point (i.e., points two to three; d_{23}) of each truck can be determined by matching the plate numbers in a database system. The time difference between the arrival and departure of trucks at the static scale is referred to as static scale service time.

The original data collection plan called for recording of only the departure times at the static scale. In developing the model, it became apparent that the service time, or the duration, for which a truck was stopped on the scale, varied significantly and effected the static scale total delay (d_{12}). Service times are dependent upon the behavior of the weigh station operator in response to the truck traffic situation within the weigh station and the condition of the truck on the static scale.

It was determined that the service times should be recorded independent of the total delay time (d_{12}). During the first data collection trip, a small sample of service times was collected. Unfortunately, the sample was too small to construct a reliable statistical distribution. A larger sample would have to be collected. A second trip to the weigh station would be necessary.

The data collection procedure was revised to include the recording of arrival times in addition of departure times and plate numbers of trucks at the static scales. The Knoxville weigh station was revisited on November 12, 1996. A new set of data was collected at the station throughout the day according to the new procedure and replaced the old data. Using the Arena Input Analyzer, the best fitted statistical distribution was estimated for the new sample of static scale service times and incorporated into the simulation model.

The static scale total delay (d_{12}), unauthorized bypass percentages, and travel time (d_{23}) are determined by running the weigh station simulation model, assuming existing conditions at a weigh station (i.e., no transponder-equipped truck participation) and using the traffic volume and service time collected at peak and off-peak periods.

The simulation results are naturally subject to the random fluctuations within the model. To account for this variation, interval estimates (also called confidence intervals) for evaluation of the generated point estimate of means are provided. Table 3 compares the field data to the simulation results that are obtained from ten two-hour simulation runs. This table also includes the 95 percent confidence intervals for evaluation of the generated point estimate of means. These confidence intervals provide lower and upper limits of the true point estimate of averages. Therefore, it can be stated that with 95 percent confidence the true afternoon peak average total delay (d_{12}), for example, is within two percent of the average delay (288 seconds). Appendix II includes the simulation results for the other weigh stations.

Table 3. Knoxville Field and Simulation Results - Northbound

Parameters	Morning			Noon			Afternoon		
	Field	Model		Field	Model		Field	Model	
	Avg	Avg	C.I.	Avg	Avg	C.I.	Avg	Avg	C.I.
Total delay (d_{12}), sec.	321	320	314,326	250	248	243,252	290	288	284,292
Unauth. bypasses %	61	60	58, 62	55	55	53, 56	63	63	62, 64
Travel time (d_{23}) sec.	38	37	36, 38	43	42	41, 43	57	57	56, 58

The comparison of the field data with the model's outputs establishes a level of confidence that the model is capable of simulating the existing conditions of the weigh station. The confidence in the simulation model yields a similar level of confidence in the model outputs obtained under the electronic screening strategy.

CONCLUSIONS

The weigh station simulation model is capable of assessing the impact of electronic screening at weigh stations. One of the advantages of this model is its ability to simulate hypothetical scenarios. Part of the electronic screening evaluation goal is to extrapolate the obtained results into the future. Thus performance measures (i.e., delay, unauthorized bypasses, trucks checked, etc.) can be projected into the future, illustrating the implications of growth in truck traffic or transponder usage.

Each of the participating states and province in the Advantage I-75 MACS project has received a copy of the simulation model for its particular weigh station providing the participants with a powerful tool for understanding the benefits of electronic screening. The model demonstrates the effectiveness in electronic screening of commercial vehicles by illustrating the reduction in travel time for vehicles and showing the increased productivity of weigh stations. As participation in the process grows, enforcement agencies and motor carriers alike share in the benefits of the system.

Appendix I. Simulation Input Parameters

Table 1.1. Hancock, Ohio – Southbound

Parameters	Morning	Afternoon
Truck volume (vph)	214	224
Safety inspection rate (%)	1	1
Average safety inspection time (min)	5	6

Table 1.2. Halton, Ontario - Eastbound

Parameters	Day one	Day two
Truck volume (vph)	503	493
Ramp bypass rate (%)	35	67
Safety inspection rate (%)	15	8
Average safety inspection time (min)	8	7

Table 1.3. Monroe, Michigan - Northbound

Parameters	Day one	Day two
Truck volume (vph)	333	331
Ramp bypass rate (%)	99	99
Safety inspection rate (%)	90	90
Average safety inspection time (min)	3	5

Table 1.4. Kenton, Kentucky - Southbound

Parameters	Day one	Day two
Truck volume (vph)	200	211
Ramp bypass rate (%)	96	97
Safety inspection rate (%)	10	10
Average safety inspection time (min)	5	5

Table 1.5. Lowndes, Georgia – Southbound

Parameters	Morning	Noon	Afternoon
Traffic volume (vph)	672	755	884
Truck percentage	17	19	19
Ramp bypass rate (%)	94	91	89
Safety inspection rate (%)	29	20	16
Average safety inspection time (min)	11	16	18

Table 1.6. Charlotte, Florida - Southbound

Parameters	Morning	Noon	Afternoon
Traffic volume (vph)	874	838	932
Truck percentage	17	18	22
Ramp bypass rate (%)	82	80	80
Safety inspection rate (%)	3	11	11
Average safety inspection time (min)	5	10	6

Appendix II. Field and Weigh Station Simulation Results

Table 11.1. Hancock, Ohio - Southbound

Parameters	Morning			Afternoon		
	Field	Model		Field	Model	
	Avg	Avg	C.I.	Avg	Avg	C.I.
Total delay (d_{12}) sec.	71	72	70,74	83	87	83, 91
Unauth. bypasses %	18	1	0, 2	23	3	1, 4
Travel time (d_{23}), sec.	52	52	51,53	50	50	49,51

The Hancock weigh station's mainline open/closed sign is changed to "closed" as soon as a full static scale queue is observed. This allows the approaching trucks to bypass the weigh station. The sign will be changed back to "open" shortly after the queue dissipation starts. The observed travel time from points one to two (d_{12}) is relatively short (average of 75 seconds per truck) for the weigh station to produce about 20 percent of unauthorized bypasses if the open/close sign operates properly. The observed number of unauthorized bypasses could be due to having the weigh station closed even after the queue has completely dissipated. The simulation model assumes the ideal open/close sign operation. The model would be capable of matching the observed unauthorized bypasses by keeping the weigh station closed more often.

Table 11.2. Halton, Ontario - Eastbound

Parameters	Day one			Day two		
	Field	Model		Field	Model	
	Avg	Avg	C.I.	Avg	Avg	C.I.
Total delay (d_{12}), sec.	194	196	192,200	182	175	170,180
Unauth. bypasses %	89	86	85, 87	73	78	77, 79
Travel time (d_{23}), sec.	61	70	67, 73	65	66	62, 70
Travel time-ramp bypass lane (d_{13}), sec.	120	124	123, 125	102	109	108,110

Table 11.3. Monroe, Michigan - Northbound

Parameters	Day one			Day two		
	Field	Model		Field	Model	
	Avg	Avg	C.I.	Avg	Avg	C.I.
Total delay (d_{12}) sec.	143	150	143,157	119	127	123,131
Unauth. bypasses %	0	0	0,0	1	0	0,0
Travel time (d_{23}), sec.	223	229	213,245	293	296	269,323
Travel time-ramp bypass lane (d_{13}), sec.	77	77	77, 77	77	77	77, 77

Table 11.4. Kenton, Kentucky - Southbound

Parameters	Day one			Day two		
	Field	Model		Field	Model	
	Avg	Avg	C.I.	Avg	Avg	C.I.
Total delay (d_{12}) sec.	97	101	98,104	96	101	97,105
Unauth. bypasses %	2	0	0,0	3	0	0,0
Travel time (d_{23}) sec.	124	131	124,138	130	127	116,138
Travel time-ramp bypass lane (d_{13}) sec.	149	144	144,144	150	144	144,144

Table 11.5. Lowndes, Georgia - Southbound

Parameters	Morning			Noon			**Afternoon**		
	Field	Model		Field	Model		Field	Mode1	
	Avg	Avg	C.I.	Avg	Avg	C.I.	Avg	Avg	C.I.
Total delay (d_{12}) sec.	131	130	123, 137	136	137	127,146	105	113	115,121
Unauth. bypasses %	0	0	0,0	0	0	0, 0	0	0	0,0
Travel time (d_{23}) sec.	229	224	200,248	188	175	159,191	259	240	220,260
Travel time-ramp bypass lane (d_{13}), sec.	71	75	75, 75	72	75	75, 75	73	75	75, 75

Table 11.6. Charlotte, Florida - Southbound

Parameters	Morning			Noon			Afternoon		
	Field	Model		Field	Model		Field	Model	
	Avg	Avg	C.I.	Avg	Avg	C.I.	Avg	Avg	C.I.
Total delay (d_{12}), sec.	120	119	118,120	207	201	200,201	102	107	106,108
Unauth. bypasses %	1	0	0,0	0	0	0,0	0	0	0,0
Travel time (d_{23}), sec.	50	53	49, 57	104	111	100,122	78	80	75, 85
Travel time-ramp bypass lane (d_{13}), sec.	74	78	78, 78	183	177	177,177	74	83	82,84

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ADVANTAGE 75

PROVING GROUND FOR ADVANCED TECHNOLOGY

Advantage I-75 Mainline Automated Clearance System

Final Report
Part 5 of 5: Jurisdictional Issues Individual Evaluation Report
Prepared for
The Advantage I-75 Evaluation Task Force

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INTRODUCTION

This report is part five of the Advantage I-75 Mainline Automated Clearance Systems (MACS) Project. The purpose of this report is to document the jurisdictional issues encountered in the implementation of electronic screening technologies for commercial vehicle operations in the participant states and provinces. The report also documents whether or not states will continue using MACS or an enhanced version of electronic screening, and motor carriers' reactions to using the MACS version of electronic screening.

This report is organized as follows:

- Purpose of the Evaluation: This section of the report provides an introduction and background to the evaluation. This section also explains the purpose, goals, hypotheses, and objectives of the evaluation.

- Evaluation Objectives: This section describes evaluation objectives pertaining to the systematic examination of the policies, procedures, and areas of jurisdiction of each of the states and provinces, and all parties within the Advantage I-75 MACS partnership involved in commercial vehicle operations.

- Identification of State Agencies: This section describes each of the states in terms of institutional roles in governing commercial vehicle operations.

- Identification of the Decision Making Processes: This section describes a state decision making process in terms of adapting electronic screening.

- Advantages and Disadvantages of Electronic Screening: This section describes the advantages and disadvantages of electronic screening as uncovered in this study.

- Identification of Motor Carrier Decision Making Process: This section documents the responses from the participating motor carriers pertaining to their experiences with electronic screening.

- Identification of Advantages and Disadvantages Considered by Motor Carriers: This section describes the advantages and disadvantages of electronic screening as reported by participating motor carriers.

- Document State, Regional and National Issues: This section describes the issues encountered by each state and the partnership in terms of "lessons learned" and implementing the field operational test.

+ Approaches Attempted to Solve Issues: This section describes the approaches used to alleviate problems, issues, and conflicts encountered by Advantage I-75 MACS.
- Survey Results: This section describes the results of the survey of the state agencies involved in the Advantage I-75 MACS project.

- Conclusions: This section includes a discussion of the benefits of electronic screening.

PURPOSE OF EVALUATION

The purpose of the jurisdictional issues evaluation was threefold. The first and primary purpose was to determine the partner states' intent to continue to offer the Advantage I-75 MACS, or an enhanced form of electronic screening. A second purpose was to determine if motor carriers' intended to continue participation in Advantage I-75 MACS, or an enhanced form of electronic screening. The third purpose was to document jurisdictional issues and impediments to implementing Advantage I-75 MACS and actions planned by those jurisdictions to overcome those issues.

An important objective of the Advantage I-75 Field Operational Test was to provide an actual operating environment for the partners to experience and to collect data and information necessary to make decisions regarding the continuation of Advantage I-75 MACS services and electronic screening. Therefore, the evaluation provided information for states and motor carriers to make decisions that may change their business practices.

As the foundation of the evaluation, the Advantage I-75 MACS test goals, as stated in the May 10, 1996, Individual Evaluation Test Plan, are as follows:

- Assess whether or not states or provinces will continue to offer Advantage I-75 MACS services, or an enhanced version of electronic screening after the operational test is completed.

- Assess whether or not motor carriers will continue to participate in Advantage I-75 MACS services after the operational test is completed.

- Record all significant institutional issues addressed during the operational test and document the resolution to the issues.

The test hypotheses that resulted from these goals were:

- The Advantage I-75 MACS Operational Test will provide jurisdictions with sufficient information to support a decision whether or not to offer Advantage I-75 MACS or an enhanced form of electronic clearance or verification in their jurisdictions.

- The Advantage I-75 MACS Operational Test will provide motor carriers with sufficient information to support a decision whether or not to adopt Advantage I-75 MACS or an enhanced form of electronic clearance or verification.

- The jurisdictional agencies involved in Advantage I-75 MACS will establish new or enhanced relationships and or methods for resolving jurisdictional issues as a result of the operational test.

The jurisdictional issues portion of the Advantage I-75 MACS evaluation examined several items including interstate, intrastate, and regional issues with regard to the implementation of electronic clearance systems. As part of the evaluation, agency staff members and motor carriers were interviewed and surveyed to obtain their views and opinions of the processes leading to electronic screening. The examination then set out to determine whether or not the states and province in the project planned to continue with electronic screening, or an enhanced form of MACS.

EVALUATION RESULTS

The jurisdictions participating in the Advantage I-75 MACS project are Michigan, Ohio, Kentucky, Tennessee, Georgia, Florida, and the Province of Ontario. Since an important objective of this evaluation was a systematic examination of the policies, procedures, and areas of jurisdiction of each of the states and provinces, all parties within the Advantage I-75 MACS partnership involved in commercial vehicle operations were included in the evaluation.

The objectives of the jurisdictional issues evaluation, as stated in the May 10, 1996, Individual Evaluation Test Plan are as follows:

1. The Advantage I-75 Operational Test will identify the key jurisdictional agency positions that are, by charter and mission, empowered to support/make a decision on whether or not to adopt MACS or an enhanced form of electronic clearance/verification.
2. The Advantage I-75 Operational Test will identify the decision making process in place in each jurisdiction to address adopting MACS or an enhanced form of electronic clearance/verification.
3. The Advantage I-75 Operational Test will identify key advantages and disadvantages considered by jurisdictions when deciding whether or not to adopt MACS or an enhanced for of election clearance/verification.
4. The Advantage I-75 Operational Test will identify the key motor carriers decision making process in place to address adopting MACS or an enhanced form of electronic clearance/verification.
5. The Advantage I-75 Operational Test will identify key advantages and disadvantages considered by motor carriers when making the decision to adopt MACS or an enhanced for of election clearance/verification.
6. Document state, regional and national issues as they arise.
7. Document attempts to solve issues, or lessons learned, as a result of the implementing the project.

The evaluation set out to determine what types of legal and institutional processes are used to decide whether or not to adopt electronic screening and/or to continue MACS on Interstate 75. Specifically, the study examined organizational issues, regulatory and legal issues, human resource issues, financial issues, and other issues on which states wanted to elaborate.

The issues raised within a given state in this study demonstrated similarities to previous studies of institutional issues and to the interstate issues that were cited in those previous studies. For example, as in the earlier studies, Advantage I-75 MACS found that upper management support was central to the project's success. In the case of Advantage 1-75 MACS, agency staff members from two states specifically cited the support that they had fi-om upper management. In fact, at the beginning of the project, the governors of each participant state signed a letter expressing their support of the project. The support from the governors provided a firm foundation for the accomplishments of the operational test.

Methods of motor carrier safety administration and regulation generally vary from state to state. Within the Advantage I-75 MACS partnership, one state utilizes a single agency to administer all motor carrier functions while another state has five agencies handling the routine administrative and safety regulatory functions that every interstate motor carrier must fulfill. Obviously the issues associated with interstate cooperation also vary based on the number and types of agencies involved with the regulatory functions. For example, the issues in Kentucky, a state with just one agency-the Kentucky Transportation Cabinet-administering the motor carrier regulatory functions, are different from the issues faced in Michigan, a state with five agencies involved in motor carrier regulatory and administrative functions.

To further illustrate the similarities and differences among the Advantage I-75 MACS participants a survey of the partnership was attempted. The survey, which was adapted from the Volpe National Transportation Systems Center Study of 1994[1], was designed to develop a deeper understanding of the states' processes leading to the implementation of electronic screening and to explain the conflicts and alliances that occur in developing a large project such as this. The results of that survey are discussed later in this section.

To avoid redundancy, however, this study does not directly investigate the issues between agencies in each state as other FHWA-sponsored institutional issues studies have done, but instead focuses on the decision making processes and the advantages and disadvantages of electronic screening in each of the participating states and province. This section lists the states and the province in the Advantage I-75 MACS project and their organizational structures pertaining to motor carrier administrative and regulatory functions and electronic screening.

Results of Evaluation Objective I: Identify Key Jurisdictional Agency Positions

For this evaluation objective, we have identified the key agencies in each state and province within the partnership. These agencies have various responsibilities pertaining to commercial vehicle operations and electronic screening. Table 1 refers to the agencies with primary responsibility for mainline electronic screening. These responsibilities are described here.

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[1] *IVHS Institutional Issues and Case Studies, Advantage I-75 Case Study,* DOT-VNTSC-FHWA-94-10, FHWA-SA-94-056, Final Report April 1994.

Kentucky

The Commonwealth of Kentucky is the lead state in the Advantage I-75 MACS project. Kentucky, through the Kentucky Transportation Cabinet and the University of Kentucky Transportation Center, has been very active in promoting the project and working to ensure its success.

The Kentucky Transportation Cabinet (KTC) is the primary agency responsible for administering the commercial vehicle program, including the construction and maintenance of the weigh stations. The KTC's other responsibilities include a) Administration of Kentucky's Intrastate Tax System, b) Issuance of Oversize and Overweight Permits, c) Administration of the Single State Registration System (SSRS), d) Administration of the Kentucky Weight-Distance Tax, and e) Administration of the International Fuel Tax Agreement (IFTA) and International Registration Plan (IRP). The Kentucky Transportation Cabinet is also responsible for constructing and maintaining the extensive road system that consists of some 14,403 miles, including 762 miles of interstate highways. Overall, Kentucky has some 73,158 miles of roads and highways. The state highway system also includes 15 permanent weigh stations in Kentucky.

Regarding mainline electronic screening of commercial vehicles presently, there are four weigh stations in Kentucky that are equipped with electronic screening as part of the Advantage I-75 MACS project. These stations are the southbound station in Kenton County, the northbound station in Scott County, and both stations in Laurel County. These stations are also equipped with mainline weigh-m-motion scales for enhanced weight enforcement capabilities.

Of the sites that are currently utilizing mainline electronic screening, the stations in Kenton and Scott Counties, are equipped with ramp weigh-in-motion (WIM) sorters, along with bypass lanes. These stations are subject to heavy volumes of traffic, yet never close due to full queues. The two stations in Laurel County close frequently due to full queues. These stations are currently being relocated to a nearby site. Once construction of the new facilities is completed, these stations will have include ramp bypass lanes and mainline electronic screening.

Besides the use of fixed scale facilities, Kentucky uses portable scale teams on alternate routes in its truck enforcement program.

Florida

Florida has been part of the Advantage I-75 MACS project since the inception of the project in 1990. Presently there are three weigh station sites in the project: the White Springs stations in Hamilton County, the Wildwood stations in Marion County, and the Punta Gorda stations in Charlotte County. At each site there are northbound and southbound facilities. The Wildwood and Punta Gorda stations are both equipped with high-speed weigh-in-motion (WIM) ramp sorters. The White Springs stations have only recently been re-constructed to include high-speed ramp WIM sorters. All of these stations are equipped with mainline electronic screening capabilities. Florida has also equipped its weigh stations on I-95 with high-speed ramp WIM sorters and currently has plans to follow the same scenario at the three existing weigh stations on I-10.

