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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INTRODUCTION

This test plan describes the methodologies that will be used to evaluate the Advantage I-75 Mainline Automated Clearance System (MACS) to determine whether the system satisfies the goals specified in the Functional Requirements Document (FRD).[1] The purpose of this test plan is to compare the performance of the as-built MACS system during the two-year operational test to the performance levels specified in the FRD. The system evaluation is a cooperative effort including the evaluation team at the Center for Transportation Research and Education (CTRE) and the operations and support staff at the Kentucky Transportation Center (KTC).

The central research questions that will be addressed in this evaluation are :

- Does the system work as specified?
- How well does the system work in meeting the needs of the stakeholders?

Document Structure

This individual evaluation plan has been prepared in accordance with the Intelligent Vehicle Highway Systems Operational Test Evaluation Guidelines and consists of two component plans. The first component plan describes the system evaluation from the nationwide perspective of electronic clearance. The evaluation activities presented in the first component focus on assessing the functional integrity and customer service delivery of the MACS system. The second component plan describes the system evaluation from the perspective of the I-75 corridor and partner states. The evaluation activities presented in the second component focus on system performance validation, special observations, and case studies and surveys. Each component test consists of three major sections that provide a test description, test schedule, and test budget.[2] This document makes numerous references to the *Description of the Advantage I-75 MACS System*, prepared by KTC, included in Appendix 1 of this document.

OVERALL TEST RESPONSIBILITY

Acting in the capacity of independent evaluator, CTRE staff will oversee the KTC system evaluation activities and analyze the data gathered by KTC. Specific responsibilities are provided below.

KTC is responsible for the following duties:

- Prepare the System Evaluation Test Plan
- Perform the tests and collect the data

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[1] *Functional Requirements Document.* Prepared for the Kentucky Transportation Cabinet. Prepared by Science Applications International Corporation. March 8, 1996.

[2] *Intelligent vehicle Highway Systems Operational Test Evaluation Guidelines.* Submitted to the Federal Highway Administration. Prepared by the Mitre Corp. November, 1993.

CTRE is responsible for the following duties:

- Collaborate with KTC in preparing the System Evaluation Test Plan
- Assist KTC in performing data collection
- Conduct the analysis
- Prepare a written report summarizing the findings

NATIONWIDE ISSUES FOR ELECTRONIC CLEARANCE

This component of the MACS system evaluation is organized around three primary data collection efforts to determine if the system is working and to assess how well it is working. These activities are shown below and further described in the following paragraphs.

- Functional integrity of the system
- Random examination of the transaction database
- Customer verification of service delivery

Functional Integrity of the System

The first evaluation activity consists of documenting the operating status of each of the system and subsystem components during the MACS operational test. As part of normal operation procedures, weigh station personnel routinely determine if the system is functioning as detailed in the *Description of the Advantage I-75 MACS System*, provided in Appendix 1.

For example, in order for the process of electronic clearance to occur, certain system components must be functioning properly. First, for the tag of any approaching vehicle to be read, the Advance AVI reader must be on and pass a "system-ready" status check. Second, the reader must have a current enrolled vehicle list to make the electronic clearance decision. Third, the Advance AVI antenna must be capable of transmitting the electronic clearance information and driver notification to the tag of the approaching vehicle. Finally, the communications link between the Advance AVI reader and the weigh station host computer must be functioning normally.

Weigh station personnel determine whether the system is ready via a combination of diagnostic programs and system status verification checks. When the system is not functioning properly, weigh station personnel notify the MACS operations center or other designated agency to remedy the problem. Written or verbal reports that document these problems will be used to assess the functional integrity of the system during the test. The KTC operations staff will prepare and collect reports detailing system integrity problems encountered by weigh station personnel and forward them to the CTRE evaluation team for analysis and review. The result of this activity will be a summary report detailing the percentage of time that each MACS system component was operational, and the nature and extent of the system defects or problems that were encountered.