Florida DOT is also responsible for constructing and maintaining the extensive road system that consists of some 11,92 1 miles, including 1,472 miles of interstate highway highways. Overall, Florida has some 60,009 miles of roads and highways. The state highway system also includes 23 permanent weigh stations in Florida.

Regarding mainline electronic screening of commercial vehicles, a site that is currently using mainline electronic screening is near Port Charlotte, five miles south of US Highway 17 on Interstate 75. Both the northbound and southbound weigh stations are equipped with two static scales and a bypass lane. The scales are situated on either side of the scale house office. The posted speed of the bypass lane is 45 mph. The volume of commercial vehicle traffic is moderate, with approximately 205 vehicles per hour traveling through the station.

Within the state of Florida there are two principal agencies responsible for administering the commercial motor vehicle (CMV) program. These two agencies are the Florida Department of Transportation (FDOT) and the Florida Department of Highway Safety and Motor Vehicles (DHS&MV). The Department of Transportation is primarily responsible for; a) Enforcement of CMV size and weight laws, b) Issuance of oversize and overweight permits, and c) Enforcement of CMV registration laws.

The DHS&MV is primarily responsible for; a) Enforcement of traffic laws, b) Issuance of drivers' licenses, c) Accident investigations, d) Enforcement of DUI and related laws, and e) Other traffic enforcement related matters. Besides the use of fixed scale facilities, Florida uses portable scale teams on alternate routes in its truck enforcement program.

Georgia

Another partner in the Advantage I-75 MACS project since 1990 is the State of Georgia. Presently there are six weigh stations in the Advantage I-75 MACS program, that are equipped with mainline electronic screening. They are: the northbound and southbound stations near Ringgold in Catoosa County, the northbound and southbound stations near Forsyth in Monroe County, and the northbound and southbound stations near Valdosta in Lowndes County. In addition to the AVI equipment, these stations are equipped with ramp weigh-in-motion sorters.

Through the use of the ramp weigh-in-motion sorters and bypass lane, these stations are able to accommodate the truck traffic most of the time. There are, however, periods of time in which the scales are forced to close for short intervals, due to the queue build up.
Within the State of Georgia, there are three principal agencies with responsibilities for commercial vehicle operations. They are the Department of Transportation, the Department of Public Safety, and the Public Service Commission.

Part of the responsibilities of Georgia's Department of Transportation include: a) Vehicle size and weight enforcement, b) Issuance of oversize and overweight permits, c) Intelligent transportation systems, d) Portable scale teams, and e) Various traffic operations planning and administration. The Georgia Department of Transportation, moreover, has other responsibilities than regulatory enforcement. These responsibilities include the construction and maintenance of the highway system. Georgia's road network consists of 111,746 miles, of which 17,809 miles are state maintained. Included in the state highway system are 1,24 1 miles of interstate highways representing just over one percent of the total highway mileage. GDOT also maintains 19 permanent weigh stations throughout the state.

The State Patrol Division of the Georgia Department of Public Safety also has responsibilities for regulating commercial vehicle operations. Some of these responsibilities are: a) Commercial driver's license issuance, b) Accident investigations, c) Enforcement of DUI and drug cases, d) Occupant restraint enforcement, and e) Enforcement of various traffic laws.

The Georgia Public Service Commission also has responsibilities with regard to commercial vehicle operations. Under a cooperative agreement with the Department of Transportation, the PSC regulates motor carrier safety and hazardous materials transportation. Some of PSC's responsibilities include: a) Vehicle safety inspections, b) Driver safety inspections, c) Hazardous materials safety inspections, d) Certification and registration of motor carriers, e) Ensure carriers maintain proper levels of insurance, and f) Maintain database of all inspections.

Tennessee

Another partner in the Advantage I-75 MACS project is the State of Tennessee. Currently, mainline electronic screening of commercial vehicles is utilized at its Knox County weigh stations, just west of the city of Knoxville. These weigh stations are a single static scale design, with heavy traffic. The northbound scale sits atop a small hill, and trucks labor to reach the top and enter the scale. The Knox County site is an ideal location for electronic screening because of its dated design and high traffic volume; approximately 430 trucks per hour pass by the weigh station. Obviously because of the physical limitations of these facilities, they cannot accommodate all the commercial vehicle traffic. Moreover, because of safety concerns, trucks are allowed to pass the weigh stations if the queue leading to these scales is full. If the trucks were not allowed to bypass the weigh station, the queue would reach the mainline highway. Therefore, approximately 66 percent of the trucks approaching this facility continue past the weigh station, and are not physically checked by officials. Consequently, the Advantage I-75 project provides officials with a method of electronically screening commercial vehicles that otherwise would not be screened.

Within the State of Tennessee, there are two principal agencies with responsibilities for governing commercial vehicle operations. These two agencies are the Departments of Transportation and Safety. The Tennessee Department of Safety, having evolved from its original state police force, is responsible for enforcement of the various laws governing transportation safety. Its responsibilities include: a) Driver's license issuance, b) Vehicle title and registration, c) Accident investigation, d) School bus inspections, e) Enforcement of commercial vehicle laws and regulations, f) Enforcement of DUI and drug cases, and g) Auto theft investigations. Other areas of responsibilities include staffing the fixed weigh stations and portable scale teams.

The Department of Transportation is responsible for constructing and maintaining the extensive road systems, including the 16 permanent weigh stations in Tennessee. Tennessee's road system stretches 85,037 miles. 13,552 miles are on the state maintained highway network, representing 16 percent of the total highway miles within the state. These highways also carry 75 percent of the total traffic. Included in the state highway system are 1,062 miles of interstate highways. Although the interstate system consists of just over one percent of the total highway mileage, it carries one quarter of all traffic in Tennessee.

Ohio

The State of Ohio is another participant in the Advantage I-75 MACS project. Presently there are two weigh stations in the project: The northbound station in Wood County, near the city of Bowling Green and the southbound station in Hancock County near the city of Findlay, Ohio. These stations are single static scale type with no bypass lane. These stations are subject to frequent queue buildup that cause the stations to close periodically.

Currently electronic screening is utilized at the weigh stations near Findlay and Bowling Green that are equipped with a single static scale. These stations are subject to moderate to heavy traffic volumes, processing approximately 212 trucks per hour. Over 1,500 transponder-equipped truck pass each site monthly, with about 85 - 95 percent of them being given "green light" electronic clearances. The primary reason for not receiving a "green light" clearance is possible weight overload detected by the mainline wiegh-in-motion (WIM) system.

Within Ohio, there are three principal agencies responsible for administering the commercial motor vehicle program. These agencies are the Ohio Department of Transportation, the Ohio Department of Public Safety, and the Public Utilities Commission of Ohio. The Department of Transportation (ODOT) is primarily responsible for construction and maintenance of the highways, including the weigh stations, and enforcement of the size and weight laws for commercial vehicles. The Department of Public Safety (ODPS), which includes the Ohio State Patrol and Bureau of Motor Vehicles, is primarily responsible for the enforcement of traffic laws, accident investigations, enforcement of DUI laws, issuance of commercial drivers' licenses, and other traffic related enforcement matters. The Public Utilities Commission of Ohio (PUCO) is responsible for regulated the safety related aspects of the truck and bus industry. The PUCO registers and reviews motor carriers to ensure compliance with state and federal regulations. The PUCO is the "lead agency" for the federal Motor Carrier Safety Assistance Program (MCSAP), and driver-vehicle inspection are performed by both the PUCO and State Patrol. The State Patrol also staffs the truck weigh stations while the PUCO uses portable scales on alternate routes.

The Ohio DOT is responsible for developing and maintaining the state's extensive highway network, which consists of 18,3 15 miles, of which 1,573 miles are interstate highway. The state maintained roads carry approximately 65 percent of the total traffic in the state. Overall the state has some 114,642 miles of roadway. ODOT also maintains 19 permanent weigh stations.

Michigan

The State of Michigan is another partner in the Advantage I-75 MACS project. Currently, mainline electronic screening is utilized at the set of weigh stations located approximately five miles north of the Ohio state line near the city of Monroe, Michigan. These stations are a single static scale design, equipped with ramp weigh-in-motion sorters and a bypass lane. These weigh stations process approximately 500 trucks per hour. While the queues at the stations are full at peak hours, the stations do not close. Trucks are, however, required enter the weigh stations when they are open. Therefore, trucks do periodically queue-up on the shoulders of the mainline highway at peak traffic intervals.

Within the State of Michigan there are five principal agencies responsible for regulating commercial vehicle operations. These five agencies are the Department of Transportation, the Department of State Police, the Public Service Commission, the Department of State, and the Department of Treasury. These agencies have separate and distinct areas of governance over commercial vehicle operations.

Regarding commercial vehicle regulatory enforcement, the Michigan Department of Transportation is responsible for issuing oversize and overweight permits.

The Michigan Department of State Police (MSP) by statute and a cooperative agreement with the Michigan Department of Transportation, is responsible for commercial vehicle size, weight, and safety enforcement. The MSP is also responsible for the physical operations and maintenance of the 22 permanent weigh stations. Other responsibilities include various traffic enforcement duties, including the use of portable scale teams on alternate routes.

The Michigan Public Service Commission (PSC) regulates commercial vehicle operations through its administration of the single-state-registration-system (SSRS) and certification of for-hire carriers.

The Department of State is responsible for commercial vehicle registration including administration of the International Registration Plan (IRP). The DOS also issues the commercial driver's license (CDL).

The Department of Treasury is responsible for fuel tax collection, reporting, and the administration of the International Fuel Tax Agreement (IFTA).

The Michigan Department of Transportation is responsible for construction and maintenance of the state's extensive road network. Michigan's road system consists of 119,113 miles, of which 9,583 miles are state maintained highways. Included in the state highway system are 1,240 miles of interstate highways representing just over one percent of the total highway mileage.

Ontario, Canada

The Province of Ontario is also a partner in the Advantage I-75 MACS project. Presently there are seven weigh stations in the project: The eastbound station in the town of Whitby; the eastbound and westbound stations at Halton near the town of Milton; the eastbound and westbound stations Middlesex, near the City of London; and the eastbound and westbound stations at Essex near the City of Windsor. Of this group, only the westbound scale at Essex is not equipped with a ramp WIM sorter. The remaining stations are equipped with ramp WIM. All of the stations are subject to heavy traffic requiring the scales to close periodically.

Currently, mainline electronic screening commercial vehicles is utilized at the seven sites, mentioned previously. These stations are subject to heavy traffic volumes. The Essex stations process approximately 153 trucks per hour, the Halton stations process approximately 232 trucks per hour, and the Middlesex stations process approximately 600 trucks per hour,

The Ministry of Transportation of Ontario (MTO) is the principal agency for administering the commercial vehicle program. In addition to being the primary agency for construction and maintenance of the highways, the MTO is responsible for the enforcement of the commercial vehicle size and weight laws, commercial vehicle operator registration and licensing, issuance of oversize and overweight permits, and other traffic related enforcement matters.

The MTO is responsible for developing and maintaining the province's extensive highway network, which consists of 16,400 kilometers (10,185 miles) of provincial highways. The MTO also maintains a total of 44 permanent weigh stations and uses portable scales on alternate routes.

Table 1: Key Agencies for Electronic Screening by Jurisdiction

Jurisdiction	Key Agency
Kentucky	Kentucky Transportation Cabinet State Office Building Frankfort, KY 40622
Florida	Florida Department of Transportation 605 Suwanne St. Tallahassee, FL 32399
Georgia	Georgia Department of Transportation 935 E. Confederate Ave Atlanta, GA 303 16
Tennessee	Department of Safety 1150 Foster Ave Nashville, TN 37219
Ohio	Ohio Department of Transportation 1980 W. Broad St. Columbus, OH 43215
Michigan	Michigan State Police 4000 Collins Rd. Lansing, MI 48890
Ontario	Ministry of Transportation Ontario 1201 Wilson Ave Downsview ON M3M 1 J8

Results of Evaluation Objective 2: Identify the Decision Making Process

In each state there is a decision making process that begins with building a base of knowledge and information, as described in Figure 5.1. The problems or issues that are identified and examined by staff members, through direct observation or by information given by members of the public. When issues arise, the staff investigates the specific problem areas, collect facts and evidence then reports their findings to the agency supervisor. While the specifics may differ somewhat from each individual state, the decision-making process generally includes the following steps:

Step 1: Identify Problem. Upon receiving the information from the staff the agency then sets forth to formally identify the problem.

Step 2: Gather Information. After identifying the problem of congested weigh stations, the next step is to gather information at selected sites. The agency has to determine the extent of the problem, who is involved and what can be done about it.

Step 3 : Build up Site Knowledge and Make Recommendations. After determining the extent and nature of the problem, the staff will address resolutions to the problems and make recommendations to the agency head.

Step 4: Agency Review of Recommendation. The agency head will then determine if there is merit to the proposal, based on agency mission and budget considerations, and then decide if the recommendations will be forwarded to the Commission. If there are shortcomings in the proposal, it goes back to Step 1 for further refinement of the problem. Otherwise the proposal goes forward to the Transportation Commission-

Step 5: Commission Review of Recommendation. The Commission reviews the agency recommendation. If there are any requests for more information it goes back to the agency. Otherwise it is approved.

Step 6: Adopt Recommendation- If the recommendation is approved by the commission, it is adopted as procedure by the agency.

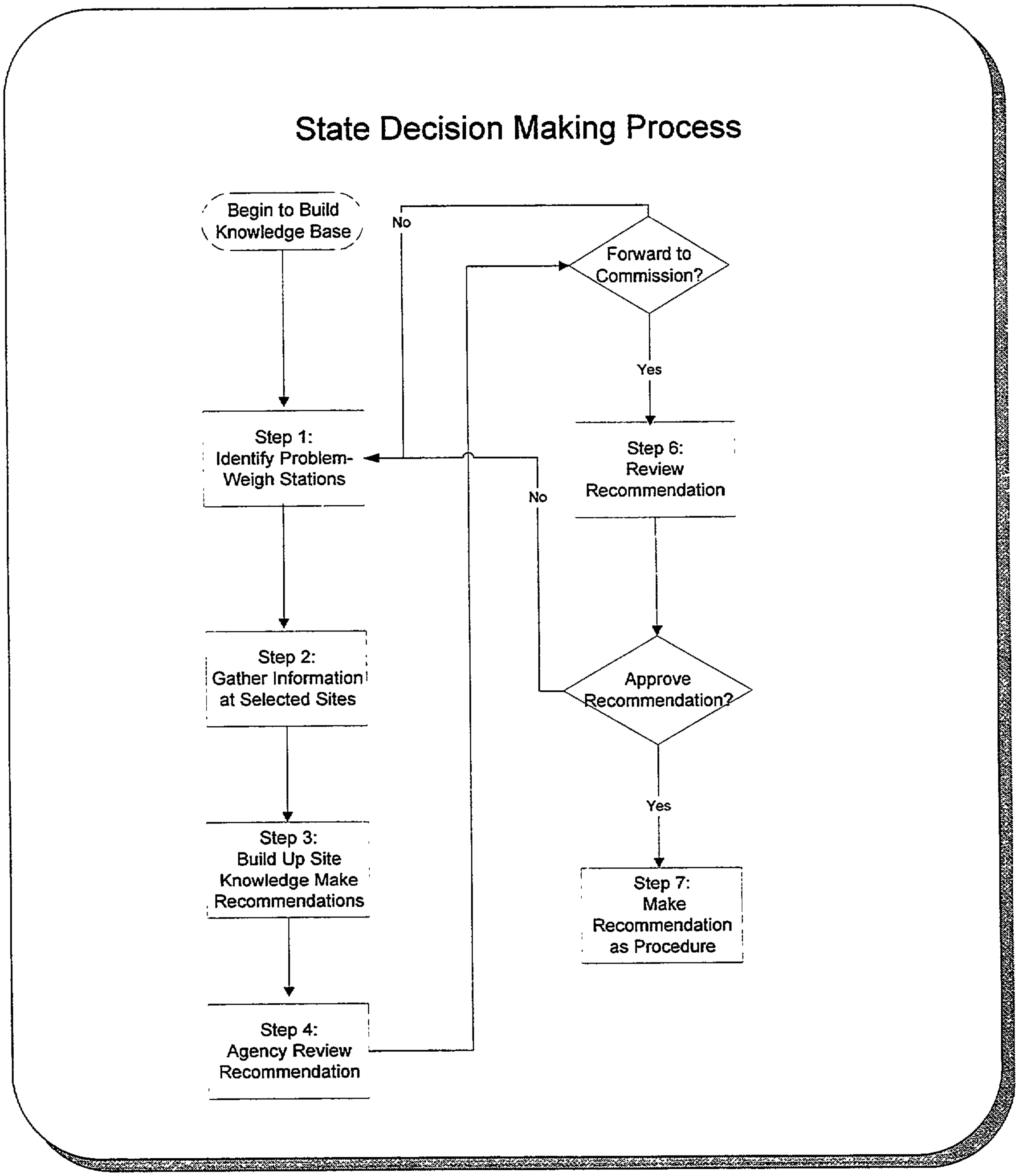

Figure 5.1: State Decision Making Process

Results of Evaluation Objective 3: Identify the Advantages and Disadvantages of Electronic Screening to States and Provinces

The third objective of the of the evaluation was to identify key advantages and disadvantages considered by the jurisdictions to address adopting electronic screening or an enhanced form of electronic screening or verification.

Many jurisdictions today are experiencing overcrowding at their weigh station facilities. One method available to alleviate the overcrowding is to employ electronic screening of commercial vehicles. Among the advantages identified by the Advantage I-75 MACS project of utilizing mainline electronic screening are:

1. <u>Reduce queues at weigh stations</u>. Using electronic screening at weigh stations permits compliant vehicles to bypass the weigh stations, decreasing the need to require all trucks to enter the weigh station. Thus, with fewer trucks entering the weigh station, queues decrease.
2. <u>Ability to screen more vehicles</u>. Using electronic screening at weigh stations allows states to check more vehicles than before. In addition to checking the vehicles that enter the weigh station, enforcement officials are screening vehicles on the mainline as well.
3. <u>The capacity of the weigh station is not compromised</u>. Using electronic screening at weigh stations means that the capacity of the weigh station will not be exceeded. As more trucks are equipped with transponders and screened on the mainline, the weigh station can continue to operate without having to expand significantly and still accommodate the non-transponder equipped trucks.
4. <u>Target enforcement resources more efficiently</u>. Using electronic screening at weigh stations allows enforcement personnel to concentrate their activities on possibly non-compliant vehicles that have not been checked. As the transponder-equipped trucks are screened on the mainline, non-transponder equipped trucks can then be checked by weigh station personnel.
5. <u>Using electronic screening reduces the cost of motor carrier compliance.</u> Using electronic screening at weigh stations reduces the cost of compliance by targeting enforcement resources and using them more efficiently.
6. <u>Protect weigh station infrastructure</u>. Using electronic screening at weigh stations protects the facility's infrastructure because there are fewer vehicles driving over the access ramps and scale platforms.