Additional checks of system integrity will be routinely conducted from the MACS operations center. On a daily basis, the Advantage Operations Center staff will run a program that checks the status of the X.25 communication network and the AVI readers at each Advantage I-75 weigh station. This program sends a signal from the operations center computer to each site over the communications network. If the site receives the signal and is able to return a signal to the operations center, then the ready status of the communication network is verified. In addition to the communications network signal, each Advantage I-75 weigh station also verifies the status of each of the AVI readers at that site. This information, for all 29 sites, is then stored in a file at one of the operations center's computers. As part of the system evaluation, these files will be examined to assess the functional integrity of the system.

Examination of Transaction Database

The second system evaluation activity consists of examining the database of tagged-truck transactions that is routinely generated as each transponder-equipped truck encounters MACS AVI system components. Essentially, the electronic clearance of any MACS-equipped vehicle that approaches a weigh station depends on the successful performance of a number of processes or transactions. For example, the electronic clearance process that occurs at the Advance AVI reader consists of:

- Read the tag of the approaching vehicle
- Correlate weigh-in-motion scale data (at those stations with mainline WIMs) to the appropriate vehicle
- Make the electronic clearance decision based on the specified weight and credential criteria
- Write electronic clearance information to the tag of that same approaching vehicle
- Activate the driver notification device
- Communicate the electronic clearance information to the weigh station host computer

The FRD specifies that the AVI subsystem will correctly process 99.99 percent of the tagged vehicles encountered at each AVI reader. One method of determining whether the system processed 99.99 percent of tagged vehicles properly would be to examine the complete transaction database for the two-year operational test. The examination would reveal those transactions that were either incomplete or errant. It will not be possible to address errors due to missed trucks or phantom trucks (e.g., transponder reads when no vehicle was present) since these errors will leave no evidence of having occurred.

The size of this database prohibits a complete transaction-level examination. The database for the remainder of the operational test will likely consist of approximately 2,800,000 transactions, assuming:

- 5,000 transponder-equipped vehicles
- Three Advantage I-75 corridor trips per week for each transponder-equipped vehicle
- Each corridor trip encounters 2.3 weigh stations
- Nineteen remaining months of the operational test (June 1, 1996–December 31, 1996)

A sample of the transaction database will be obtained. This will be accomplished through a combination of scheduled and random samples.

The amount of transaction level data that we collect will be determined by considering the type of analysis planned. In this case, the null hypothesis is that each subsystem works as advertised (with probability of a successful read .9999). If the evaluation goal is to detect significant under performance (e.g., the system works with accuracy .98) then a relatively small sample may suffice. If the evaluation goal is to detect even mild under performance than a large sample will be required. To illustrate our approach, Table One describes the amount of under performance that we would be almost certain to detect for different sample sizes. The table also describes the number of failures that would be considered sufficient evidence to reject the null hypothesis. The number of failures required to reject the null increases because some failures are acceptable under the specifications. At the present time, CTRE has not specified a specific alternative and therefore no sample size is determined.

Table One: Sample Size Required to Reject the Null Hypothesis of 99.99 Percent System Accuracy

Sample Size	Number of Failures to Reject 99.99 Percent System Accuracy	Alternative We Would Be Confident of Detecting
100	1	0.9600
200	1	0.9800
1,000	2	0.9950
10,000	4	0.9990
100,000	18	0.9997

This portion of the system evaluation is based on using data recorded stored in the host and gateway computers during a vehicle transaction. According to the Functional Requirements Document, complete records of each tagged vehicle transaction for the entire two-year operational test will be recorded and forwarded to the Gateway computer. Each transaction, known as a "trip data packet," includes such data as:[3]

- Vehicle identification
- Weigh station location
- Arrival and departure time information
- Scale related data including
  - » Axle weight
  - » Axle spacing
  - » Gross weight and
  - » Length

[3] *Functional Requirements Document.* Prepared for the Kentucky Transportation Cabinet. Prepared by Science Applications International Corporation. March 8, 1996. pp. 56–63.

This transaction-level data will be sampled as necessary to reveal those transactions with obvious errors or incomplete records. Primary data collection will be done by the KTC. Data will also be collected by CTRE on a random basis to identify the system accuracy and validate the data collected by KTC. CTRE will establish remote access to both the host and gateway computers to conduct data collection. System accuracy observations will be forwarded to KTC following each data collection session conducted by CTRE. Initially, it is anticipated that CTRE will conduct data collection sessions once a week.