Among the disadvantages of electronic screening at weigh stations are:

1. Transponder market penetration. While not specifically a disadvantage, the issue of significant transponder penetration in the marketplace is a challenge to productive electronic screening. Therefore, for the jurisdictions to realize significant benefits of electronic screening, there must be thorough market penetration of transponders. The more trucks screened and cleared on the mainline, the more benefits are realized by the participants. Depending on the type of system the states employ, they must develop innovative methods to distribute transponders to the motor carriers wanting to use them.
2. Ensuring the system is interoperable with other electronic screening systems. Electronic screening systems cannot be deployed in a vacuum. There are presently three electronic screening systems in the United States. Each truck with a transponder should be screened by each system. Federal initiatives require interoperability with other systems to ensure "transparent borders" between states.
3. Cost of system upgrades. Because of the multitude of new and evolving technologies and new applications of high technology, there is a potential for required system upgrades that must be planned and accounted for.
4. Specialized maintenance personnel. parts. and equipment. Traditionally, personnel in state departments of transportation and other agencies have specialized in road construction and law enforcement. Rarely have these departments developed personnel that have sufficient technical expertise to effectively procure and maintain all ITS equipment and functions. Such a need for specialized knowledge may be beyond some public agencies, and some may not want to become expert in or add expert staff to handle the development of systems, due to budget or staffing restraints.
5. Data privacy and information exchange. An issue for several partners in the Advantage I-75 MACS project was data privacy and information exchange. Both public and private sectors are concerned with the potential numerous uses of data. Motor carriers do not want the data generated by electronic screening to be used to "target" them for enforcement activities. The carriers choosing to use electronic screening are concerned that they may lose the competitive advantage gained from that technology, if they are treated differently by the enforcement agencies. Motor carriers using the electronic screening technology want a "level playing field" when it comes to enforcement and do not want to be treated differently from other carriers that are not using the technology. Likewise, the public sector has similar concerns for screening carriers, and ensuring that the data generated by electronic screening are secure. The public sector does not want any information generated by electronic screening to be used, or misused, for purposes other than what it is intended for, i.e., to screen compliant commercial vehicles.
6. Acceptance by enforcement personnel Many enforcement personnel in commercial vehicle safety, believe it is imperative that each commercial vehicle must pass through the weigh station for weight and visual checks. Others believe, however, that queues building up on the highway and slow moving vehicles entering the highway from weigh stations pose safety hazards that are potentially more significant than the potential hazards posed by allowing electronically screened vehicles to bypass the weigh stations. Whatever position one advances, however, electronic screening must not compromise

the safety mission of the enforcement agencies. The operational test demonstrates that electronic screening can accomplish its goals and not compromise safety.

Results of Evaluation Objective 4: Identify Motor Carrier Decision Making Process

As part of the evaluation, the participating motor carriers were surveyed about Advantage 1-75 MACS project and what decisions they could make pertaining to electronic screening. 120 surveys were mailed, and 3 1 were returned for a response rate of twenty-six percent. The survey revealed several interesting results.

Result 1: The responding motor carriers indicated that they were either satisfied or somewhat satisfied with the system. Most of the carriers' satisfaction lay in the fact that the Advantage I-75 MACS saved them time because drivers did not have to wait in long lines to enter the weigh stations. The carriers that were most satisfied with the system were the ones that enrolled the earliest. Twenty one carriers of the thirty one that responded to the survey, enrolled in the program within the first year of the test. These twenty one carriers also indicated that they were the most satisfied with Advantage I-75 MACS.

The motor carriers were also asked to list their reasons for their satisfaction or dissatisfaction with Advantage I-75 MACS. As stated previously, the carriers were generally satisfied with the performance of Advantage I-75 MACS. The reasons indicated for their satisfaction were related to transit time savings, and those drivers were pleased with the system

Result 2: Next, the motor carriers were asked to elaborate on the process they used to reach their decision to enroll in the program. Twenty-five respondents indicated that it was a business decision to reduce travel time and increase customer service. Nine respondents also indicated that they wanted to reduce the business costs of operating their trucks. Thus, their decisions were based on anticipated reductions in fuel and maintenance costs.

Finally, motor carriers were also asked if they would pay an additional fee for electronic screening services. The responses from this question were wide-ranging. Ten carriers stated that a nominal fee would be in order. Eleven carriers responded that since they currently pay enough in taxes, any additional fees would be out of line. This question was designed to seek out what support, if any, there is for a fee structure to make the system self-supporting. From the responses received, however, there does not appear to be a firm consensus among the Advantage I-75 MACS project respondents on the issue of paying an additional cost for electronic screening. One respondent indicated that if the fees were dedicated to system operation and maintenance, the imposition of fees would be acceptable to his company. If the fees were to go into the states' general funds, however, then any additional fees would be unacceptable.

Results of Evaluation Objective 5: Identify Advantages and Disadvantages Considered by Motor Carriers

As part of the evaluation motor carriers were asked to consider any advantages and disadvantages they determined as a result of using electronic screening. The advantages they stated were the following:

1. Participating motor carriers indicated that they joined Advantage I-75 MACS to cut travel time and reduce business costs (fuel, equipment maintenance, etc.).
2. Other reasons listed by the motor carriers indicated their reasons for enrolling in the program were related to safety, either public safety or driver safety. They felt that, by keeping the drivers on the mainline and reducing travel time, they would reduce driver fatigue as well.
3. Carriers indicated that drivers viewed automated clearance as reducing the "hassle factor" that sometimes occurs at weigh stations; the fact that drivers can continue past the stations without further scrutiny was a pleasant element of the system.

The disadvantages motor carriers cited pertaining to using electronic screening:

1. Motor carriers would like the system to be expanded and utilized beyond weigh stations, such as at agricultural inspection stations, Canadian customs stations, and toll booths.
2. Motor carriers indicated that the auditory signal of the transponder needs to be louder because the signal was hard to hear at times.
3. The current system of approving carriers for electronic screening is lengthy and needs to be shortened.

Results of Evaluation Objective 6: Document State, Regional, and National Issues

The evaluation objectives included identification of legal and institutional issues encountered during the project, or likely to be faced if states want to continue offering electronic screening. These issues could also be termed "lessons learned" resulting from implementing a large demonstration project. Overall, the project demonstrated that electronic screening, even in its early stage, is technically viable and increasingly acceptable as a method of commercial vehicle monitoring and enforcement. Participants in the Advantage I-75 MACS project are confident in the concept of electronic screening and perceive the program as a success. The participants also believe that there have been positive benefits produced as a result of this project, including the realization of the potential public and private sector benefits of Advanced Vehicle Identification (AVI) technology and electronic screening of commercial vehicles.

During the operational test several issues arose and lessons were learned and documented. These lessons could provide valuable assistance for future ITS projects. These major lessons include the following:

- From the beginning, the project partners knew that upper management buy-in of the project was crucial to its success. Obtaining the support of the governors by signing an agreement to support the project and provide matching funds helped facilitate the project and overcome many institutional uncertainties.

- The evaluation must be built into the project from the beginning. Evaluation is expensive and complex, but productive. All participants must be brought in on the original evaluation plan and program decisions. Input is required from all participants.

- There must be a clear, concise plan of action that is followed. Achieving the necessary results from a given proposed plan of action is not always possible. The political system is complex and unpredictable; therefore gaining the support necessary to sponsor and champion a course of action is difficult. However, a lead agency can obtain the desired results of agreement, support, and follow-through with a clear and concise plan action.

Results of Evaluation Objective 7: Attempts to Solve Issues

As with any large project covering numerous jurisdictions, problems and conflicts arose and had to be alleviated. During the implementation of the project, several approaches were attempted to solve these problems and conflicts. Some of the major issues are listed here.

1. Partnerships require communication. commitment and trust. With the large number of parties involved in this project, clear communication was essential to ensure success. Essentially, the jurisdictions have worked together to move the project along and keep each participant living up to its commitments. With few exceptions, the public and private sectors have worked together to implement electronic screening at weigh stations. Future ITS projects will want to develop routine communication time tables to achieve program success.
2. Large research projects require cooperation and compromise from all parties. The interstate nature of electronic screening and commercial vehicle operations requires aggressive cooperation between states due to the need for interoperability and coordination of functions, operation, and maintenance among the partner states. For example, electronic screening is intended to increase highway efficiency by allowing safe, legal, and weight-compliant commercial vehicles to pass the weigh stations. Increased productivity results for both motor carriers and enforcement agencies as compliant vehicles save time and money by being allowed to pass and enforcement efforts are focused on possible non-compliant vehicles. Such electronic screening functions required that data regarding the vehicles' credentials be either stored and read from the vehicle or stored and read from a shared database.

   For the process to succeed, the partners had to agree to the status and accessibility of the commercial vehicle information. For example, it had to be decided whether to update the data daily, monthly, quarterly, etc. The status and accuracy of the data on vehicle credentials could vary widely from jurisdiction to jurisdiction. Such differences in the status and accuracy of the data could reduce the benefits of electronic screening. If the accuracy of information available on the electronic screening system lags behind actual vehicle credentialing, newly credentialed vehicles could be required to stop for compliance checks even though they are in compliance, thus eliminating the benefits of electronic screening for these commercial vehicles and affected enforcement agencies.

   Subsequently, the implementation of Advantage I-75 MACS required the partners to cooperate and coordinate in the development of standards and protocols for the design, operation, and maintenance of the system. Without such cooperation, the goals of increased highway efficiency and safety would not be met as electronic screening would not be able to transcend state borders.

3. There must be early, verifiable benefits to be effective. Because of the high deployment costs involved in electronic screening, the risks are great. Therefore, to be effective and keep the partners involved the project, the benefits of electronic screening had to be

demonstrated and verified early in the project. Also, the power of the partnership demonstrated the benefits of electronic screening through the economy of scale, and eliminating redundant costs of each state conducting its own procurement of equipment.

4. Business Practices Must Change. The technology in use can readily be made compatible with other systems. In many states, the commercial vehicle regulatory responsibilities are distributed among several agencies. There are also legal impediments in states that do not recognize today's technologies. Regulations that refer to "written communication" and "paper" credentials hinder the expansion of technology. The extent of interagency cooperation also varies from state to state. As the states and their agencies strive to meet their objectives, they till proceed toward greater interagency coordination and cooperation in ITS/CVO activities and deployment.

Survey Results

As part of the evaluation the staffs of the state agencies participating in the project were sent a survey. The original sample of this study consisted of six states, one Canadian province, and 12 agencies with jurisdiction over commercial vehicle operations. The jurisdictions participating are Michigan, Ohio, Kentucky, Tennessee, Georgia, Florida, and Ontario, Canada. Since an important objective of the evaluation was a systematic assessment of the states' decision making processes and whether or not the states will continue to offer electronic clearance, each agency within the Advantage I-75 MACS partnership was included in the survey.

The questionnaire used was developed and adapted from the Volpe study of IVHS institutional issues conducted in 1993. The Volpe framework was used as a basis for the questionnaire, and issues germane to the Advantage I-75 MACS projected were inserted into the existing survey. A copy of the survey questionnaire is included in the Appendix.

The fifteen-page survey was then mailed to the department heads of each participating agency, covering the issues described previously. Several follow-up contacts by telephone and electronic mail were made to each potential survey participant. The response rate, however, was not significant enough to draw any conclusions.

Notwithstanding, several observations about the project could be made from the comments and responses that were received. They are:

- Some staff members, particularly lower-level staff, felt left out of the decision-making processes and communication exchanges pertaining to the implementation of electronic screening at weigh stations.

- Some members of the partnership felt that the project was moving too slowly and were impatient at the apparent lack of progress.

- Members of some agencies are concerned about the funding methods that will be used to continue electronic screening. These staff members are concerned whether it will publicly or privately financed.

CONCLUSIONS

As a primary goal, the Advantage I-75 MACS operational test was to demonstrate and evaluate the jurisdictional issues involving electronically screening commercial vehicles at weigh stations. This evaluation of jurisdictional issues among the Advantage I-75 MACS partnership was designed to provide states and motor carriers with information to support decisions about continuing or discontinuing electronic screening or an enhanced form of electronic clearance and verification.

The first goal of the evaluation was to determine whether or not states, along with Province of Ontario will continue to offer electronic screening of motor vehicles. This first goal of the evaluation was reached, as the states in the partnership, along with the Province of Ontario, have agreed to offer electronic screening, as shown in Table 2.

Table 2: States and Provinces Adopting Electronic Screening

Ontario	Yes
Michigan	Yes
Ohio	Yes
Kentucky	Yes
Tennessee	Yes
Georgia	Yes
Florida	Yes

The second goal of the evaluation was to determine whether or not motor carriers will continue to participate in Advantage I-75 MACS after the operational test is completed. From the beginning of the Advantage I-75 MACS project, there has been involvement with the motor carriers. Carrier representatives were active participants from the beginning on policy-making committees, evaluation committees, and the alpha test groups. Motor carriers have been instrumental in seeing the project through to its conclusion and beyond. The participating carriers are eager to tout the benefits of electronic screening at the weigh stations. Established systems that can reduce motor carriers' transit times to their destinations, are welcome improvements along the corridor. Thus, our findings conclude that there is support from the industry to continue with electronic screening of commercial vehicles.

The third goal of the evaluation was to record all significant institutional issues addressed during the operational test and document the resolution to issues addressed. The first institutional issue addressed in the evaluation of the Advantage I-75 MACS is that to facilitate the implementation of the system, technical standards and information sharing must be agreed to early on in the project. Within Advantage I-75 MACS, the transponder capabilities, communications protocols, data definitions, and vehicle and carrier identifications were decided upon at the beginning, in order to eliminate problems later on in the project.

The second institutional addressed is that there must be "buy-in" from upper management in order to succeed. Obtaining the backing of the governors by having them sign an agreement to support the project and provide matching funds helped facilitate the project and overcome many institutional uncertainties

Finally, future ITS projects should seriously consider the methods developed by Advantage I-75 MACS. This method includes a lead agency to facilitate the project and lead representatives from each jurisdiction in close contact with the lead agency to enhance communication. While there were issues that caused minor delays in the project because of uncertainties, with few exceptions, the parties made the commitment to work together to satisfactorily complete the goals and objectives for the project. The lessons learned from this project will serve others well in future ITS projects.

APPENDIX I

1. Bills of Lading Indidcating Loads Used in Fuel Consumption Test

Carrier | Carrier's No.

RECEIVE, subject to the classifications and lawfully filed tariffs in effect on the date of the issue of this Shipping Order,

at FINDLAY OH 8-2 1996 from CIRE C/O FFIDC

Consigned to FINDLAY'S TALL TIMBERS DIST. CTR., INC.

Destination | State OH | Zip Code | County HANCOCK

Delivery Address ★ 2001 INDUSTRIAL DRIVE

Route

Delivering Carrier COLLINS & AIKMAN | Car or Vehicle Initials | No. T476

No. Packages	Kind of Package, Description of Articles, Special Marks, and Exceptions	Weight (Sub. to Cor.)	Class or Rate	Check Column
26	778825 49 9703 CULLET	30,472		
	LOADS FOR CIRE FUEL COMBUSTION TESTING			

If charges are to be prepaid, write or stamp here, "To be Prepaid." PREPAID

RECEIVED AUG 06 1996 SUBJECT TO INSPECTION TALL TIMBERS DISTRIBUTION CTR. FINDLAY, OHIO

Shipper, Per

Agent must detach and retain this Shipping Order and must sign the Original Bill of Lading.

2

REDIFORM 65695
POLY PAK (50 SETS) 6P695

CARBONLESS SPEEDISET

This Shipping Order must be legibly filled in, in Ink, in Indelible Pencil, or in Carbon, and retained by the Agent.

Shipper's No. 969

CIRE c/o FFIDC | Carrier Collins & Aikman | Carrier's No.

RECEIVE, subject to the classifications and lawfully filed tariffs in effect on the date of the issue of this Shipping Order,

at Findlay OH 8/2/96 19 96 from CIRE c/o FFIDC

Consigned to Findlay's Tall Timbers Dist.Ctr.,Inc.

Destination 2001 Industrial Drive Findlay | State OH | Zip Code 45840 | County HANCOCK

Delivery Address ★

Route

Delivering Carrier Collins & Aikman | Car or Vehicle Initials | No. T467

No. Packages	Kind of Package, Description of Articles, Special Marks, and Exceptions	Weight (Sub. to Cor.)	Class or Rate	Check Column
[illegible]	778825 [illegible] 9703 CULLET	30,472		
	Loads for CIRE fuel combustion testing			

If charges are to be prepaid, write or stamp here, "To be Prepaid." Prepaid

RECEIVED AUG 06 1996 SUBJECT TO INSPECTION TALL TIMBERS DISTRIBUTION CTR. FINDLAY, OHIO

CIRE c/o FFIDC Shipper, Per G. Bills

Agent must detach and retain this Shipping Order and must sign the Original Bill of Lading.

2

REDIFORM 65695
POLY PAK (50 SETS) 6P695

CARBONLESS SPEEDISET

"WEIGH WHAT WE SAY OR WE PAY"

If you get an overweight fine from the state after one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:
(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
(2) A representative of CAT Scale Company will appear in court WITH the driver as an expert witness if we believe our scale was correct.

IF YOU SHOULD GET AN OVERWEIGHT FINE, YOU SHOULD DO THE FOLLOWING TO GET THE PROBLEM RESOLVED:

1) Post bond and request a court date.
2) Call the CAT Scale location where you got the weigh ticket in question and inform them of the fine, or call CAT Scale Company direct during normal business hours.
3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale.

CERTIFIED AUTOMATED TRUCK SCALE

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 08/02/96

SCALE LOCATION: PILOT OIL, I 75 EXIT 164, FINDLAY OHIO

141500
18538
PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

STEER AXLE	11200 lb
DRIVE AXLE	28300 lb
TRAILER AXLE	25900 lb
* GROSS WEIGHT	65400 lb

IMPRINT SEAL HERE (IF APPLICABLE)

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED

COMPANY Collins & Aikman TRACTOR # 728 TRAILER # 476

WEIGHMASTER OR WEIGHER SIGNATURE [signature] FEE 7.00 FULL WEIGH TICKET # (IF REWEIGH)

6312584
TICKET NUMBER

DRIVER IN TRUCK UNLESS CHECKED HERE: ___

CAT 406

THANK YOU FOR WEIGHING ON CAT SCALE!

THE CAT SCALE GUARANTEE

The CAT Scale Company guarantees that our scales will give an accurate weight. What makes us different from other scale companies is that we back up our guarantee with cash.

"WEIGH WHAT WE SAY OR WE PAY"

If you get an overweight fine from the state after one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:
(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
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CERTIFIED AUTOMATED TRUCK SCALE

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 08/02/96

SCALE LOCATION: PILOT OIL, I 75 EXIT 164, FINDLAY OHIO

105706
PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

STEER AXLE	10700 lb
DRIVE AXLE	13460 lb
TRAILER AXLE	10080 lb
* GROSS WEIGHT	34240 lb

IMPRINT SEAL HERE (IF APPLICABLE)

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED

COMPANY Collins & Aikman TRACTOR # 728 TRAILER # T476

WEIGHMASTER OR WEIGHER SIGNATURE [signature] FEE 7.00 FULL WEIGH TICKET # (IF REWEIGH)

6312563

RTIFIED
TOMATED
UCK
ALE

T SCALE COMPANY
P.O. BOX 630
ALCOTT, IA 52773
(319) 284-6263

"WEIGH WHAT WE SAY OR WE PAY"

If you get an overweight fine from the state after one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:

(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
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3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale.

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 08/02/96

STEER AXLE 11340 lb

DRIVE AXLE 27980 lb

TRAILER AXLE 25580 lb

* GROSS WEIGHT 64900 lb

SCALE LOCATION: PILOT OIL
I 75 EXIT 164
FINDLAY OHIO

141605
UBLIC WEIGHMASTER'S 18539
CERTIFICATE OF
WEIGHT & MEASURE

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

IMPRINT SEAL HERE
(IF APPLICABLE)

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED

COMPANY Collins & Aikman TRACTOR # 761 TRAILER # 467

WEIGHMASTER OR WEIGHER SIGNATURE [signature] FEE 7.00

FULL WEIGH TICKET # (IF REWEIGH)

6312585

TICKET NUMBER

DRIVER IN TRUCK UNLESS CHECKED HERE: CAT 406

CAT SCALE ®

ERTIFIED
UTOMATED
RUCK
CALE

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

THANK YOU FOR

THE CAT SCALE GUARANTEE

The CAT Scale Company guarantees that our scales will give an accurate weight. What makes us different from other scale companies is that we back up our guarantee with cash.

"WEIGH WHAT WE SAY OR WE PAY"

If you get an overweight fine from the state after one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:

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3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale.

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 08/02/96

STEER AXLE 10720 lb

...ance of this Shipping Order.

at FINDLAY OH 8/19 19 96 from FTIDC

[illegible]

Consigned to CENTER FOR TRANSPORTATION RESEARCH AND EDUCATION (Mail or street address of consignee—For purposes of notification only.)

Destination AMES State IOWA Zip Code ______ County ______

Delivery Address ★ 2625 N LOOP DRIVE SUITE 2100

(★ To be filled in only when shipper desires and governing tariffs provide for delivery thereat.)