Customer Verification of Service Delivery

The third evaluation activity consists of a cooperative effort between the CTRE evaluation team, KTC operations staff and participating motor carriers. Information about the number of tagged-vehicle visits to the weigh stations on the corridor and the dispensation of the vehicle at each station will be gathered and shared with motor carriers. This will allow for the diagnosis of problems in the system affecting user satisfaction. Such reports will, for example, pinpoint trucks that are never electronically cleared because of a malfunctioning transponder. This same methodology is currently used by many fleet fueling services and motor carriers to verify daily, weekly, or monthly fuel purchases or cash advances made while on the road. The fuel card or cash advance provider sends the carrier a statement for all fuel purchases or cash advances to the motor carrier each business day. The carrier then remits payment for all purchases or cash advances. Using this system, a carrier can review and verify any or all of the fuel purchases on a daily statement and request correction or clarification of any that are questioned.

As part of the evaluation, report forms that provide the unit number, time, and location of electronic clearance will be developed and sent on daily, weekly, or monthly intervals to MACS-participant carriers for verification. An example of a daily customer verification report is provided in Figure One.

Figure One: Daily Customer Verification Report

Memo to : Participant motor carrier (enter appropriate name)
From : MACS Operations Center

For the 24 hour period beginning at 12:00:00 am and ending at 11:59:59 pm on _____ (enter appropriate date), the following vehicles from your fleet were encountered at Advantage I-75 corridor weigh stations.

Unit Number	Location	Time	Status	Verified
762	Scott, KY northbound	01:12:33	Bypassed	_____
762	Wood, OH northbound	05:21:15	Bypassed	_____
187	Monroe, GA southbound	07:44:19	Pull-in	_____
187	Lowndes, GA southbound	10:56:23	Bypassed	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

We are asking you to examine your records and verify whether the information shown in the abo report is accurate. For each of the above records, please place a check for those vehicles accurat reported and circle those records reported in error. Also please use the blank lines of the form to note the unit number, time, and location for those vehicles in your fleet that may have been omit from this report.

After you have verified the above information and/or added any omitted records, please return th

These reports would be sent to a weighted random sample (i.e., carriers with a greater population of tagged vehicles would have a greater probability of being sampled) of the participant motor carrier population periodically. The reports would be return-addressed to expedite completion of the survey. Individuals would be given instructions to return the form by return mail or fax.

Summary reports would also be developed and sent to participant carriers. These summary reports would provide the number of vehicles that were encountered and the processing scenario (bypassed or pulled in) at MACS weigh stations for a given reporting period (e.g., one week or one month). Similar to the Daily Customer Verification Report, individuals would be asked to verify that the information shown on the report was accurate.

Hypotheses to be Tested

The following hypotheses will be tested in the system evaluation.

- **Hypothesis One** : The functional integrity of the system will be sufficient to routine electronic clearance.
- **Hypothesis Two** : The AVI subsystem will correctly process 9,950 out of 10,000 of vehicles encountered.
- **Hypothesis Three** : The electronic clearance services delivered to MACS partici will meet customer expectations.

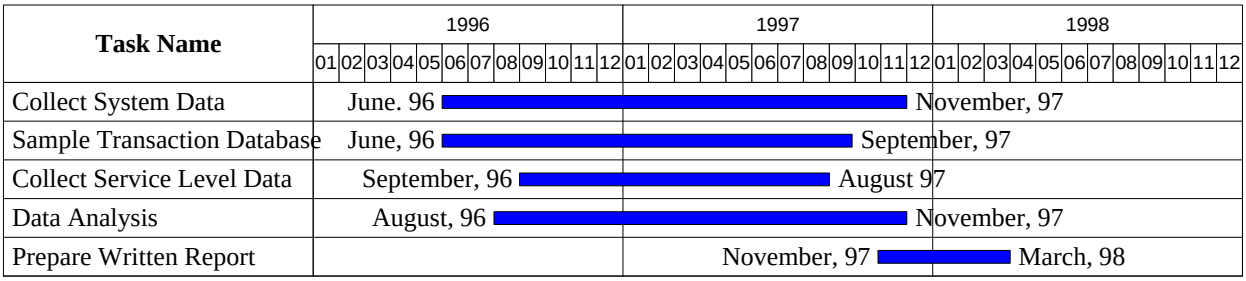
Test Schedule

The test is scheduled to begin June 1, 1996 and will be completed at the end of the operational test period. An overview of the major test activities is provided below.