Route ______

Delivering Carrier COLLINS & AIKMAN Car or Vehicle Initials ______ No. 4074

No. Packages		Kind of Package, Description of Articles, Special Marks, and Exceptions	*Weight (Sub. to Cor.)	Class or Rate	Check Column
26		25V CULLET GLASS	30,920		
		CARGO LOAD FOR ADVANTAGE I-75 FUEL			
		CONSUMPTION TEST			

Subject to Section 7 of Conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

(Signature of Consignor.)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Received $______ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per ______ (The signature here acknowledges only the amount prepaid.)

Charges Advanced: $

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."

NOTE—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.

The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ______ per ______

†The fibre boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Uniform Freight Classification.

‡Shipper's imprint in lieu of stamp; not a part of bill of lading approved by the Interstate Commerce Commission.

______ Shipper, Per FTIDC 4/17

Agent must detach and retain this Shipping Order and must sign the Original Bill of Lading.

2

Permanent postoffice address of shipper.

CARBONLESS SPEEDISET

REDIFORM® 65695

POLY PAK (50 SETS) 6P695

This Memorandum is an acknowledgment that a Bill of Lading has been issued and is not the Original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record.

Monroe 9070011 Carrier COLLINS & AIKMAN Shipper's No. 314

Carrier's No.

RECEIVED, subject to the classifications and lawfully filed tariffs in effect on the date of the receipt by the carrier of the property described in the Original Bill of Lading

at FINDLAY OH 8/19 19 96 from FTIDC

[illegible]

Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

Consigned to CENTER FOR TRANSPORTATION RESEARCH AND EDUCATION (Mail or street address of consignee—For purposes of notification only.)

Destination AMES State IOWA Zip Code ______ County ______

Delivery Address ★ 2525 N LOOP DRIVE SUIET 2100

(★ To be filled in only when shipper desires and governing tariffs provide for delivery thereat.)

Route ______

Delivering Carrier COLLINS & AIKMAN Car or Vehicle Initials ______ No. 474

No. Packages		Kind of Package, Description of Articles, Special Marks, and Exceptions	*Weight (Sub. to Cor.)	Class or Rate	Check Column
26		25V CULLET GLASS	40,000		
			30,920		
		CARGO LOADS FOR ADVANTAGE I-75 FUEL			
		CONSUMPTION TEST			

Subject to Section 7 of Conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

(Signature of Consignor.)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Received $______ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per ______ (The signature here acknowledges only the amount prepaid.)

Charges Advanced: $

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."

NOTE—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.

The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ______ per ______

†The fibre boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of Uniform Freight Classification.

‡Shipper's imprint in lieu of stamp; not a part of bill of lading approved by the Interstate Commerce Commission.

______ Shipper, Per ______ FTIDC Agent, Per ______

3

Permanent postoffice address of shipper.

CARBONLESS SPEEDISET

REDIFORM® 65695

POLY-PAK (50 SETS) 6P695

If you get an overweight fine from the state after one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:
(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
(2) A representative of CAT Scale Company will appear in court WITH the driver as an expert witness if we believe our scale was correct.

IF YOU SHOULD GET AN OVERWEIGHT FINE, YOU SHOULD DO THE FOLLOWING TO GET THE PROBLEM RESOLVED:

1) Post bond and request a court date.
2) Call the CAT Scale location where you got the weigh ticket in question and inform them of the fine, or call CAT Scale Company direct during normal business hours.
3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale.

CERTIFIED AUTOMATED TRUCK SCALE

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

DATE: 08/19/96

STEER AXLE 10640 lb
DRIVE AXLE 31700 lb
TRAILER AXLE 23280 lb
* GROSS WEIGHT 65620 lb

160013 SCALE
19825 LOCATION: PILOT OIL
I 75 EXIT 164
FINDLAY OHIO

PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

IMPRINT SEAL HERE (IF APPLICABLE)

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED

COMPANY Collins & Aikman TRACTOR # 261 TRAILER #

WEIGHMASTER OR WEIGHER SIGNATURE [signature] FEE 7.00 FULL WEIGH TICKET # (IF REWEIGH)

6413086

TICKET NUMBER

DRIVER IN TRUCK UNLESS CHECKED HERE: CAT 406

© CAT SCALE COMPANY® 10/95

THE CAT SCALE GUARANTEE

The CAT Scale Company guarantees that our scales will give an accurate weight. What makes us different from other scale companies is that we back up our guarantee with cash.

"WEIGH WHAT WE SAY OR WE PAY"

If you get an overweight fine from the state after one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:
(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
(2) A representative of CAT Scale Company will appear in court WITH the driver as an expert witness if we believe our scale was correct.

THANK YOU FOR WEIGHING ON CAT SCALE!

IF YOU SHOULD GET AN OVERWEIGHT FINE, YOU SHOULD DO THE FOLLOWING TO GET THE PROBLEM RESOLVED:

1) Post bond and request a court date.
2) Call the CAT Scale location where you got the weigh ticket in question and inform them of the fine, or call CAT Scale Company direct during normal business hours.
3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale.

CERTIFIED AUTOMATED TRUCK SCALE

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

DATE: 08/19/96

STEER AXLE 10720 lb
DRIVE AXLE 31360 lb
TRAILER AXLE 23060 lb
* GROSS WEIGHT 65140 lb

155854 SCALE
19824 LOCATION: PILOT OIL
I 75 EXIT 164
FINDLAY OHIO

PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

IMPRINT SEAL HERE (IF APPLICABLE)

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED

COMPANY Collins & Aikman TRACTOR # 29 TRAILER # 484

WEIGHMASTER OR WEIGHER SIGNATURE [signature] FEE 7.00 FULL WEIGH TICKET # (IF REWEIGH)

6413085

TICKET NUMBER

DRIVER IN TRUCK UNLESS CHECKED HERE:

© CAT SCALE COMPANY® 10/95

This Shipping Order must be legibly filled in, in Ink, in Indelible Pencil, or in Carbon, and retained by the Agent.

RECEIVE, subject to the classifications and tariffs in effect on the date of the issue of this Shipping Order,

the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated below, which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth, (1) Uniform Freight Classifications in effect on the date hereof, if this is a rail or a rail-water shipment, or (2) in the applicable motor carrier classification or tariff if this is a motor carrier shipment, or (3) in the applicable water or barge carrier classifications or tariff if a water or barge carrier shipment.

Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation of this shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

PLACE CAR AS PLACARDED.

AVERAGE WEIGHT AGREEMENT SHIPMENT
The description and weight indicated on this bill of lading are correct, subject to verification by carrier(s) or its (their) designated agent.

This is to certify that the below named articles are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Interstate Commerce Commission.

Subject to Section 7 of Conditions of applicable bill of lading if this shipment is to be delivered to the consignee, without recourse on the consignor, the consignor shall sign the following statement:
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

GENERAL SHALE PRODUCTS CORP.
(Signature of Consignor)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Agent must detach and retain this Shipping Order and must sign the Original Bill of Lading.

Agent, Per ______

Received $______ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per ______
(The signature here acknowledges only the amount prepaid.)

BRICK STCC 32 511

DATE	9/16/96	CNTRL	1263048	BILL OF LADING	KN1304024
OUR ORDER	KN 13822	VIA	PX	YOUR P.O.	
TIME	13:45:05	CAR OR TRUCK NO.			

SOLD TO 105607 CONSIGNED TO 43-047

CENTER FOR TRANSP. RESEARCH &
ED. ATTN-DIANE LOWE
2625 N LOOP DR SUITE 2100
AMES IO 50010

ROUTE

SHIPPER GENERAL SHALE PRODUCTS CORP.
KNOXVILLE TN

DESCRIPTION	RATE	WEIGHT
007-11-508-0 S/S SEDGWICK BRICK 8000 090 001 LOWER 7B YARD		31600

S/S

31600

DELIVERY RECEIPT

Knoxville

PLACE CAR AS PLACARDED

AVERAGE WEIGHT AGREEMENT SHIPMENT
The description and weight indicated on this bill of lading are correct, subject to verification by carrier(s) or its (their) designated agent.

This is to certify that the below named articles are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Interstate Commerce Commission.

Subject to Section 7 of Conditions of applicable bill of lading if this shipment is to be delivered to the consignee, without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

GENERAL SHALE PRODUCTS CORP.
(Signature of Consignor)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Shipper, Per

Agent, Per ______

Received $______ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per ______
(The signature here acknowledges only the amount prepaid.)

BRICK STCC 32 511

DATE	9/16/96	CNTRL	1269843	BILL OF LADING	KN1358023
OUR ORDER	KN 13022	VIA	PX	YOUR P.O.	
TIME	13:41:27	CAR OR TRUCK NO.	494		

SOLD TO: 105697

CONSIGNED TO 43-047

CENTER FOR TRANSP. RESEARCH &
ED. ATTN-DIANE LOVE
2625 N LOOP DR SUITE 2100
AMES IO 50010

ROUTE.

SHIPPER GENERAL SHALE PRODUCTS CORP.
KNOXVILLE TN

DESCRIPTION	RATE	WEIGHT
097-11-508-0 S/S SEDGWICK BRICK .8000 090 001 LOWER 7B YARD		31600

31600

DELIVERY RECEIPT

PLACE CAR AS PLACARDED

AVERAGE WEIGHT AGREEMENT SHIPMENT
The description and weight indicated on this bill of lading are correct, subject to verification by carrier(s) or its (their) designated agent.

This is to certify that the below named articles are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Interstate Commerce Commission.

Subject to Section 7 of Conditions of applicable bill of lading if this shipment is to be delivered to the consignee, without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

GENERAL SHALE
PRODUCTS CORP.
(Signature of Consignor)

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Shipper, Per

Agent, Per ______

Received $______
to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per ______
(The signature here acknowledges only the amount prepaid.)

BRICK STCC 32 511

DATE	7/16/96	CNTRL	1263849	BILL OF LADING	KN1384924
OUR ORDER	KN 13022	VIA	PX	YOUR P.O.	
TIME	13:45:07	CAR OR TRUCK NO.			

SOLD TO 105627 CONSIGNED TO 43-047

CENTER FOR TRANSP. RESEARCH &
ED. ATTN-DIANE LOWE
2625 N LOOP DR SUITE 2100
AMES IO 50010

ROUTE

SHIPPER GENERAL SHALE PRODUCTS CORP.
KNOXVILLE TN

DESCRIPTION	RATE	WEIGHT
007-11-508-0 S/S SEDGWICK BRICK 8000 090 001 LOWER 76 YARD		31600

31600

"WEIGH WHAT WE SA[Y OR WE PAY"]

If you get an overweight fine from the state AFTER one of o[ur] CAT Scales showed a legal weight, we will immediately check our scale and we will:

(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
(2) A representative of CAT Scale Company will appear in court WITH the driver as an expert witness if we believe our scale was correct.

IF YOU SHOULD GET AN OVERWEIGHT FINE, YOU SHOULD DO THE FOLLOWING TO GET THE PROBLEM RESOLVED:

1) Post bond and request a court date.
2) Or call CAT Scale Company direct 24 hours a day at 1-800-336-9889.
3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale Company Attn: Operations Manager.

CERTIFIED AUTOMATED TRUCK SCALE

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 09/16/96

SCALE LOCATION: CAT 35
PILOT OIL
I40 AT LOVELL RD
KNOXVILLE TN

STEER AXLE 10480 lb
DRIVE AXLE 28880 lb
TRAILER AXLE 26040 lb
* GROSS WEIGHT 65400 lb

PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

IMPRINT SEAL HERE (IF APPLICABLE)

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED ______

COMPANY C&A TRACTOR # 428 TRAILER # ______

FEE - 00 WEIGHMASTER OR WEIGHER SIGNATURE [signature] FULL WEIGH TICKET # (IF REWEIGH) ______

8424312
TICKET NUMBER

DRIVER IN TRUCK UNLESS CHECKED HERE: ___

THE CAT SCALE GUARANTEE

The CAT Scale Company guarantees that our scales will give an accurate weight. What makes us different from other scale companies is that we back up our guarantee with cash.

CAT SCALE® COLLECTOR CARD INSIDE!

"WEIGH WHAT WE SAY OR WE PAY"

If you get an overweight fine from the state AFTER one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:

(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
(2) A representative of CAT Scale Company will appear in court WITH the driver as an expert witness if we believe our scale was correct.

IF YOU SHOULD GET AN OVERWEIGHT FINE, YOU SHOULD DO THE FOLLOWING TO GET THE PROBLEM RESOLVED:

1) Post bond and request a court date.
2) Or call CAT Scale Company direct 24 hours a day at 1-800-336-9889.
3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale Company Attn: Operations Manager.

CERTIFIED AUTOMATED TRUCK SCALE

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 9-16-96

SCALE LOCATION: Cat 35
Pilot Oil
I40 At Lovell Rd
Knox TN

STEER AXLE 10480
DRIVE AXLE 28040
TRAILER AXLE 27000
* GROSS WEIGHT 65520

PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

IMPRINT SEAL HERE (IF APPLICABLE)

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED ______

COMPANY Collins + Aikman TRACTOR # 761 TRAILER # ______

FEE WEIGHMASTER OR WEIGHER SIGNATURE [signature] FULL WEIGH TICKET # (IF REWEIGH) ______

8424313

ONET, FL Sept 30 1996 FROM

CORONET INDUSTRIES, INC.
P.O. Box 760 • Plant City, FL 33564-0760

...erty described below, in apparent good order, except as noted (contents and condition of contents unknown) marked, consigned, and destined as indicated below, which said carrier (the word carrier being understood throughout this ...d as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. ...ually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be ...to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Uniform Freight Classification in effect on the date hereof, if this is a rail or rail-water shipment, or (2) in the applicable motor carrier classification if this is a motor carrier shipment. Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation ...shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns. (Mail or street address of consignee—For purposes of notification only.)

...NED TO: CORONET INDUSTRIES. INC.

...Y ADDRESS *: 4082 CORONET RD.

(* To be filled in only when shipper desires and governing tariffs provide for delivery thereat.)

...TION: PLANT CITY   STATE: FL   COUNTY

...ING CARRIER: COLLINS & AIKMAN PRODUCTS   CAR OR VEHICLE INITIALS

HM	DESCRIPTION AND CLASSIFICATION (Proper Shipping Name and Class Per 49 CFR 172.101)			
	DEFLUORINATED PHOSPHATE, FEED GRADE CDP REG 50# BAGS W/PLT CLASS 50	50# BAGS W/PALLETS	30240# (15)	GUARANTEED UNIFORM ANALYSIS PHOSPHORUS 18.0% MIN. CALCIUM 30.00% MIN-33.00% MAX. FLUORINE 0.18% MAX.

R	#	PRD	CUST PO	GRSWT	TARWT	NETWT	NET TONS
7		103					

Totals

...to certify that the materials named adjacently are properly classified, ...d, packaged, marked and labeled and are in proper condition for ...ation according to the applicable regulations of the Department of ...rtation."

CORONET INDUSTRIES, INC.

Signature

...certify that the contents of this consignment are fully and accurately ...d adjacently by proper shipping name and are classified, packed, marked ...led, and in proper condition for carriage by air according to applicable government regulations."

Signature

Subject to Section 7 of conditions of applicable bill of lading, if this shipment is to be delivered to consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

CORONET INDUSTRIES, INC.

If charges are to be prepaid, write or stamp here, "To be Prepaid."

PREPAID

SPECIAL INSTRUCTIONS:

"If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."

Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of property. The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding ... per ...

PREPAID
FREIGHT CHARGES TO:

CORONET INDUSTRIES, INC.
P.O. Box 760
Plant City, FLORIDA 33564-0760

...CARDS TENDERED: YES ☐ NO ☐

...ONET INDUSTRIES, INC.   SHIPPER, PER   AGENT, PER

...ent post-office address of shipper, P.O. Box 760, Plant City, FLORIDA 33564-0760

(This Bill of Lading is to be signed by the shipper and the agent of the carrier issuing same.)

3

ubject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading.

NET, FL Sept 30 1996 FROM

CORONET INDUSTRIES, INC.
P.O. Box 760 • Plant City, FL 33564-0760

erty described below, in apparent good order, except as noted (contents and condition of contents unknown) marked, consigned, and destined as indicated below, which said carrier (the word carrier being understood throughout this as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. ually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be to all the terms and conditions of the Uniform Domestic Straight Bill of Lading set forth (1) in Uniform Freight Classification in effect on the date hereof, if this is a rail or rail-water shipment, or (2) in the applicable motor carrier classification if this is a motor carrier shipment. Shipper hereby certifies that he is familiar with all the terms and conditions of the said bill of lading, including those on the back thereof, set forth in the classification or tariff which governs the transportation shipment, and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns. (Mail or street address of consignee—For purposes of notification only.)

NED TO CORONET INDUSTRIES, INC.

RY ADDRESS * 4082 CORONET RD (* To be filled in only when shipper desires and governing tariffs provide for delivery thereat.)

TION PLANT CITY STATE FL COUNTY

ING CARRIER COLLINS & AIKMAN PRODUCTS CAR OR VEHICLE INITIALS

HM	DESCRIPTION AND CLASSIFICATION (Proper Shipping Name and Class Per 49 CFR 172.101)			
	DEFLUORINATED PHOSPHATE, FEED GRADE CDP REG 50# BAGS W/PLT CLASS 50	50# BAGS W/PALLETS	30240# (15)	GUARANTEED UNIFORM ANALYSIS PHOSPHORUS 18.0% MIN. CALCIUM 30.00% MIN-33.00% MAX. FLUORINE 0.18% MAX.

DER #	PRD	CUST PO	GRSWT	TARWT	NETWT	NET TONS
966	103	WEIGHT TES	30000.00		30000.00	15.00
				Totals	30000.00	15.00

"This is to certify that the materials named adjacently are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation."

CORONET INDUSTRIES, INC.

Signature

"I hereby certify that the contents of this consignment are fully and accurately described adjacently by proper shipping name and are classified, packed, marked and labeled, and in proper condition for carriage by air according to applicable national government regulations."

Signature

Subject to Section 7 of conditions of applicable bill of lading, if this shipment is to be delivered to consignee without recourse on the consignor, the consignor shall sign the following statement:

The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

CORONET INDUSTRIES, INC.

If charges are to be prepaid, write or stamp here, "To be Prepaid."

PREPAID

SPECIAL INSTRUCTIONS:

"If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is "carrier's or shipper's weight."

NOTE–Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property. The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding per

PREPAID FREIGHT CHARGES TO:

CORONET INDUSTRIES, INC.
P.O. Box 760
Plant City, FLORIDA 33564-0760

PLACARDS TENDERED: YES ☐ NO ☐

CORONET INDUSTRIES, INC. SHIPPER, PER AGENT, PER [signature]

Permanent post-office address of shipper, P.O. Box 760, Plant City, FLORIDA 33564-0760

(This Bill of Lading is to be signed by the shipper and the agent of the carrier issuing same.)

3

CORONET INDUSTRIES, INC.
P.O. Box 760
Plant City, FL 33564-0760

No 16757

Date

WEIGHT

lbs. GROSS

lbs. TARE ID NO. 1259 12:49 PM
WEIGHIN 34100 LB

lbs. NET ID NO. 1259 TICKET 1235
GROSS 65000 LB
W TARE 34100 LB
NET 30900 LB
TIME 02:13 PM 30 SEP 96

Truck No 761-416

Hauler Aikman Collins TARE DATE 30 SEP 96

Commodity CDP- Reg Bags

Load No. Driver On ☑ Off ☐

Weigher In A.A.K. Weigher Out GK

Driver's Signature

prestige printing pp-7710067 10/93

CORONET INDUSTRIES, INC.
P.O. Box 760
Plant City, FL 33564-0760

No 16756

Date

WEIGHT

lbs. GROSS

lbs. TARE ID NO. 1258 12:48 PM
WEIGHIN 34160 LB

lbs. NET ID NO. 1258 TICKET 1234
GROSS 64920 LB
W TARE 34160 LB
NET 30760 LB
TIME [illegible] 30 SEP 96

Truck No 782-463

Hauler Collins/Aikman TARE DATE 30 SEP 96

Commodity CDP Reg (Bags)

Load No. Driver On ☑ Off ☐

Weigher In W.A.K. Weigher Out GK

Driver's Signature

prestige printing pp-7710067 10/93

CERTIFIED AUTOMATED TRUCK SCALE

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

"WEIGH WHAT WE SAY OR WE PAY"

If you get an overweight fine from the state AFTER one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:

(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
(2) A representative of CAT Scale Company will appear in court WITH the driver as an expert witness if we believe our scale was correct.

IF YOU SHOULD GET AN OVERWEIGHT FINE, YOU SHOULD DO THE FOLLOWING TO GET THE PROBLEM RESOLVED:

1) Post bond and request a court date.
2) Or call CAT Scale Company direct 24 hours a day at 1-800-336-9889.
3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale Company Attn: Operations Manager.

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 09/30/96

152705 SCALE CAT 200

40949 LOCATION: TAMPA 301 CITGO
US 301 92 AND I4
TAMPA FL.

STEER AXLE 10080 lb
DRIVE AXLE 24620 lb
TRAILER AXLE 30140 lb
*GROSS WEIGHT 64840 lb

PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

IMPRINT SEAL HERE (IF APPLICABLE)

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED ______

COMPANY Collins Atkins TRACTOR # 761 TRAILER # 416

FEE 7.00 WEIGHMASTER OR WEIGHER SIGNATURE [signature] FULL WEIGH TICKET # (IF REWEIGH) ______

7785378
TICKET NUMBER

DRIVER IN TRUCK UNLESS CHECKED HERE: ___

CERTIFIED AUTOMATED TRUCK SCALE

CAT SCALE COMPANY
P.O. BOX 630
WALCOTT, IA 52773
(319) 284-6263

THE CAT SCALE GUARANTEE

The CAT Scale Company guarantees that our scales will give an accurate weight. What makes us different from other scale companies is that we back up our guarantee with cash.

CAT SCALE COLLECTOR CARD INSIDE!

"WEIGH WHAT WE SAY OR WE PAY"®

If you get an overweight fine from the state AFTER one of our CAT Scales showed a legal weight, we will immediately check our scale and we will:

(1) Reimburse you for the cost of the overweight fine if our scale is wrong, OR
(2) A representative of CAT Scale Company will appear in court WITH the driver as an expert witness if we believe our scale was correct.

IF YOU SHOULD GET AN OVERWEIGHT FINE, YOU SHOULD DO THE FOLLOWING TO GET THE PROBLEM RESOLVED:

1) Post bond and request a court date.
2) Or call CAT Scale Company direct 24 hours a day at 1-800-336-9889.
3) IMMEDIATELY send a copy of the citation, CAT Scale Ticket, your name, company, address, and phone number to CAT Scale Company Attn: Operations Manager.

* The four weights shown below are separate weights. The GROSS WEIGHT is the CERTIFIED WEIGHT and was weighed on a full length platform scale.

DATE: 09/30/96

152555 SCALE CAT 200

40948 LOCATION: TAMPA 301 CITGO
US 301 92 AND I4
TAMPA FL.

STEER AXLE 10040 lb
DRIVE AXLE 24520 lb
TRAILER AXLE 30180 lb
*GROSS WEIGHT 64740 lb

PUBLIC WEIGHMASTER'S CERTIFICATE OF WEIGHT & MEASURE

IMPRINT SEAL HERE (IF APPLICABLE)

This is to certify that the following described merchandise was weighed, counted, or measured by a public or deputy weighmaster, and when properly signed and sealed shall be prima facia evidence of the accuracy of the weight shown as prescribed by law.

LIVESTOCK, PRODUCE, PROPERTY, COMMODITY, OR ARTICLE WEIGHED ______

COMPANY Collins Atkins TRACTOR # 728 TRAILER # 443

FEE 7.00 WEIGHMASTER OR WEIGHER SIGNATURE [signature] FULL WEIGH TICKET # (IF REWEIGH) ______

7785377
TICKET NUMBER

DRIVER IN TRUCK UNLESS CHECKED HERE: ___

DELIVERY RECEIPT

PLACE CAR AS PLACARDED

AVERAGE WEIGHT AGREEMENT SHIPMENT
The description and weight indicated on this bill of lading are correct, subject to verification by carrier(s) or its (their) designated agent.

This is to certify that the below named articles are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Interstate Commerce Commission.

Subject to Section 7 of Conditions of applicable bill of lading if this shipment is to be delivered to the consignee, without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

GENERAL SHALE PRODUCTS CORP.
(Signature of Consignor)

If charges are to be prepaid, write or stamp here, "To be Prepaid."
Collect

Shipper, Per

Agent, Per

Received $ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per
(The signature here acknowledges only the amount prepaid.)

BRICK STCC 32 511

DATE	2/24/97	CNTRL	1301676	BILL OF LADING	CH3161570
OUR ORDER	CB 3200	VIA	PX	YOUR P.O.	
TIME	11:26:18	CAR OR TRUCK NO.			

SOLD TO: 105607
CENTER FOR TRANSP. RESEARCH &
ED. ATTN-DIANE LOWE
2625 N LOOP DR SUITE 2100
AMES IA 50010

CONSIGNED TO: 11-060
GENERAL SHALE BRICK
PLANT 31
JAMES JACKSON PARKWAY
ATLANTA GA 30318

ROUTE: ++ SHRINK WRAP ++

SHIPPER: GENERAL SHALE PRODUCTS CORP.
ATLANTA, GA.

DESCRIPTION	RATE	WEIGHT
031-10-417-0 M/S CAMBRIDGE BRICK		30240
8400 8 1 RIGHT OF RAIL DOCK OFFICE		

#1

11 PK

30240

DELIVERY RECEIPT

PLACE CAR AS PLACARDED

This is to certify that the below named articles are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Interstate Commerce Commission.

Subject to Section 7 of Conditions of applicable bill of lading if this shipment is to be delivered to the consignee, without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

GENERAL SHALE PRODUCTS CORP.

(Signature of Consignor)

AVERAGE WEIGHT AGREEMENT SHIPMENT.
The description and weight indicated on this bill of lading are correct, subject to verification by carrier(s) or its (their) designated agent.

If charges are to be prepaid, write or stamp here, "To be Prepaid."

Collect

Shipper, Per

Agent, Per

Received $
to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per
(The signature here acknowledges only the amount prepaid.)

BRICK STCC 32 511

DATE	2/24/97	CNTRL	1301676	BILL OF LADING	CH3161568
OUR ORDER	CB 2203	VIA	PX	YOUR P.O.	
TIME	11:25:54	CAR OR TRUCK NO.			

SOLD TO 1XX607

CENTER FOR TRANSP. RESEARCH &
ED. ATTN-DIANE LOWE
2625 N LOOP DR SUITE 2100
AMES IA 50010

CONSIGNED TO 11 32

GENERAL SHALE BRICK
PLANT 31
JAMES JACKSON PARKWAY
ATLANTA GA 30318

ROUTE ++ SHRINK WRAP ++

SHIPPER GENERAL SHALE PRODUCTS CORP.
ATLANTA, GA.

DESCRIPTION	RATE	WEIGHT
031-10-417-0 M/S CAMBRIDGE BRICK		30240
8400 9 1 RIGHT OF RAIL DOCK OFFICE		#2

16 PKS

30240

FLYING J TRAVEL PLAZA

J-SCALE-GUARANTEED WEIGHT

TICKET #[illegible]
02:42 PM
02-24-97

WEIGH #: [illegible]

WEIGHED AT:

TOTAL WT. [illegible] lb

10400 lb	[illegible] lb	[illegible] lb

GUARANTEED
J-SCALE
Our Seal Means It's "GUARANTEED"

C A

TRUCK [illegible]
TRAILER 487

COMMODITY

X ______ WEIGHER SIGNATURE

FLYING J TRAVEL PLAZA

J-SCALE-GUARANTEED WEIGHT

TICKET #24
02:44 PM
02-24-97

WEIGH #: 6.00

WEIGHED AT:

TOTAL WT. 65520 lb

10360 lb	28380 lb	26780 lb

GUARANTEED
J-SCALE
Our Seal Means It's "GUARANTEED"

C A

TRUCK 617
TRAILER 471

COMMODITY

WEIGHER SIGNATURE

APPENDIX II

1. Copy of SAE Fuel Consumption Test Procedure

Report of the SAE/DOT Advisory Committee, approved October 1981 and reaffirmed by the Truck and Bus Fuel Economy Committee, October 1986.

1- Scope - This recommended practice provides a standardized test procedure for comparing the in-service fuel consumption of two conditions of a test vehicle or of one test vehicle to another when it is not possible to run the two or more test vehicles simultaneously. An unchanging control vehicle is run in tandem with the test vehicle(s) to provide reference fuel consumption data. This procedure is especially suitable for testing components, which require substantial time for removal and replacement or modification, such as engines, transmissions, axles, and cab sheet metal. This procedure may also be used for comparison of entire vehicles and for easy-to-change components (those referenced in the Type I test described in SAE Recommended Practice, SAE J1264). The test may utilize fleet vehicles operating over representative routes.

The result of a test using this procedure is the percent difference in fuel consumption between the two test vehicles or the difference in fuel consumption of one vehicle in two different test conditions.

The fuel measurement method is a key factor in determining the overall accuracy achievable with this procedure. If the weighing method is used, overall test accuracy is best and, based on test experience, will be within ±1% (for example, 6% measured improvement can be from 5-7% actual improvement). (See Section 6, Test Accuracy.)

The following four basic rules must be applied to this procedure to insure test result validity:

(a) The test routes and cargo weight should be representative of actual operation.

(b) *A single test is inconclusive regardless of the results. A single test should be taken as an indicator. Test results must be repeatable to have validity.*

(c) The more variables controlled, the more conclusive the results.

(d) All test procedures or methods are accurate within prescribed limits. If the component or system being tested by a given procedure shows a degree of improvement which is equal to or less than the accuracy limit of the procedure, an additional number of tests should be conducted to determine its true value. If a number of tests do not show consistent results, then one must conclude that the changes caused by the component or vehicle system are less than can be measured by the test procedure.

2. Identification - Sufficient information is to be recorded to identify the vehicles under test and the route over which the test is conducted. Minimum information required is shown on the Type II Test Data Form # 1 (Vehicle Identification).

3. Definitions

3.1 Vehicles "C" and "T"--The vehicles being used for test purposes are identified "C" and "T." This identification applies to the vehicles and associated equipment, including the trailer, in the case of tractor/trailer combinations. Vehicle "C" is the control and is not modified in any way during the entire test. Control vehicle fuel consumption is used only to generate control data. It is necessary that Vehicle "C" be dedicated to the test and not used for other purposes until the entire series of tests is completed. The singular purpose of Vehicle "C" is to monitor the test route, ambient conditions, and test procedures for each test run. Vehicle "T" is the test vehicle used to evaluate components. The procedure also has the capability to test two test vehicles, comparing one to the other. (See paragraphs 5.12 and 5.13 for explanation of the two-vehicle test.)

3.2 Test Run--A test run is a complete circuit of the test route. A test run always starts and ends at a common point. This may be accomplished by using either a closed loop of highways or a single highway with one-half of the test run outbound, a turnaround point, and one-half of the test inbound, or a test track. Each vehicle test run generates one data point. To be usable, a test run must meet the constraint of paragraph 5.9.

3.3 Data Point--A data point is the quantity of fuel consumed by a vehicle on a test run.

3.4 T/C Ratio--A T/C ratio is the ratio of the quantity of fuel consumed (data point) by the test vehicle to the quantity of fuel consumed (data point) by the control vehicle during one test run.

3.5 Baseline Segment-A baseline segment *is* composed of a minimum of three valid T/C ratios. A baseline segment establishes baseline fuel consumption of test vehicles or the first of two vehicles to be tested. (See paragraphs 5.10, 5-11, 5.12, and Appendix I, Sample Calculations, for further explanation.)

Note: TMC-The Maintenance Council of the American Trucking Association, Inc.

3.6 Test Segment-A test segment is also composed of a minimum of three valid T/C ratios. A test segment establishes the fuel consumption of the test vehicle after modification or the fuel consumption of the sec- ond of two vehicles tested, .a valid test segment must be compared to a valid baseline segment. (See paragraphs 5.10, 5.11, 5.12, and Appendix I, Sample Calculations, for further explanation.)

3.7 Complete Test--A complete test is composed of a baseline segment and a test segment.

4. Test Preparations

4.l Test Route Selection

4.1.1 FOR LONG-HAUL OPERATIONS-A test route representative of actual operation of not less than 40 miles (64.4 km) should be selected for conducting the test. The route selected must allow high probability of an uninterrupted test. (Record on Test Data Form #1.)

4.1.2 FOR OTHER OPERATIONS (PICK-UP AND DELIVERY (P&D). CONSTRUCTION, TRANSIT BUSES, ETC.)--A representative test route must be selected which will provide sufficient distance and time to consume a minimum of 30% of the test tank capacity or a minimum of 6 gal (22.7 L), of fuel, whichever is greater. The route selected must allow high probability of an uninterrupted test. (Record on Test Data Form #1.)

4.2 Vehicle Test Speeds-The test speeds selected should be representative of average operation as determined by the operator conducting the test and be within the capability of the test vehicles. Vehicles are to be operated according to vehicle, engine, and transmission manufacturers' recommendations (engine speeds and shift points). If the test vehicles can be operated in more than one transmission or differential ratio over any part of the test route at the speed selected, a pre-determined driving procedure must be specified. At no time during the test cycle should one vehicle control the speed or performance of the other vehicle; however, they should be run at basically the same time in order to experience the same ambient operating conditions. (See paragraph 5.4.)

4.3 Vehicle Type and Configuration-Vehicles "C" and "T" are not required to be of the same general configuration. However, it may require more test runs to obtain three valid T/C ratios when extreme differences in configuration exist between control and test vehicles. All vehicles must be in proper operating condition as determined by the operator conducting the test. (See paragraph 7.7.) Vehicle "C" need not have the same engine, driveline, axle ratio, or tire size as the test vehicle. (Record on Test Data Form #1.)

4.4 Cargo Weights-The cargo weights selected for the test should be representative of the fleet operations and be within the capability of the vehicles under test. Equal gross weights for Vehicles "C" and "T" are not necessary but are desirable. If two test vehicles are being compared, the cargo weights must be the same. Cargo weight must not change during a test unless a change in weight is a factor being tested. (Record measured weights of control and test vehicles on Test Data Form #1.)

4.5 Driver Selections-Drivers selected should be sufficiently skilled so that test results are not affected by the driver's technique improvement during the test period. Drivers should also have a strong motivation for unbiased results and excellence of test procedure conduct.

4.6 Observers-Observers should be assigned to each vehicle. The observer records the data outlined in paragraph 5.5. Complex driving cycles require observers; simple driving cycles may not require observers.

4.7 Fuel Measuring

4.7.l PORTABLE WEIGH TANK METHOD-This method of fuel consumption measurement requires that a portable tank of at least 16 gal (60.6 L) capacity be installed on each vehicle. The portable tank[1] must have provisions for both supply and return of fuel. The fuel line connections to the portable[2] tank must be fitted with quick-disconnect fittings to allow for removal without spillage. The portable tank weigh method, requires a good quality scale[2], accurately calibrated in increments of 0.1 lb (45 g) or 1 oz (28.4 g). (Use Test Data Form #2 for recording data.) When reading a scale with graduations marked at each ounce, it is a simple matter to interpolate to ¼ oz. A deadweight of approximately 100 lb (45.4 kg, is required to check scale repeatability immediately preceding each series of fuel tank weighings. (See paragraph 7.4.)

[1] It is strongly recommended that the portable tanks selected have a high degree of mechanical integrity. Temporary installation of an automobile fuel tank is not recommended

[2] A good scale for this purpose is Accu-weight Model 200 or equivalent.

4.72 FLOW METER METHOD-If vehicles are fitted with on-board flow meters, these meters must be capable of temperature density compensation and must be calibrated to a minimum accuracy of ±1% at a flow rate consistent with the vehicle being tested. (Use Form #2 for recording data.) (See paragraph 6.2 for test accuracy with fuel meter.)

4.7.3 FUEL TEMPERATURES-The fuel temperature in the portable weighing tanks should be kept below 160°F (71°C). Fuel coolers can be used to maintain the temperature below that value but positioning the portable weigh tank in an area of good air flow is an easier solution.

4.8 Baseline Segment-Vehicles “C” and “T” must make sufficient test runs to complete a baseline segment. (See Appendix I, Sample Calculations.) After the baseline has been established, modification is made to Vehicle “T.” *No change is made to Vehicle “C” for the duration of the test.* Vehicle “C” must remain the same vehicle, without change, and used for test purposes only, even if modification to Vehicle “T” requires several weeks. If trailers are used, the trailers and loads must be used for test purposes only, or be set aside, unchanged, until the test is completed.

4.9 Test Segment-Vehicle “C” and modified or new Vehicle “T” must make sufficient test runs to complete a segment. (See Appendix I, Sample Calculations.)

5. Test Procedures

5.1 Vehicles “C” and “T” must follow the same start and warm-up procedures. Warm-up speeds should be at or near test speeds. The time of warm-up must not be less than 1 h. Longer warm-up periods may be required at colder temperatures. Warm-up and driver familiarization with the test route can be accomplished at the same time. This test procedure is structured to measure fuel consumption differences of warmed-up vehicles.

5.2 Record weather, road conditions, traffic conditions, wind velocity, wind direction, temperature, humidity, and barometric pressure for each test run. (Record on Test Data Form #2.) These data are not used in calculation but are useful in evaluation of test results.

5.2.1 Wind velocity may be checked with an inexpensive *marine type*[3] hand held wind indicator.

5.2.2 Weather data may be obtained from a local airport or other weather bureau service.

5.3 Vehicles “C” and “T” are moved to the marked starting point and parked with engines stopped. Portable fuel tanks are topped off, weighed, and the weight recorded. Fuel measuring equipment, if used, and odometers are read and the data recorded. (Use Test Data Form #2.) Vehicles must be fueled from the same dispenser during the entire test to insure consistent fuel grade and quality.

5.4 The driver of Vehicle “T” should start the engine and leave the starting area on a predetermined test route. (Engine start time is recorded on Test Data Form #2-2.) After approximately 5 min, the driver of Vehicle “C” should start the engine and leave on the test route. (Engine start time is recorded on Test Data Form #2-1.) The interval spacing is to insure that one vehicle will not impose an artificial performance limit on the following vehicle and will also allow fueling between runs without disproportionate cooling. Care should be taken to insure chat cool-down periods are identical for both vehicles and for all test runs. Cool-down periods at start of test and between runs should not be more than 5 min.

5.5 Observers, if used, should make and record a minimum of ten elapsed time recordings on each run using the Observer’s Worksheet. These calculations are made using stopwatches and mile (km) posts. If mile (km) posts do not exist on the test route, measured miles (km) must be laid out prior to conducting the test. Using a stopwatch, observers also record the time the vehicle is stopped at any point on the test route other than at the start and finish points. The time stopped on the course should occur only at stop signs. The vehicle stopped time is subtracted from the total time to obtain running time for each run. (See Form #4, the Observers Worksheet.)

5.6 If, due to conditions or vehicle specifications, a pre-determined driving cycle is specified for the test the observer is to coach the driver, making sure that the vehicle is operated as described in the predetermined driving cycle.

5.7 At the end of each test run, each vehicle must stop at the start (fueling) point. Immediately after full stop, engines are idled for 1 min and then shut down. (Time is recorded using Forms #2-l and #2-2.) Fuel measurement equipment and odometers are read and recorded. (Use Forms #2-1 and #2-2.)

5-8 The driver of Vehicle “C” should drive that vehicle for the complete test. The driver of Vehicle “T” should drive that vehicle for the complete test. After refueling occurs, repeat paragraph 5.3. (Record weather, road, traffic conditions, wind velocity, and wind direction on Forms #2-3 and #2-4.) Observers should also remain with their respective vehicles throughout the complete test since their instructions may influence driver performance.