- Data Collection: June 1, 1996–November 1, 1997
- Data Analysis: August 1, 1996–November 1, 1997
- Final Report Preparation: November 1, 1997–March 31, 1998

A Gantt Chart illustrating the above schedule is shown in Figure Two.

Figure Two: System Evaluation Test Schedule



Budget

The budget for conducting the national perspective portion of the system evaluation plan is provided in Table Two. This budget provides two separate expense subtotals (e.g., personnel and equipment and travel). The total project budget for this plan is the sum of the personnel and equipment subtotals and the Iowa State University indirect cost. The project term begins on June 1, 1996 and runs through March 31, 1998. The budget has been reviewed and approved, as shown in Exhibit A of the letter of transmittal, by the Director of the Center for Transportation Research and Education and the Contracts and Grants Officer for Iowa State University.

Table Two: Plan Budget

Personnel Budget		Time (Hrs)	Rate/ Hour	Budget
Faculty				
Tom Maze		30	$55.94	$1,678
Hal Stern		173	$35.47	$6,147
Professional and Scientific				
Jim York		173	$19.87	$3,443
Bill McCall		390	$38.20	$14,898
Marcia Brink		12	$16.51	$198
Jan Graham		75	$18.69	$1,570
Merit Staff				
Dianne Love		97	$14.44	$1,570
Secretary		102	$13.74	$1,570
Research Students				
Iowa State University Student		130	$14.64	$1,903
Post Doctorial Research Associate				
Dr. Ali Kamyab		0	$20.19	$0
Fringe Benefits				
Faculty Fringe @24.55%			24.55%	$1,921
Professional and Scientific Fringe @30.8%			30.80%	$6,194
Merit Fringe @ 39.45%			39.45%	$1,239
Research Student Fringe @$625/year			$0.00	$0
Post Doctorial Fringe Benefits			16.14%	$0
Total Personnel Budget				***$42,331***
Supplies				$250
Phone, postage, and communications equipment rent				$450
Subcontracts				$0
Additional Domestic Travel	Cost per Trip		$1,460.00	$2,920
Total Equipment and Travel Budget				***$3,620***
Subtotal Project Budget				$45,951
Indirect Cost @25%				$11,488
Total Project Budget				**$57,439**

ADVANTAGE I-75 CORRIDOR ISSUES FOR ELECTRONIC CLEARANCE

work in progress by the Kentucky Transportation Center

Performance Validation

work in progress by the Kentucky Transportation Center

Special Observations

work in progress by the Kentucky Transportation Center

Case Studies and Surveys

work in progress by the Kentucky Transportation Center

Hypothesis to be Tested

work in progress by the Kentucky Transportation Center

Test Schedule

work in progress by the Kentucky Transportation Center

Budget

work in progress by the Kentucky Transportation Center

APPENDIX

Appendix 1: Description of Advantage I-75 MACS System

The following paragraphs provide a detailed description of each of the MACS subsystem components.

Description Of The Advance AVI Reader Subsystem

Components of the subsystem:

- Advance AVI Reader
- Mainline WIM (optional)
- Truck (Transponder)
- Weigh Station Host Computer

Every weigh station included in the Advantage I-75 program will have an Advance AVI Reader along the mainline (i.e. on the shoulder of the Interstate) at a location approximately one quarter mile to one half mile prior to the weigh station entrance ramp. Some of these locations will also include a mainline weigh-in-motion (WIM) scale interfaced to the Advanced AVI Reader. If the mainline WIM is present, it provides the Advance AVI Reader vehicle gross weight, classification, axle weight and axle spacing data. Date and time are also provided in the message from the Mainline WIM, and a set date and time message is provided for synchronizing the time between the AVI Reader and the scale. The content and format of the vehicle data is presented in Appendix 2. This mainline WIM-derived vehicle data is not transmitted to the Advance AVI Reader until the vehicle has exited the last element of the mainline WIM and the vehicle classification calculations are complete.