5.9 At the conclusion of each test run, all data are recorded and the next test run is started by repeating paragraphs 5.3-5.6. Time to complete a test run must be repeated within ±0.5%. For a run which requires 1 h to complete, repeatability must be ±18 s. Fuel consumption data should not be used from runs which failed to repeat time within ±0.5% of other runs in the same segment for the same vehicle. With a 40-50 mile (64.4-80.5 km) long haul course, the use of runs that do not repeat within ±0.5%, excluding time stopped on the test route, will affect the accuracy of the results. The operational events of these runs must be identical. The only allowed variable is time stopped at scheduled stops. More complex test schedules may be less tolerant of variations in stop time.

5.10 A test consists of two segments, a baseline segment and a test segment. Each segment is made up of a minimum of three valid T/C ratios (Test Vehicle Fuel Used/Control Vehicle Fuel Used.) Valid T/C ratios must fit within a 2% band. (See Appendix I, Sample Calculations.) The 2% band means that the lowest T/C ratio cannot be more than 2% below the highest.

5.11 If only one test vehicle is used, a baseline segment is run: The vehicle is then modified and a test segment is run as outlined in paragraphs 4.1-4.9 and 5.l-5.9. The comparison of the baseline and test segments for the test vehicle gives the test results. (See Appendix I, Sample Calculations.)

5.12 If two complete vehicles are to be compared, the Control Vehicle (C) and Test Vehicle One (T_1) are used in the baseline segment. The Control Vehicle (C) and Test Vehicle Two (T_2) are used in the test segment. Both segments are run as outlined in paragraphs 4.1-4.9 and 5.1 - 5.9. The comparison of the baseline and test segments of the test vehicle(s) gives the test results. More than one test vehicle can be run simultaneously in which case the divisor of the ratio is always the Control Vehicle (C). (T_1/C, T_2/C, T_3/C, etc.) (See Appendix I, Sample Calculations.)

5.13 This test procedure is for use when testing a modification to test vehicle or when comparing two vehicles employing a switch of the complete test vehicle between baseline segment and test segment. For example, when comparing one test tractor to another, the driver and trailer of the baseline segment vehicle are the driver and trailer of the test segment vehicle. The test segment is then comparable to the baseline segment. More than one test can be conducted and several test vehicles can be operated at the same time. When more than one test vehicle is run at the same time, the control vehicle should be run between the test vehicles and as near the middle as possible. A single test is inconclusive regardless of the results. A single test should be taken as an indicator. Test results must be repeatable to have validity.

6. *Test Accuracy*

6.1 Properly conducted tests using portable tank weigh methods are considered, based on test experience with long-haul test routes, to have an overall accuracy within ±1% (for example, 6% measured difference can be from 5-7% actual difference.)

6.2 The use of on-board meters has not been succcssfully demonstrated during the validation this procedure.

7. *Cautionary notes*

7.1 Test Route-It has been determined during validation of the procedure that the optimum long haul test route is one that starts and stops at a common point, has a fueling point with easy access to the test route, and has no traffic control lights. The turnaround should be either the cloverleaf type or an off ramp with a stop sign, an overhead (or underneath) crossover, and an on ramp. A turnaround point with traffic-control lights must be avoided. A test route that has had mile (km) markers installed is recommended. For other test routes (P&D, construction, transit buses, etc.) experience has shown that this procedure is acceptable. However, care must be taken in establishing routes and their inherent driving cycles to insure they are representative of the operating parameters of the equipment under test.

7.1.1 For transit buses, the Transit Coach Operating Profile Dump Cycle[4] may be used.

7.2 Trailers and Weight Dedication-If trailers are used, the trailer matched to Vehicles “C” and “T” should stay with their respective tractors throughout the entire test. If this cannot be done with the operator’s revenue equipment, consideration should be given to renting trailers for the duration of the series of test segments. Under no circumstance should the trailers be exchanged between Vehicles “C” and “T.” The use

3 Edmund Scientific Co. Barrington, NJ, or Dwyer Instrument, Inc., Michigan City, IN, or equivalent.

4 Baseline Advanced Design Transit Coach Specification, Part II. Paragraph I (17). Guideline procurement document for new 30 and 40 ft (10.4 and 12.2 m) coach design. Published by DOT and UMTA.

of revenue cargo for test weight should be avoided to prevent delay of weight or loss of costly test data due to an unavoidable extension of the test period and/or cargo delivery commitments.

7.3 Vehicles "C" and "T" should be operated at test speeds for not less than 1 h. for warmup before test cycles are run, to insure that the vehicles approach temperature stabilization in all components. Invalid test runs may result if higher fuel consumption is caused by temperature-induced frictional resistance in one, but not all, of the vehicles used to conduct the test. If fuel consumption during warm-up is being tested. Vehicles "C" and "T" should not be operated for a minimum of 12 h prior to starting each test run.

7.4 Portable tanks must be weighed on the same portable scales, (See paragraph 4.7.1.) The outside of the portable fuel tanks should be wiped clean of dirt and fuel each time they are weighed. The scale site should be protected from winds. *Scales must be checked with a known deadweight of approximately 100 lb (45.4 kg) before each series of readings.* The portable scales should not be moved between the initial and final weighing of a given test run unless particular attention is paid to checking the scale's repeatability in a second location. (See paragraph 4.7.1, etc.)

7.5 It is strongly recommended that all drivers and observers of Vehicles "C" and "T" be required to drive and ride over the test route at least once before testing. Familiarity with grades, required shifting, braking, speed maintenance, etc. will lead to greater accuracy and repeatability.

7.6 To minimize test variability when driving the warm-up run or first test run, it is recommended that each driver mentally note the precise location on the test route where he applies the brakes and for how long, where he shifts gears, and where he accelerates and decelerates. Each subsequent run should be an exact duplicate of the previous run and no attempt to improve should be made.

7.6.1 The use of stopwatches by observers and/or drivers to facilitate the measurement of time and speed between mile (km) markers has been found to be a valuable aid in meeting the time requirements of this test procedure.

7.6.2 It has also been found useful to select mile (km) marker check points along the route and record the time between markers, the time to negotiate a cloverleaf, and the time elapsed from interstate ramp to ramp. The selected check points should remain the same for each test run. No attempt should be made to compensate for a fast or slow elapsed time between two previous check points.

7.7 To minimize test variability, it is recommended that all vehicles (C and T) being tested be in similar mechanical conditions, be representative of the operator's vehicle(s) involved in the test, and have (except in one case where this is the item being evaluated):

(a) Each engine governor set to manufacturer's recommendation or the operator's standard.

(b) New air cleaner element and new fuel filters. Installation of new air cleaner element can be waived if vehicle's inlet restriction does not exceed 0.5 in H_2O (3.7 kPa).

(c) Each vehicle reasonably clean and free of sheet metal dents, tears, or missing body parts. Fiberglass hoods should be intact.

(d) Cab side window openings the same in each vehicle, open or closed, for the entire test. For transit buses, all windows should stay the same (open or closed) for entire test.

(e) Accessory load for each vehicle as consistent as possible (for example by turning air conditioning off, defroster off, heat switch at the same position, and lights on).

(f) Trailer free of damage to exterior surfaces that would affect aerodynamic drag.

(g) Truck/tractor alignment checked and proper. Trailer axle align-ment checked and proper.

(h) Each vehicle properly lubricated prior to test. All fluid levels should be checked and be at prescribed levels.

(i) Temperature controlled fan drives and shutters locked in the same operating mode throughout the test.

(j) Cold tire pressures measured and inflated to operator's standard.

(k) A stall check made on vehicles equipped with automatic transmis- sion and torque converters.

(l) Exhaust system back pressure below engine manufacturer's maxi-mum recommended limit and within 0.5 in Hg (1.7 kPa) between test vehicle engines of the same make and model.

(m) Proper brake adjustment.

7.8 At the end of each warm-up and at the end of each test run, all vehicles must be checked for mechanical changes that would affect test results. Typical checks would include:

(a) Oil pressure and leaks.
(b) Coolant temperature and leaks.
(c) Exhaust gas temperature.
(d) Engine air filter restriction.
(e) Electrical load.
(f) Tire pressures.
(g) Brake dragging (i.e. temperature).
(h) Exhaust smoke.
(i) Observed ability to maintain selected test speed.
(j) Transmission or differential leaks.
(k) Intake manifold pressure (turbocharger boost).

7.9 Drivers of Vehicles "C" and "T" should be interviewed between test runs to ascertain any differences in the apparent handling, power, and braking characteristics of their respective vehicle. If changes occur between the test runs of either the baseline segment or the test segment, the test data should be discarded and the test re-run after correction of the problem.

7.10 In order to obtain results which may be considered representative of actual service conditions, it is important to reproduce typical service conditions during the test. This applies to load weights, routes, grades, vehicle speeds, weather, wind conditions, drivers, etc. For example, if the actual service vehicles generally operate in a part of the country where hills exist over a substantial portion of the routes, the test should be conducted on similar terrain in order to obtain the most representative results.

7.11 Because of the specific nature of aerodynamic drag reduction equipment (deflectors, body fairings, roof fairings, vortex stabilizers, etc.) comparison tests between brands or types should not be run with two trucks. If comparative results are required, additional test trucks are recommended during any given test. The entire range of trucks may be either higher or lower than average conditions depending upon the weather (wind velocity and direction) on the days during which the tests were conducted. To minimize the effects of high or low yaw angle wind effects, a circular route or closed loop of highways is recommended.

7.12 The accuracy of odometers and speedometers of Vehicles "C" and "T" should be determined during the warm-up test and compensations made for error during actual test runs. If odometer readings (total miles (km)) between two vehicles differ, it is recommended that the two elapsed mileage (km) readings be averaged and this value be used for calculation purposes. Another acceptable method would be to use a vehicle with known speedometer and odometer accuracy and use that distance for calculations of mpg (km/L) conversions.

7.13 If test participants are currently careful and pay attention to all details of the procedure, it has been found that it is highly unusual that more than five test runs are required to complete a segment. It has also been found that, almost without exception, a procedural error or a mechanical problem can be identified when it is necessary to throw out a test run.

8. *Bibliography*

TMC Report, "Report of Frederick, Maryland, Truck and Bus Fuel Economy Demonstration, Conducted October 22-November 1, 1979, by the Joint TMC/SAE Task Force for In-Service Test Procedures of The American Trucking Industry," November 1980.

Proposed SAE Information Report, "Bus Advisory Group-Information Report."

SAE Paper No. 810025.

APPENDIX I

SAMPLE CALCULATIONS

A1. Derivation of Baseline Data

A1.1 Baseline Segment

A.

Test Run No.	Fuel Consumed lb or kg, Test Vehicle (Data Point)	)	Fuel Consumed lb or kg. Control Vehicle (Data Point)	=	T/C Ratio
1	78.94		68.04		1.1602
2	79.41		66.84		1.1881
3	77.50		66.84		1.1595

Check T/C values must be within 2%[1]:

After three test runs:

B. Highest T/C ratio X 0.98 = minimum acceptable T/C ratio

1.1881 X 0.98 = 1.1643

The T/C ratios derived by test runs #1 and #3 are less than the minimum acceptable T/C ratios calculated in B. Therefore, additional baseline data are required. This comparative test to assure T/C ratios

[1] Use 0.98 as a multiplier for this purpose.

within 2% should be made after the third test run and then after each succeeding test run that is required. When three test runs repeated within 25 of each other, .as checked in B, have been computed, the baseline segment is complete. In this example, an additional test run is required.

Test Run No.	Fuel Consumed lb or kg. Test Vehicle (Data Point)	÷	Fuel Consumed lb or kg, Control Vehicle (Data Point)	=	T/C Ratio
1	78.94		68.04		1.1602
2	79.41		66.84		1.1881
3	77.50		66.84		1.1595
4	78.54		67.34		1.157

After four test runs:

C.

1. Highest T/C ratio X 0.98 = minimum acceptable T/C ratio
   1.1881 X 0.98 = 1.1643
2. Second highest T/C ratio X 0.98 = minimum acceptable T/C ratio
   1.1602 X 0.98 = 1.1370

Because there are three T/C ratios greater than the minimum acceptable T/C ratio as determined by calculation C.2., the requirement that three test runs fall within a 2% band has been met and the baseline segment is complete.

Test runs #1 and #3 were valid when tested by comparison with test run #4. Therefore, run #2 is considered faulty and is deleted as part of the baseline segment. Since test runs #1, #3, and #4 meet the 2% requirement, a #5 test run is not required.

The same procedure shown at A and B is repeated as in C.

If a fifth test is required to get three valid T/C ratios, the determination of those runs is done per item D.

D.

1. Highest T/C ratio X 0.98 = minimum acceptable T/C ratio
2. Second highest T/C ratio X 0.98 = minimum acceptable T/C ratio
3. Third highest T/C ratio X 0.98 = minimum acceptable T/C ratio

NOTE: If test participants are extremely careful and pay attention to all details of the procedure, it has been found that it is highly unusual that more than five test runs are required to complete a segment. It has also been found that, almost without exception, a procedural error or a mechanical problem can be identified when it is necessary to throw out a test run.

The test segment may now be started.

A1.2 Test Segment-Make similar calculations as in baseline segment. (Typical test segment results are shown in paragraph A2.2.)

A2. Calculation of Results – After finishing a baseline segment and a test segment, calculate the result. That is, compare the baseline segment, performed before the component change was made to the truck, to the test segment, performed after the change. Each segment was run until three T/C ratios of fuel consumption were obtained which met the 2% test. For calculating the results, we must now compare them.

A2.1 Baseline Segment T/C Ratios

Test Run	#1	1.1602
	#3	1.1595
	#4	1.1577
Ave.		3.4774 ÷ 3 = 1.1591

A2.2 Test Segment T/C Ratios-(See paragraph Al .2.)

Test Run	#2	1.0959
	#3	1.1080
	#4	1.0936
Ave.		3.2975 ÷ 3 = 1.0992

The T/C ratios derived in each segment are ratios comparing the fuel consumption of the test vehicle (T) to the control vehicle (C). It is by comparing these ratios that we derive the percentage improvement (positive or negative) between the baseline segment (before the component change) and the test segment (after the component change).

A2.3 Percent Fuel Saved
= (Ave. Baseline T/C - Ave Test T/C) ÷ Ave. Baseline T/C
= (1.1591 - 1.0992) ÷ 1.1591
= (0.0517 X 100) = 5.17% Fuel Saved.

A2.4 Percent Improvement.
= (Ave. Baseline T/C - Ave Test T/C) ÷ Ave. Test T/C
= (1.1591 - 1.0992) ÷ 1.0992
= (0.0545 X 100) = 5.45% Fuel Saved.

A3. mpg (km/L) Conversion-The preferred method of expressing the result of a test is as a percent of fuel saved, as described in paragraph A2.3. If it is desired to see fuel consumption stated in mpg (km/L) it must be emphasized that these values apply to the specific test conditions only. This section of the procedure describes how to state the results in consistent mpg (km/L) values. The fuel consumption of the control vehicle is used, in an arbitrary role, in this calculation. For reasons of consistency, and so that the resulting mpg (km/L) values can be compared with each other, it is important that the same control vehicle mpg (km/L) value be used to derive all test vehicles' mpg (km/L) values. Two ways of calculating this representative control vehicle mpg (km/L) are shown and the choice between them is not important. It is important that the precaution be followed of using only one representative control vehicle (including driver) mpg (km/L) value to calculate all mpg (km/L) values which might be compared with each other.

The fuel specific weight of the actual test fuel should be determined and used for this calculation. As an alternative, a value of 7.05 lb/gal (0.84 kg/L) for #2 diesel and 6.0 lb/gal (0.72 kg/L) for gasoline may be used.

A3.1 Representative Control Vehicle mpg (km/L) - The control vehicle representative mpg (km/L) can be obtained from valid fuel consumption for one day or from the valid fuel consumption for every time that control vehicle was used.[2] For this example, the baseline segment valid runs will be used:

68.04	Run #1
66.84	Run #3
67.84	Run #4
202.72 lb for 3 runs	

202.72 lb ÷ 7.05 lb/gal = 28.75 gal
(91.95 kg ÷ (0.85 kg/L = 108.17L)[3]

50 miles X 3 runs = 150 miles
(80.5 km X 3 runs = 241.4 km)[4]

150 miles ÷ 28.75 gal = 5.22 miles/gal[4]
(24 1.4 km ÷ 10s. IT L = 2.23 'km/L)

A3.2 Test Vehicle Baseline mpg (km/L)

Control vehicle representative mpg (km/L) ÷ Ave. Baseline T/C Ratio
5.22 mpg + 1.1591 = 4.50 mpg
(2.23 km/L + 1.1591 = 1.92 km/L)

Test Vehicle Test mpg (km/L)

Control vehicle representative mpg (km/L) ÷ Ave. Test T/C Ratio
5.22 mpg ÷ 1.0992 = 4.75 mpg
(2.23 km/L ÷ 1.0992 = 2.03 km/L)

A3.3 Improvement in mpg (km/L)

Test - Baseline
4.75 - 4.50 = 0.25 mpg improvement
(2.02 - 1.92 = 0.10 km/L improvement)

[2] 5.22 mpg (2.23 km/L) has been established as representative of this control vehicle recognizing that tests run on other days under different weather conditions, will result in a different mpg (km/L) value for the control vehicle. However, for other tests where this control vehicle is used for the purpose of converting to mph (km/L the 5.22 mpg (2.23 km/L) must be used as the representative value if a valid mpg (km/L) conversion is to be made. If a new representative value is used, a previous mpg (km/L) improvements must be recalculated using the new representative value.

[3] To convert lb to kg multiply lb by 0.4536.

[4] To convert miles to km multiply miles by 1.6093.

TYPE II TEST DATA FORM #1 (VEHICLE IDENTIFICATION)

Power Unit

Fleet____________________ Date____________________ Test #____________________

	Control Vehicle	Test Vehicle
Unit Number	__________	__________
Make	__________	__________
Model	__________	__________
Year	__________	__________
Number of Axles	__________	__________
Number of Drive Axles	__________	__________
Engine Make/Model	__________	__________
Governed Speed @ No Load (High Idle)	__________RPM	__________RPM
Rated Power	__________hp (kw)	__________hp (kw)
Rated Speed	__________RPM	__________RPM
Peak Torque	__________lb-ft	__________lb-ft
Peak Torque Speed	__________RPM	__________RPM
Transmission Make Model	__________	__________
Geared For	__________mph (km/h)	__________mph (km/h)
	at__________RPM	at__________RPM
	in__________gear	in__________gear
Differential Make/Model	__________	__________
Differential Ratio	__________	__________
Tire Size/Type/Make/Model	_____/_____/_____	_____/_____/_____
Tire Pressure (Cold)	__________psi (kPa)	__________psi (kPa)
5th Wheel Setting (express in in (mm) the distance 5th wheel fulcrum is ahead or behind the center line of bogie)	__________in (mm)	__________in (mm)

NOTE: In areas where two units are shown [i.e., hp (kw)] circle the unit used.

TYPE II TEST DATA FORM #1 (VEHICLE IDENTIFICATION) (CONTINUED)

Power Unit

Fleet______________________ Date______________________ Test #______________________

	Control Vehicle	Test Vehicle
Unit Number	________	________
Make	________	________
Model	________	________
Year	________	________
Type (Van, Flatbed, Tank, Etc.)	________	________
Type of Side	________	________
Type of Corner	________	________
Height	________	________
Length	________	________
Tire Size/Type/Make/Model	____/____/____	____/____/____
Tire Pressure (Cold)	________psi (kPa)	________psi (kPa)
Number of Axles on Trailer(s)	________	________
G.V.W. (Measured on Scale)	________	________
Kingpin Setting	________in (mm)	________in (mm)
Cab-to-Trailer Gap	________in (mm)	________in (mm)

TYPE II TEST DATA FORM #1 (VEHICLE IDENTIFICATION) (CONTINUED)

Devices, Components, or System That Are Incorporated
Into Control and Test Vehicle Specifications

Fleet____________________Date____________________Test #____________________

	Control Vehicle			Test Vehicle		
	No	Yes	Type	No	Yes	Type
Radiator Shutters (on-off or modulating)						
Engine Cooling Fan Sys. (Describe below – A)						
Aerodynamic Device (Describe below – B)						
Engine Oil						
Transmission Lube						
Differential Lube						
Fuel Heater						
Oil Cooler						
Tag Axle						
Air Lift Axle(s)						
Low Back Pressure Exhaust System						
Other:						

A ______________________________/______________________________

B ______________________________/______________________________

TYPE II TEST DATA FORM #1 (VEHICLE IDENTIFICATION) (CONTINUED)

Fleet_______________________ Date_______________________ Test #_______________

Detailed Description of Vehicle, Component, or System Modification Being Tested:

Length of Test Route from Start to Stop Point: _______________________miles (km)

Test Route: (Describe in detail number of lanes; types of road surface; type of turnarounds; type, if any, of traffic control devices; type of terrain, hill, cuts, curves; special driving instructions; etc.)

Driver(s) Interview

Handling, Power, and Braking Characteristics of Vehicle(s) during Test (see paragraph 7.5):

Control Vehicle _______________________

Test Vehicle_______________________

TYPE II – FUEL ECONOMY TEST DATA FORM #2-1

BASELINE SEGMENT OF THE CONTROL VEHICLE

Type II Test – Portable Fuel Tank Weighing Method or Fuel Flow Meter Method

Fleet________________ Control Tractor # ____________ Control Trailer # ____________

Driver ________________ Observer ________________

Test # ________________ Date ________________

Test Speed ________________ Route ________________

Test Run #1

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ____________ lb/gal kg/L (circle one)

Time from Start to Finish _____ h _____ m _____ s

Subtract Vehicle Stopped Time _____ h _____ m _____ s

Vehicle Running Time[1] _____ h _____ m _____ s

Test Run #2

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ____________ lb/gal kg/L (circle one)

Time from Start to Finish _____ h _____ m _____ s

Subtract Vehicle Stopped Time _____ h _____ m _____ s

Vehicle Running Time[1] _____ h _____ m _____ s

Test Run #3

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ____________ lb/gal kg/L (circle one)

Time from Start to Finish _____ h _____ m _____ s

Subtract Vehicle Stopped Time _____ h _____ m _____ s

Vehicle Running Time[1] _____ h _____ m _____ s

Test Run #4

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	___________________________	_____________	_______________
Finish	___________________________	_____________	_______________

Fuel Used ___________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m ________ s

Subtract Vehicle Stopped Time ________ h _______ m ________ s

Vehicle Running Time[1] ________ h _______ m ________ s

Test Run #5

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	___________________________	_____________	_______________
Finish	___________________________	_____________	_______________

Fuel Used ___________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m ________ s

Subtract Vehicle Stopped Time ________ h _______ m ________ s

Vehicle Running Time[1] ________ h _______ m ________ s

Control Vehicle MPG Calculation

Total Fuel Used_________lb/gal kg/L (circle one) __________ Time __________ h ____________ m ____________ s

Total Fuel Used lb/gal kg/L[2] ________ ÷[3] __________ = ____________ gal (L)

Total Miles (km) Run _________ ÷ ________ gal (L) used = __________ miles/gal (km/L)

Miles (km) Run __________ ÷ ________ h = ___________miles/h (km/h)

Weather	**Temperature**	**Humidity**	**Barometric Pressure**	**Wind Speed**	**Wind Direction**
Run # 1	______________	__________	___________	_____________	__________
Run # 2	______________	__________	___________	_____________	__________
Run # 3	______________	__________	___________	_____________	__________
Run # 4	______________	__________	___________	_____________	__________
Run # 5	______________	__________	___________	_____________	__________

[1] Running Time must repeat within ± 18 s for 1 h run or ±0.5% of the time required to complete the test run or run data point must not be used. See paragraphs 3.2, 3.3, 5.1.
[2] If fuel meter is used record meter readings in this column.
[3] For No. 2 diesel, use 7.05 lb/gal (0.84 kg/L); or for gasoline use 6.0 lb/gal (0.72 kg/L); or actual specific weight of fuel can be used.

TYPE II – FUEL ECONOMY TEST DATA FORM #2-2

BASELINE SEGMENT OF THE CONTROL VEHICLE

Type II Test – Portable Fuel Tank Weighing Method or Fuel Flow Meter Method

Fleet ______________________ Control Tractor # ______________ Control Trailer # ____________

Driver ______________________ Observer ______________________

Test # ______________________ Date ______________________

Test Speed ______________________ Route ______________________

Test Run #1

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ______________ lb/gal kg/L (circle one)

Time from Start to Finish _____ h _____ m _____ s

Subtract Vehicle Stopped Time _____ h _____ m _____ s

Vehicle Running Time[1] _____ h _____ m _____ s

Test Run #2

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ______________ lb/gal kg/L (circle one)

Time from Start to Finish _____ h _____ m _____ s

Subtract Vehicle Stopped Time _____ h _____ m _____ s

Vehicle Running Time[1] _____ h _____ m _____ s

Test Run #3

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ______________ lb/gal kg/L (circle one)

Time from Start to Finish _____ h _____ m _____ s

Subtract Vehicle Stopped Time _____ h _____ m _____ s

Vehicle Running Time[1] _____ h _____ m _____ s

TYPE II – FUEL ECONOMY TEST DATA FORM #2-2 (CONTINUED)

Test Run #4

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	____________________________	_____________	_______________
Finish	____________________________	_____________	_______________

Fuel Used ____________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m ________ s

Subtract Vehicle Stopped Time ________ h _______ m ________ s

Vehicle Running Time[1] ________ h _______ m ________ s

Test Run #5

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	____________________________	_____________	_______________
Finish	____________________________	_____________	_______________

Fuel Used ____________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m ________ s

Subtract Vehicle Stopped Time ________ h _______ m ________ s

Vehicle Running Time[1] ________ h _______ m ________ s

Weather	**Temperature**	**Humidity**	**Barometric Pressure**	**Wind Speed**	**Wind Direction**
Run # 1	______________	__________	___________	_____________	__________
Run # 2	______________	__________	___________	_____________	__________
Run # 3	______________	__________	___________	_____________	__________
Run # 4	______________	__________	___________	_____________	__________
Run # 5	______________	__________	___________	_____________	__________

[1] Running Time must repeat within ± 18 s for 1 h run or ±0.5% of the time required to complete the test run or run data point must not be used. See paragraphs 3.2, 3.3, 5.1.

TYPE II – FUEL ECONOMY TEST DATA FORM #2-3

BASELINE SEGMENT OF THE CONTROL VEHICLE

Type II Test – Portable Fuel Tank Weighing Method or Fuel Flow Meter Method

Fleet______________________________ Control Tractor # ________________ Control Trailer # ____________

Driver ______________________________ Observer ______________________________

Test # ______________________________ Date ______________________________

Test Speed ______________________________ Route ______________________________

Test Run #1

Scale Repeatability Check Weight _____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ______________________lb/gal kg/L (circle one)

Time from Start to Finish ______ h ______ m ______ s

Subtract Vehicle Stopped Time ______ h ______ m ______ s

Vehicle Running Time[1] ______ h ______ m ______ s

Test Run #2

Scale Repeatability Check Weight _____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ______________________lb/gal kg/L (circle one)

Time from Start to Finish ______ h ______ m ______ s

Subtract Vehicle Stopped Time ______ h ______ m ______ s

Vehicle Running Time[1] ______ h ______ m ______ s

Test Run #3

Scale Repeatability Check Weight _____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ______________________lb/gal kg/L (circle one)

Time from Start to Finish ______ h ______ m ______ s

Subtract Vehicle Stopped Time ______ h ______ m ______ s

Vehicle Running Time[1] ______ h ______ m ______ s

Test Run #4

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	____________________________	_____________	_______________
Finish	____________________________	_____________	_______________

Fuel Used ____________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m _______ s

Subtract Vehicle Stopped Time ________ h _______ m _______ s

Vehicle Running Time[1] ________ h _______ m _______ s

Test Run #5

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	____________________________	_____________	_______________
Finish	____________________________	_____________	_______________

Fuel Used ____________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m _______ s

Subtract Vehicle Stopped Time ________ h _______ m _______ s

Vehicle Running Time[1] ________ h _______ m _______ s

Control Vehicle MPG Calculation

Total Fuel Used_________lb/gal kg/L (circle one) __________ Time __________ h ____________ m ____________ s

Total Fuel Used lb/gal kg/L[2] ________ ÷[3] __________ = ____________ gal (L)

Total Miles (km) Run _________ ÷ ________ gal (L) used = __________ miles/gal (km/L)

Miles (km) Run __________ ÷ ________ h = ___________miles/h (km/h)

Weather	**Temperature**	**Humidity**	**Barometric Pressure**	**Wind Speed**	**Wind Direction**
Run # 1	______________	__________	___________	_____________	__________
Run # 2	______________	__________	___________	_____________	__________
Run # 3	______________	__________	___________	_____________	__________
Run # 4	______________	__________	___________	_____________	__________
Run # 5	______________	__________	___________	_____________	__________

[1] Running Time must repeat within ± 18 s for 1 h run or ±0.5% of the time required to complete the test run or run data point must not be used. See paragraphs 3.2, 3.3, 5.1.
[2] If fuel meter is used record meter readings in this column.
[3] For No. 2 diesel, use 7.05 lb/gal (0.84 kg/L); or for gasoline use 6.0 lb/gal (0.72 kg/L); or actual specific weight of fuel can be used.

TYPE II – FUEL ECONOMY TEST DATA FORM #2-4

BASELINE SEGMENT OF THE CONTROL VEHICLE

Type II Test – Portable Fuel Tank Weighing Method or Fuel Flow Meter Method

Fleet____________________ Control Tractor # ____________ Control Trailer # ____________

Driver ____________________ Observer ____________________

Test # ____________________ Date ____________________

Test Speed ____________________ Route ____________________

Test Run #1

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ____________ lb/gal kg/L (circle one)

Time from Start to Finish ______ h ______ m ______ s

Subtract Vehicle Stopped Time ______ h ______ m ______ s

Vehicle Running Time[1] ______ h ______ m ______ s

Test Run #2

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ____________ lb/gal kg/L (circle one)

Time from Start to Finish ______ h ______ m ______ s

Subtract Vehicle Stopped Time ______ h ______ m ______ s

Vehicle Running Time[1] ______ h ______ m ______ s

Test Run #3

Scale Repeatability Check Weight ____________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start			
Finish			

Fuel Used ____________ lb/gal kg/L (circle one)

Time from Start to Finish ______ h ______ m ______ s

Subtract Vehicle Stopped Time ______ h ______ m ______ s

Vehicle Running Time[1] ______ h ______ m ______ s

Test Run #4

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	____________________________	_____________	_______________
Finish	____________________________	_____________	_______________

Fuel Used ____________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m ________ s

Subtract Vehicle Stopped Time ________ h _______ m ________ s

Vehicle Running Time[1] ________ h _______ m ________ s

Test Run #5

Scale Repeatability Check Weight ________________

	Fuel Weight/Fuel Meter Reading	Odometer	Time
Start	____________________________	_____________	_______________
Finish	____________________________	_____________	_______________

Fuel Used ____________________________lb/gal kg/L (circle one)

Time from Start to Finish ________ h _______ m ________ s

Subtract Vehicle Stopped Time ________ h _______ m ________ s

Vehicle Running Time[1] ________ h _______ m ________ s

Weather	**Temperature**	**Humidity**	**Barometric Pressure**	**Wind Speed**	**Wind Direction**
Run # 1	______________	__________	___________	_____________	__________
Run # 2	______________	__________	___________	_____________	__________
Run # 3	______________	__________	___________	_____________	__________
Run # 4	______________	__________	___________	_____________	__________
Run # 5	______________	__________	___________	_____________	__________

[1] Running Time must repeat within ± 18 s for 1 h run or ±0.5% of the time required to complete the test run or run data point must not be used. See paragraphs 3.2, 3.3, 5.1.

TYPE II – FUEL ECONOMY TEST DATA FORM #3

CALCULATION SUMMARY SHEET

Fleet________________________ Date________________________ Test #________________

	Baseline Runs	Test Vehicle Fuel Used, lb/gal kg/L (circle one) Form # 2-2	Control Vehicle Fuel Used, lb/gal kg/L (circle one) Form # 2-1	T/C Ratio	Checked Valid T/C Ratos Used
	1				
	2				
Baseline Data	3				
	4				
	5				

NOTE: Use only valid T/C ratios for calculation of average T/C.

Sum of valid baseline T/C ÷ No. of valid baseline T/C's = average baseline T/C

________________ ÷ ________________ = ____________

	Test Runs	Test Vehicle Fuel Used, lb/gal kg/L (circle one) Form # 2-2	Control Vehicle Fuel Used, lb/gal kg/L (circle one) Form # 2-1	T/C Ratio	Checked Valid T/C Ratos Used
	1				
	2				
Baseline Data	3				
	4				
	5				

NOTE: Use only valid T/C ratios for calculation of average T/C.

Sum of valid baseline T/C ÷ No. of valid baseline T/C's = average baseline T/C

________________ ÷ ________________ = ____________

CALCULATION OF T/C LIMITS FORM # 3-1

Fleet______________________________Date____________________________Test #__________________

After 3 Runs:

Highest T/C Ratio __________ X 0.98 = ______________ minimum acceptable T/C ratio

After 4 Runs:

Highest T/C Ratio ______________ X 0.98 = ______________ minimum acceptable T/C ratio
Second Highest T/C Ratio __________ X 0.98 = ______________ minimum acceptable T/C ratio

After 5 Runs:

Highest T/C Ratio ______________ X 0.98 = ______________ minimum acceptable T/C ratio
Second Highest T/C Ratio __________ X 0.98 = ______________ minimum acceptable T/C ratio
Third Highest T/C Ratio ___________ X 0.98 = ______________ minimum acceptable T/C ratio

CALCULATION OF % FUEL SAVED FORM # 3-2

Fleet______________________________Date____________________________Test #__________________

% Fuel Saved = (Ave. Baseline T/C – Ave. Test T/C) ÷ Ave. Baseline T/C
% Fuel Saved = (_____________ - _____________) ÷ ______________
% Fuel Saved = _____________

Calculation of % Improvement:

Improvement = (Ave. Baseline T/C – Ave. Test T/C) ÷ Ave. Baseline T/C
Improvement = (_____________ - _____________) ÷ ______________
Improvement = _____________

TYPE II – FUEL ECONOMY TEST DATA FORM # 3-3

Fleet____Date_______________________________________Test #_________________________

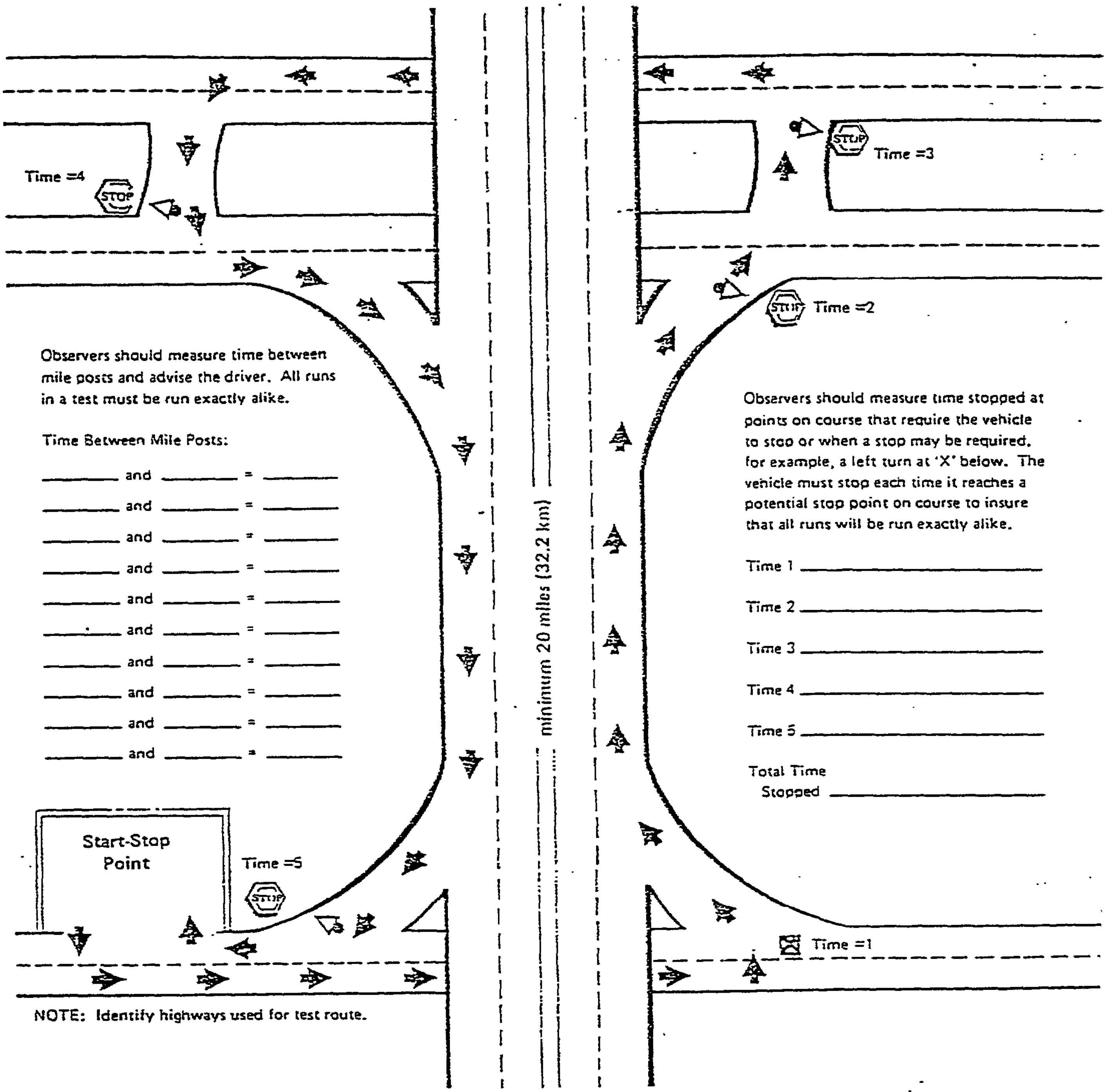
Test Results:

_________________ % fuel saved after change

_________________ % improvement in fuel economy after change (describe below):

TYPE II—FUEL ECONOMY TEST
THE OBSERVER'S WORKSHEET FORM #4

Fleet ______________ Date ______________ Test # ______________



Observers should measure time between mile posts and advise the driver. All runs in a test must be run exactly alike.

Time Between Mile Posts:

________ and ________ = ________
________ and ________ = ________
________ and ________ = ________
________ and ________ = ________
________ and ________ = ________
________ and ________ = ________
________ and ________ = ________
________ and ________ = ________
________ and ________ = ________
________ and ________ = ________

Observers should measure time stopped at points on course that require the vehicle to stop or when a stop may be required, for example, a left turn at 'X' below. The vehicle must stop each time it reaches a potential stop point on course to insure that all runs will be run exactly alike.

Time 1 ______________
Time 2 ______________
Time 3 ______________
Time 4 ______________
Time 5 ______________
Total Time Stopped ______________

NOTE: Identify highways used for test route.

OBSERVER'S NAME ______________________

APPENDIX III

1. Copy of Fuel Consumption Test Measurement Form

Fuel Consumption Test Measurement Form

Control Truck

Driver Name		Location	
Date		Time of Day (Start)	
Temperature	Weather Conditions		Wind Speed
Test Run Number: _____________		**Scenario** (circle one) **Test** **Control**	
Tractor Unit Number: _____________		Trailer Unit Number: ________________	
Fuel Tank #_____________	Fuel Tank Weight	Odometer	Test Run Time
Start			
Finish			
Fuel Used		**Test Run Events**	
Start to Finish Time			
Vehicle Stopped Time			

Total Number of Stops During Test Run: ___________
Total Time During Stops: ___________

Test Truck

Driver Name		Location	
Date		Time of Day (Start)	
Temperature	Weather Conditions		Wind Speed
Test Run Number: _____________		**Scenario** (circle one) **Test** **Control**	
Tractor Unit Number: _____________		Trailer Unit Number: ________________	
Fuel Tank #_____________	Fuel Tank Weight	Odometer	Test Run Time
Start			
Finish			
Fuel Used		**Test Run Events**	
Start to Finish Time			
Vehicle Stopped Time			

Total Number of Stops During Test Run: ___________
Total Time During Stops: ___________

APPENDIX V

1. Copies of Data Collection Forms Used in Weigh Station Throughput Test

Vehicle Arrival/Identification Form Page One

Weigh Station Name:						Traffic Direction: (circle one) North South				
Observation Point: (circle one) 1 2 3					Date:		Session Start Time: ________________			
Observer Name:						Recorder Name:				
Weather Conditions:						Point____-Point____Distance:________________				
Minute	Vehicle Identification and Arrival Time (Seconds)									
0 ID.										
Secs.										
1 ID.										
Secs.										
2 ID.										
Secs.										
3 ID.										
Secs.										
4 ID.										
Secs.										
5 ID.										
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6 ID.										
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16 ID.										
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17 ID.										
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18 ID.										
Secs.										
19 ID.										
Secs.										