The Advance AVI Reader automatically reads data from a truck's tag as an I-75 enrolled vehicle enters the field of the RF antenna at the Advance Reader location. The data read from the tag includes the following:

- Tag number — A unique serial number identifying the tag.
- Agency data- — Corridor and carrier/vehicle identifying information.
- Date- — Date that tag was last written.
- Time- — Time that tag was last written.
- Location- — Code identifying the weigh station where the tag was last written.
- Weight- — Gross weight previously recorded in the tag.
- Scale quality- — Code indicating quality of scale from which weight was obtained.
- Bridge formula flag- — Indication that the bridge formula was computed and passed.
- Axle weights- — Weight of each axle obtained at time gross weight was written to the tag.
- Axle spacings- — Distances between axles obtained at the time gross weight was written to the tag.
- Violation flag- — Indication of unauthorized bypass at prior weigh station.

Upon receipt of all the tag data (Appendix 2), the Advance Reader determines whether each vehicle should bypass or pull-in to the station. The arithmetic and logical computations undertaken can be found in Appendix 2.

Regardless of the results of the above decision process, if the weigh station is closed the vehicle will always be given clearance to bypass. Date, time, location, and scale data (if available and of greater or equal quality to the data in the tag) should be acquired and written to the tag by the Advance AVI Reader at a closed weigh station. This will facilitate clearance to bypass a subsequent weigh station. The violation flag, if set, will not be cleared at a closed weigh station. Before the vehicle exits the Advance AVI Reader's antenna field, the AVI tag is written with the following information:

- Date- Current date.
- Time- Current time.
- Location- Code identifying this weigh station.
- Weight- If mainline WIM is available (and scale quality is equal or superior to weight previously recorded in the tag).
- Scale quality- Code indicating weight from mainline WIM if weight data is replaced.
- Bridge formula flag- Indication that the bridge formula was computed and passed using the mainline WIM data. (Written only if weight is replaced.)
- Axle weights- Weight of each axle.
- Axle spacings- Distances between axles.
- Violation flag- This flag indicates that unauthorized bypass is cleared if the station is open.
- Bypass/pull in-Decision by Advance AVI Reader. This data controls driver communications.
- Pull-in reason code- A code indicating the reason that the vehicle was selected for pull-in.

Driver notification is performed by illumination of either the red (pull-in) or green (bypass) LED on the Driver Communications Device along with unique audible signals for each. The audible and visual indication is driven by the writing of either a bypass or pull-in status to the bypass/pull-in code on the tag. The indication is present for a short time (15 seconds) and then is extinguished.

The Advance Reader then communicates tag, WIM (when present) and status data to the weigh station host computer.

The messages sent from the Advance Reader are:

a) Trip data packet for vehicle passing the reader.
b) Response to vehicle data from enrolled vehicle list request.
c) Response to configuration data request.
d) Response to status request.
e) Unsolicited status.
f) Response to read message string request.

The weigh station host computer is responsible for downloading configuration data and enrolled vehicle list to the Advance AVI Reader. The weigh station host is also responsible for periodically synchronizing date and time with the Advance AVI Reader. In addition, the weigh station sends a trip data packet to downstream weigh stations.

Description Of The Compliance AVI Reader Subsystem

Components of the subsystem:

- Compliance AVI Reader
- Mainline Classifier
- Truck (Transponder)
- Weigh Station Host Computer

The next subsystem of the MACS that the vehicle encounters (if it bypasses the weigh station) is the Compliance AVI Reader subsystem. The purpose of the Compliance AVI Reader is to detect unauthorized trucks bypassing the weigh station on the mainline, issue an alarm to the weigh station operator and report passage of tagged and untagged vehicles to the weigh station host computer.

The Compliance AVI Reader automatically reads data from the tag as the I-75 enrolled vehicle enters the field of the RF antenna at the Compliance AVI Reader location. The data read from the tag includes the following:

- Tag number- A unique serial number identifying the tag.
- Agency data- Corridor and carrier/vehicle identifying information.
- Date- Date that tag was last written.
- Time- Time that tag was last written.
- Location- Code identifying the weigh station where the tag was last written.
- Weight- Gross weight previously recorded in the tag.
- Scale quality- Code indicating quality of scale from which weight was obtained.
- Bridge formula flag- Indication that the bridge formula was computed and passed.
- Axle weights- Weight of each axle obtained at time gross weight was written to the tag.
- Axle spacings- Distances between axles obtained at the time gross weight was written to the tag.
- Violation flag- Indication of unauthorized bypass at prior weigh station.
- Bypass/pull-in- Decision by advance reader.
- Pull-in reason code- A code indicating the reason that the vehicle was selected for pull-in.