Vehicle Arrival/Identification Form

Minute	Vehicle Identification and Arrival Time (Seconds)									
20 ID.										
Secs.										
21 ID.										
Secs.										
22 ID.										
Secs.										
23 ID.										
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24 ID.										
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38 ID.										
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39 ID.										
Secs.										
40 ID.										
Secs.										
41 ID.										
Secs.										
42 ID.										
Secs.										

Minute		Vehicle Identification and Arrival Time (Seconds)									
43	ID.										
	Secs.										
44	ID.										
	Secs.										
45	ID.										
	Secs.										
46	ID.										
	Secs.										
47	ID.										
	Secs.										
48	ID.										
	Secs.										
49	ID.										
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50	ID.										
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56	ID.										
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57	ID.										
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58	ID.										
	Secs.										
59	ID.										
	Secs.										
00	ID.										
	Secs.										
01	ID.										
	Secs.										
02	ID.										
	Secs.										
03	ID.										
	Secs.										
04	ID.										
	Secs.										
05	ID.										
	Secs.										

Truck Bypass Form

Weigh Station Name:			Traffic Direction: (circle one) North South	
Observer Name:			Date:	Session Start Time:____________
Point One-Point Three Mainline Distance:____________________(ft.)				
Minute	**Number of Truck Bypasses**		**Minute**	**Number of Truck Bypasses**
0			30	
1			31	
2			32	
3			33	
4			34	
5			35	
6			36	
7			37	
8			38	
9			39	
10			40	
11			41	
12			42	
13			43	
14			44	
15			45	
16			46	
17			47	
18			48	
19			49	
20			50	
21			51	
22			52	
23			53	
24			54	
25			55	
26			56	
27			57	
28			58	
29			59	

Vehicle Approach Speed Form

Weigh Station Name:		Traffic Direction: (circle one) North South		
Observer Name:		Date:		Obs. Point: 1 2 3
Observation Time	**Approach Speed (mph)**		**Observation Time**	**Approach Speed (mph)**

Vehicle Approach Speed Form

Weigh Station Name:		Traffic Direction: (circle one) North South		
Observer Name:		Date:		Obs. Point: 1 2 3
Observation Time	**Approach Speed (mph)**		**Observation Time**	**Approach Speed (mph)**

Mainline Bypass Speed Form

Weigh Station Name:		Traffic Direction: (circle one) North South		
Observer Name:		Date:		
Observation Time	**Bypass Speed (mph)**		**Observation Time**	**Bypass Speed (mph)**

Mainline Bypass Speed Form

Weigh Station Name:		Traffic Direction: (circle one) North South		
Observer Name:		Date:		
Observation Time	**Bypass Speed (mph)**		**Observation Time**	**Bypass Speed (mph)**

Static Scale Service Time Form

Weigh Station Name:		Traffic Direction: (circle one) North South		
Observer Name:		Date:		
Observation Time	**Service Time (seconds)**		**Observation Time**	**Service Time (seconds)**

Static Scale Service Time Form

Weigh Station Name:		Traffic Direction: (circle one) North South		
Observer Name:		Date:		
Observation Time	**Service Time (seconds)**		**Observation Time**	**Service Time (seconds)**

APPENDIX V

1. Copies of Surveys Sent to State Agencies and Motor Carriers for the Jurisdictional Issues Evaluation

COPY OF MOTOR CARRIER SURVEY

I. One of the evaluation objectives of the Advantage I-75 Mainline Automated Clearance System (MACS) is to determine institutional or jurisdictional issues that may impact the development of implementing Intelligent Transportation Systems (ITS) technologies, specifically electronic screening.

II. To that end, we are examining two hypotheses:

A. The Advantage I-75 MACS Operational Test will provide motor carriers with sufficient information to support a decision whether or not to adopt MACS or an enhanced form of electronic clearance/verification system.

B. The motor carriers involved in the MACS project will establish new or enhanced relationships and/or methods for resolving institutional issues as a result of the operational test.

III. The purpose of this questionnaire is to address the following questions:

A. What, if any, jurisdictional or legal impediments did motor carriers encounter while implementing electronic clearance?

B. What were the causes of these impediments and how were they overcome?

C. What lessons were learned in dealing with these impediments that can be applied to other deployments of ITS products and services?

D. What are motor carriers' intentions for continuing Advantage I-75 or another enhanced form of electronic clearance/verification?

The information will be helpful in assessing potential preferences in future Intelligent Transportation Systems (ITS) projects.

Please take a few moments and complete the following survey. You can mail the completed survey form to: CTRE, Iowa State University, 2625 N. Loop DR. Suite 2100 Ames, Iowa 50010-8615, Attn: Dennis

Or you can fax your completed survey form to CTRE at 5 15-294-0467.

Thank you for your participation. If you have any questions or need assistance, please call Dennis Kroeger at 515-294-8103, or email: dennis@ctre.iastate.edu

Please answer the questions below.

1. When did your company first enroll in the Advantage I-75 Mainline Automated Clearance System (MACS) Project?____

2. Please explain the reasons why your company decided to participate in MACS.

3. Please describe the process used to reach the decision to participate in the MACS project. (For example, was the decision based upon improvement of service to customers, reducing business operating costs, etc.?)

4. Please indicate your company's satisfaction with the MACS process:
   1. Very Satisfied ______
   2. Somewhat Satisfied ______
   3. Satisfied ______
   4. Somewhat Dissatisfied ______
   5. Very Dissatisfied ______

5. Please indicate the reasons for your satisfaction or dissatisfaction with the MACS process:

6. Based upon your participation in the MACS Project, what lessons were learned in the test, that may be applied to other ITS projects?

7. Based upon your participation in the MACS Project, is there a fee you would feel comfortable paying for electronic screening?
   If so, how much?

COPY OF SURVEY SENT TO STATE AGENCY PARTICIPANTS

I. One of the purposes of the Mainline Automated Clearance Systems (MACS) is to determine institutional or jurisdictional issues that may impact the development of implementing Intelligent Transportation Systems (ITS) technology.

The hypotheses to be examined are:

- The Advantage I-75 MACS Operational Test will provide jurisdictions with sufficient information to support a decision whether or not to offer MACS or an enhanced for of electronic clearance/verification system in their jurisdiction.

- The jurisdictional agencies involved in the MACS project will establish new or enhance relationships and/or methods for resolving institutional issues as a result of the operational test.

The purpose of this questionnaire is to address four questions:*

1. What institutional and legal impediments did the MACS Project participants encounter while establishing partnerships and deploying MACS services and products?

2. Where in the life cycle of the operational test did these impediments occur?

3. What were the causes of these impediments and how were they overcome?

4. What lessons were learned in dealing with these impediments that can be applied to other deployments of ITS products and services?

---

[1] ***"Project Memorandum U. S. Department of Transportation, Research and Special Projects Administration, John A. Volpe National Transportation Systems Center, Cambridge, Massachusetts, IVHS Institutional Issues, Monitoring Program Framework"*** Page 2, by Allan J. Deblasio dated September 13, 1993.

1. Organizational issues can impact the MACS project. Of these types of issues listed below, please indicate which issues have emerged on this project. For those issues that are applicable, please rate each one on the degree of severity each has (or had) impacted the project within each phase of the project.

Degree of Issue Severity: (Please rank the issues accordingly) NA = Not Applicable 1 = Encountered but not Severe 2 = Slight, An Irritant 3 = Moderate, Hinders Progress 4 = Severe, Impedes Progress 5 = Critical, Could Stop the Project X = Did Not Impede But Facilitated Progress	**Program Phase**				
I. ORGANIZATIONAL	Planning	Design/ Development	Implementation/ Testing	Evaluation	Deployment
1. Intra-Agency Communication: To what degree do the communications within any of the partner organizations impede the achievement of program cost, schedule, or performance goals?					
2. Inter-Agency Communications To what degree do channels of communication across organizations impede the achievement of program cost, schedule, or performance goals?					
3. Public/Private Partnerships: To what degree do differences in business practices (i.e. organizational cultures) between public and private sectors impede the achievement of program cost, schedule, or performance goals?					
4. Definition of Goals, Roles and Responsibilities: To what degree does the clarity, or lack thereof in program goals or organizational roles and responsibilities impede the achievement program cost, schedule, or performance goals?					
5. Allocation of Responsibilities: To what degree does the allocation of responsibilities across program partners/participants (i.e. knowing who's in charge of what) impede the achievement of program cost, schedule, performance goals?					

6. Upper Management "Buy-In": To what degree does inconsistency in upper management buy-in impede the achievement of program cost, schedule, or performance goals?					

2. Regulatory and legal issues also, may have impacted the MACS project. Of these types of issues listed below, please indicate which issues have emerged on this project. For those issues that are applicable, please rate each one on the degree of severity each has (or had) impacted the project within each phase of the project.

Degree of Issue Severity: (Please rank the issues accordingly) NA = Not Applicable 1 = Encountered but not Severe 2 = Slight, An Irritant 3 = Moderate, Hinders Progress 4 = Severe, Impedes Progress 5 = Critical, Could Stop the Project X = Did Not Impede But Facilitated Progress	**Program Phase**				
II. REGULATION/LEGAL	Planning	Design/ Development	Implementation/ Testing	Evaluation	Deployment
1. Corporate Favoritism: To what degree do concerns that taxpayer funds are contributing to the competitive advantage of private sector parties impede the achievement of program cost, schedule, or performance goals?					
2. Authority: To what degree does local authority over arterial roads and state highways impede the achievement of program cost, schedule, or performance goals?					
3. Administrative Requirements: To what degree do administrative requirements (i.e., accounting, reporting, etc.) associated with the conduct of this ITS operational test impede the achievementof program cost, schedule, or performance goals?					
4. Standards and Protocols: To what degree does the demand for, or absence of a national architecture impede the achievement program cost, schedule, or performance goals?					

2. Organizational issues can impact the MACS project. Of these types of issues listed below, please indicate which issues have emerged on this project. For those issues that are applicable, please rate each one on the degree of severity each has (or had) impacted the project within each phase of the project.

Degree of Issue Severity: (Please rank the issues accordingly) NA = Not Applicable 1 = Encountered but not Severe 2 = Slight, An Irritant 3 = Moderate, Hinders Progress 4 = Severe, Impedes Progress 5 = Critical, Could Stop the Project X = Did Not Impede But Facilitated Progress	**Program Phase**				
III. HUMAN RESOURCES	Planning	Design/ Development	Implementation/ Testing	Evaluation	Deployment
1 Staff Size: To what degree does the availability of sufficient numbers of staff impede the achievement of program cost, schedule, or performance goals?					
2. Staff Expertise: To what degree has the availability of people with particular expertise (i.e., electrical, communications, systems, hardware, software, human factors, systems integration, federal contracting, etc.) impeded the achievement of program cost, schedule, or performance goals?					

4. Financial issues can also impact the MACS project. Of these types of issues listed below, please indicate which issues have emerged on this project. For those issues that are applicable, please rate each one on the degree of severity each has (or had) impacted the project within each phase of the project.

Degree of Issue Severity: (Please rank the issues accordingly) NA = Not Applicable 1 = Encountered but not Severe 2 = Slight, An Irritant 3 = Moderate, Hinders Progress 4 = Severe, Impedes Progress 5 = Critical, Could Stop the Project X = Did Not Impede But Facilitated Progress	**Program Phase**				
IV. FINANCIAL	Planning	Design/ Development	Implementation/ Testing	Evaluation	Deployment
1. National Priority: To what degree does the uncertainty regarding continued federal funding or public support of MACS impede the achievement of program cost, schedule, or performance goals?					
2. Market Uncertainty: To what degree does the uncertainty regarding motor carriers' willingness to pay for MACS impede the achievement of program cost, schedule, or performance goals?					
3. Cost Sharing: To what degree does the cost-sharing approach for MACS impede the achievement of program cost, schedule, or performance goals					
4. Technology Development: To what degree has the underestimation of technology-related cost, schedule, or performance goals impeded the program from attaining its goals?					
5. Program Cost: Are the program and project budgets sufficient? If not, to what degree are they insufficient?					

5. Other issues that may have impacted the MACS project. Of these types of issues listed below, please indicate which issues have emerged on this project. For those issues that are applicable, please rate each one on the degree of severity each has (or had) impacted the project within each phase of the project.

Degree of Issue Severity: (Please rank the issues accordingly) NA = Not Applicable 1 = Encountered but not Severe 2 = Slight, An Irritant 3 = Moderate, Hinders Progress 4 = Severe, Impedes Progress 5 = Critical, Could Stop the Project X = Did Not Impede But Facilitated Progress	**Program Phase**				
IV. FINANCIAL	Planning	Design/ Development	Implementation/ Testing	Evaluation	Deployment
1. Privacy Issues: To what degree have privacy issues and development of appropriate confidentiality safeguards been an impediment to achieving program cost, schedule, or performance goals?					
2. Environmental Concerns: To what degree have environmental concerns (i.e. reducing truck emissions, etc.) impeded the achievement of program cost, schedule, or performance goals?					
3. Transponder Issues: To what degree has the concern of how to issue and maintain transponders impeded the achievement of program cost, schedule, or performance goals?					
4. System Deployment: To what degree have the concerns of how administer the overall MACS, and how to operate and maintain the system impeded the achievement of program cost, schedule, or performance goals?					

Choose three *to five* (3 – 5) most severe issues (those issues that have had the most impact on MACS) from the previous tables and please answer the following questions (e.g. Issue III Human Resources, Staff Size):

6 (a) ISSUE #__: ______________________________

i) Among which institutions were these issues evident (e.g. DOT, State Dept. of Revenue, etc .)?

ii) What specifically was (were) the impacts/impediments/constraints?

iii) When in the project life cycle did each of these occur?

iv) How did the issue(s) affect the overall project?

v) Was each issue resolved? If so, how? If not, why not?

vi) Could each have been handled more efficiently/effectively? What advice would you give the members of a similar project in identifying and/or resolving these issues?

6 (b) ISSUE# : ______________________________

i) Among which institutions were these issues evident?

ii) What specifically was (were) the impacts/impediments/constraints?

iii) When in the project life cycle did each of these occur?

iv) How did the issue(s) affect the overall project?

v) Was each issue resolved? If so, how? If not, why not?

vi) Could each have been handled more efficiently/effectively? What advice would you give the members of a similar project in identifying and/or resolving these issues?

6 (c) ISSUE#__: ______________________________

i) Among which institutions were these issues evident?

ii) What specifically was (were) the impacts/impediments/constraints?

iii) When in the project life cycle did each of these occur?

iv) How did the issue(s) affect the overall project?

v) Was each issue resolved? If so, how? If not, why not?

vi) Could each have been handled more efficiently/effectively? What advice would you give the members of a similar project in identifying and/or resolving these issues?

6 (d) ISSUE # : ______________________________

i) Among which institutions were these issues evident?

ii) What specifically was (were) the impacts/impediments/constraints?

iii) When in the project life cycle did each of these occur?

iv) How did the issue(s) affect the overall project?

v) Was each issue resolved? If so, how? If not, why not?

vi) Could each have been handled more efficiently/effectively? What advice would you give the members of a similar project in identifying and/or resolving these issues?

6 (e) ISSUE# : ______________________________

i) Among which institutions were these issues evident?

ii) What specifically was (were) the impacts/impediments/constraints?

iii) When in the project life cycle did each of these occur?

iv) How did the issue(s) affect the overall project?

v) Was each issue resolved? If so, how? If not, why not?

vi) Could each have been handled more efficiently/effectively? What advice would you give the members of a similar project in identifying and/or resolving these issues?

7. What do you consider to be the most important measures of success of the MACS project? (How do you know that it has succeeded or met its goals?)

7 (a). In your opinion, is the program *a* success? If so, what are its positive contributions?

7 (b). Knowing what you know now, how would you have done your job differently if you had to do it over from the beginning?

7 (c). Knowing what you know now, if you were assigned to be the project manager in charge of all resources, how would you have the project manager's job differently if you had to it from the beginning? Why?

8. It is possible that several points of contact within your organization eventually became involved during the course of participation in the MACS project. For the benefit of others contemplating starting an ITS operational test, please list the names of such offices or organizations that have been active participants in one phase or another:

Of the institution types listed in the following table, please list the most actively participating organization:

8 (a) What degree of involvement does the most active participant within each category have or will have in your part of the MACS operational test phase and deployment, respectively? The operational test phase includes planning, design, development, integration, bench and field testing, and evaluation. The deployment phase assumes that the operational field test has been successful and a commitment has been made to commercially market a product.

8 (b) Which of the institutions listed in the following table have or will be in your critical path to successfully completing the MACS project's operational test and deployment phases, respectively? An organization is in your organization's critical path if the project could not be successful without it being involved.

8. INSTITUTION TYPE		8 (a): TO WHAT DEGREE INVOLVED IN PROJECT? NA = No Involvement 3 = Moderate 1 = Slight 4 = Active 2 = Minimal 5 = Intense		8 (b): WHICH ARE IN YOUR CRITICAL PATH? (Check all that apply)	
General	Specify Most Active Participant	Test	Deployment	Test	Deployment
US DOT					
State DOT					
Law Enforcement Agencies					
Department of Motor Vehicles					
Public Service Commission					
Private Sector					
Universities					
Bridge/Tunnel Authorities					
Port Authorities					
MPO'S					
Transit Agencies					
Regional Agencies					
Counties/Cities					
Environmental Agencies					

9. Have we missed any other issues or concerns that were not covered that you would like to include? (Feel free to use additional paper if necessary.)

APPENDIX VI

1. Copies of Detailed Test Plans used in the Evaluation of the Advantage CVO Mainline Automated Clearance System (MACS)

PROVING GROUND FOR ADVANCED TECHNOLOGY

U.S. Department of Transportation

Advantage I-75 Mainline Automated Clearance System

Detailed Evaluation Plan Part Two: Motor Carrier Fuel Consumption Individual Evaluation Test Plan

Prepared for
The Advantage I-7.5 Evaluation Task Force

Submitted to
The Kentucky Transportation Center

Prepared by the
Center for Transportation Research and Education
Iowa State University Research Park
2625 N. Loop Drive, Suite 2100
Ames, Iowa 50010-8615

Principle investigator:
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May 10, 1996

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Research and Education

CTRE is an Iowa State University center.

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U.S. Department of Transportation

Advantage 1-75 Mainline Automated Clearance System

Detailed Evaluation Plan Part Three: Weigh Station Individual Evaluation Test Plan

Prepared for
The Advantage I-7.5 Evaluation Task force

Submitted to
The Kentucky Transportation Center

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May 10, 1996

Center for Transportation
Research and Education

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PROVING GROUND FOR ADVANCED TECHNOLOGY

Advantage l-75 Mainline Automated Clearance System

Detailed Evaluation Plan Part Four: Jurisdictional Issues Individual Evaluation Test Plan

Prepared for
The Advantage 1-75 Evaluation Task Force

Submitted to
The Kentucky Transportation Center

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ADVANTAGE 75
PROVING GROUND FOR ADVANCED TECHNOLOGY

U.S. Department
of Transportation

Advantage I-75 Mainline Automated Clearance System

Detailed Evaluation Plan Part Five: System Individual Evaluation Test Plan

Prepared for
The Advantage I-75 Evaluation Task Force

Submitted to
The Kentucky Transportation Center

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