The Compliance AVI Reader must rely on its truck detector (mainline classifier) in the mainline roadbed to identify the passage of a candidate commercial vehicle among all vehicles passing the station. The Compliance AVI Reader must then attempt to correlate the candidate commercial vehicle with an Advantage I-75 tag read. At an open weigh station, the candidate vehicle is not a violator only if it has

an AVI tag written at the Advance AVI Reader of the corresponding station with a bypass clearance code. Before the vehicle exits the Compliance AVI Reader's antenna field, the AVI tag is written with the following information:

- Date- Current date.
- Time- Current time.
- Location- Code identifying this weigh station.
- Bypass/pull-in- Cleared by compliance AVI reader.
- Violation flag- Indication of unauthorized bypass at this weigh station.

In the event that an unauthorized bypass occurs, a contact closure output provided by the Compliance AVI Reader will be used to alert the weigh station personnel. The Compliance AVI Reader will notify the driver of a participating truck by setting a violation status in the tag which will turn on the red LED for 15 minutes to facilitate enforcement.

The Compliance AVI Reader communicates tag, violation and status data to the weigh station host computer. The Compliance AVI Reader sends the trip data packet containing the information from the AVI tag of a single passing tagged AVI vehicle or a trip data packet without vehicle data for a non tagged vehicle as soon as the vehicle is processed. The weigh station host computer is responsible for downloading configuration data to the Compliance AVI Reader, and it is also responsible for periodically synchronizing date and time with the Compliance AVI Reader.

The messages sent from the Compliance AVI Reader are:

a) Trip data packet for vehicle passing the reader.
b) Response to configuration data request.
c) Response to status request.
d) Unsolicited status.
e) Response to read message string request.

Description Of The Ramp Sorter AVI Reader Subsystem

Components of the subsystem:

- Entrance Ramp WIM Scale
- Ramp Sorter AVI Reader
- Truck (Transponder)
- Weigh Station Host Computer

Some weigh station configurations along the Advantage I-75 corridor use a weigh-in-motion (WIM) scale sorter on the entrance ramp to direct vehicles whose weight, height or speed limits are exceeded to the stations' scales while directing all others to a bypass lane. These ramp WIM's will be interfaced to Ramp Sorter AVI Readers to identify the vehicles, receive weight data from the sorter WIM and write scale data to the tag as appropriate (but not communicate with the driver).

The ramp WIM is typically composed of a scale element surrounded by vehicle sensors (loops) and axle sensors. The ramp WIM derived data is not transmitted to the Ramp Sorter AVI Reader until the vehicle has exited the last element of the ramp WIM and vehicle classification calculations have been completed. It is at this time, when the cab of the vehicle (AVI tag) is well beyond the WIM location, that the Ramp Sorter AVI Reader will receive the serial transmission of the WIM data packet. The content and format of the vehicle data can be found in Appendix 2.

The Ramp Sorter AVI Reader automatically reads data from the tag as the I-75 enrolled vehicle enters the field of the RF antenna at the ramp sorter reader location. The data read from the tag contains the following:

- Tag number- A unique serial number identifying the tag.
- Agency data- Corridor and carrier/vehicle identifying information.
- Date- Date that tag was last written.
- Time- Time that tag was last written.
- Location- Code identifying the weigh station where the tag was last written.
- Weight- Gross weight previously recorded in the tag.
- Scale quality- Code indicating quality of scale from which weight was obtained.
- Bridge formula flag- Indication that the bridge formula was computed and passed.
- Axle weights- Weight of each axle obtained at time gross weight was written to the tag.
- Axle spacings- Distances between axles obtained at the time gross weight was written to the tag.
- Violation flag- Indication of unauthorized by pass at prior weigh station.

The computations required to determine the bypass/pull-in decision for each tagged vehicle reaching the Ramp Sorter AVI Reader are as follows:

a) If tag is not an I-75 tag, skip further processing.
b) Correlate sorter WIM data with tagged vehicle.
c) Locate the tagged vehicles record in the list of enrolled vehicles permitted to operate in this state. Extract valid credentials flag, operator pull in flag, and registered weight from the record. Set the status to pull-in if no record found for this vehicle and also set the pill-in reason code to “credentials.”
d) Check the violation flag and set status to pull-in if violation is set, and also set the pull-in reason code to “violation.”
e) Check the pull-in reason code from the tag. If the reason is other than “need weight” or “weight violation,” set the status to pull-in.
f) Compare weight against vehicle’s registered weight. Set the status to pull-in if the registered weight limit is exceeded and also set the pull-in reason code to “weight violation.”

g) Check the operator pull-in flag for the tagged vehicle. Set the status to pull-in if the operator pull-in flag is set for the tagged vehicle and also set the pull-in reason code to "operator."

h) If the status has not been set to pull-in for the tagged vehicle, set the status to bypass and clear any reason code.

i) Compare scale quality code in the tag with the configuration data scale quality. If the scale quality code in the tag is less than or equal to the configuration data scale quality code, replace the weights and scale quality code in the tag with weights obtained from the Ramp Sorter WIM and the configuration data scale quality code.

The bypass decision as computed by the AVI reader may conflict with the decision of the sorter indicated on variable message signs. Driver notification via transponder is therefore not used at the ramp sorter and the driver follows the sorter signage. Before the vehicle exits the Ramp Sorter AVI Reader's antenna field, the AVI tag is written with the data needed by other AVI readers that the vehicle will encounter on the trip. Before the vehicle exits the Ramp Sorter AVI Reader's antenna field, the AVI tag is written with the following information:

- Date- Current date.
- Time- Current time.
- Location- Code identifying this weigh station.
- Bypass/pull-in-As determined by the Ramp Sorter AVI reader.
- Weight- Written only if Ramp Sorter WIM scale quality is equal or superior to weight previously recorded in the tag.
- Scale type- Code indicating weight from sorter WIM if weight data is replaced.
- Bridge formula flag- Indication that the bridge formula was computed and passed using the sorter WIM data. Written only if weight data is replaced.
- Axle weights- Weight of each axle. Written only if weight data is replaced.
- Axle spacings- Distances between axles. Written only if weight data is replaced.

The Ramp Sorter AVI Reader communicates tag, WIM and status data to the weigh station host computer. The weigh station host computer is responsible for downloading configuration data and enrolled vehicle list to the Ramp Sorter AVI Reader, and is also responsible for periodically synchronizing date and time with the Ramp Sorter AVI Reader. The messages and protocol between the weigh station host computer and the Ramp Sorter AVI Reader are similar to the communications with the Advanced AVI Reader.

Description Of The Optional Slow Roll-Over WIM S AVI Reader

Components of the subsystem:

- Optional Slow Roll-Over WIM Scale AVI Reader (at station house) or
- Optional Static Scale AVI Reader (at station house)
- Truck (Transponder)

- Weigh Station Host Computer

The Functional Requirements Document (FRD) refers to an Optional Slow Roll-Over WIM Scale AVI Reader and an Optional Static Scale AVI Reader. Only one participating state, Florida, considered using one of these configurations, but subsequently decided against it. Therefore, these configurations will probably not exist during the remainder of the alpha test and the subsequent operational test, and thus will not be evaluated unless they are actually installed during these tests.

Description Of The Exit AVI Reader Subsystem

Components of the subsystem:

- Exit AVI Reader
- Truck (Transponder)
- Weigh Station Host Computer

All trucks leaving a weigh station pass an Exit AVI Reader. The Exit AVI Reader automatically reads data from the tag as an I-75 enrolled vehicle enters the field of the RF antenna prior to exiting the weigh station to return to the mainline. The data read from the tag includes the following:

- Tag number- A unique serial number identifying the tag.
- Agency data- Corridor and carrier/vehicle identifying information.
- Date- Date that tag was last written.
- Time- Time that tag was last written.
- Location- Code identifying the weigh station where the tag was last written.
- Weight- Gross weight previously recorded in the tag.
- Scale quality- Code indicating quality of scale from which weight was obtained.
- Bridge formula flag- Indication that the bridge formula was computed and passed.
- Axle weights- Weight of each axle obtained at time gross weight was written to the tag.
- Axle spacings- Distances between axles obtained at the time gross weight was written to the tag.
- Violation flag- Indication of unauthorized by pass at prior weigh station.
- Bypass/pull-in-Decision by advance reader.
- Pull-in reason code- A code indicating the reason that the vehicle was selected for pull-in.

In addition, scale data can be communicated to the Exit AVI Reader from the weigh station host computer with the correlated vehicle tag number included in the message. The Exit AVI Reader is responsible for seeing that superior weight data is written to the AVI tag of the proper vehicle. Unlike the Advance AVI Reader or the Ramp Sorter AVI Reader, the Exit AVI Reader receives any weight data in communications from the weigh station host computer (as opposed to a WIM scale). The logical computations that guide the processing at the Exit AVI Reader are as follows:

a) If tag is not an I-75 tag, skip further processing.
b) Locate the tagged vehicle's record in the list of correlated tag numbers and weights downloaded from the weigh station host. If the vehicle is not found, go to step g.
c) Write date, time, and location code to the tag.
d) If the scale quality code in the tag is less than or equal to the configuration item scale quality, write the weights to the tag and update the scale quality code in the tag.
e) Remove the record from the list of correlated tag numbers and weights.
f) Go to step j.
g) If the weigh station is closed, go to j.
h) Write date, time, and location code to tag.
i) If the scale quality code in the tag is less than or equal to the configuration item scale quality, write the jurisdictional gross weight to the tag and set the minimum scale quality code in the tag.
j) Build trip data packet and send to host.

The Exit AVI Reader communicates tag, status and weight data to the weigh station host computer. The weigh station host computer is responsible for downloading configuration data to the Exit AVI Reader. If an optional scale interface on either of these scale AVI Readers exists, the weigh station computer also sends correlated tag number and weight data to the Exit AVI Reader. The weigh station also is responsible for periodically synchronizing date and time with the Exit AVI Reader.

The messages sent from the Exit AVI Reader are:

a) Trip data packet for vehicle passing the reader.
b) Response to configuration data request.
c) Response to status request.
d) Response to read message string request.

Description Of The Weigh Station Host Computer
Components of the subsystem:

- Weigh Station Host Computer (DEC 486)
- 17" Monitor
- Printer
- DSU and X.25 Lines
- Modem and Phone Line

The weigh station host computer (WSHC) provides the weigh station operator with information on trucks approaching, entering and passing the weigh station. The weigh station operator is given advanced notice of probable preclearances and allowed to override the computer's decision.

The WSHC is responsible for initialization and data maintenance of the AVI subsystems, and communication with other weigh stations and the Gateway Computer. This interaction between the

WSHC and the other components is depicted graphically in Figure 8 (Appendix 2) and is discussed in the paragraphs that follow.

Advance AVI Reader The Advance AVI Reader communicates tag, WIM and statu weigh station host computer. The weigh station host computer is responsible for downloading configuration data and updated enrolled vehicle lists to the Advance AVI Reader. The weigh station computer is also responsible for periodically synchronizing date and time with the Advance AVI Reader.

The messages sent from the WSHC are:

a) Clear enrolled vehicle list.
b) Add or replace vehicle data in enrolled vehicle list.
c) Delete vehicle from enrolled vehicle list.
d) Request vehicle data from enrolled vehicle list.
e) Download configuration data.
f) Request configuration data.
g) Request status of reader and associated scale.
h) Set date and time.
i) Set message string for transmit to in-vehicle device over RS232 port.
j) Read message string received from in-vehicle list.

The trip data packets received from the Advance AVI Reader are the notice to the weigh station operator that an enrolled vehicle has entered the vicinity of the weigh station with either permission to by-pass or direction to pull in. These packets can be sent to the WSHC for enrolled and non-enrolled vehicles for statistics gathering purposes where a mainline WIM is installed.

The WSHC receiving the trip data packet processes it as follows:

a) Calculate statistics based on data received from the Advance AVI Reader.
b) Discard trip data packets for non-enrolled vehicles.
c) Add the vehicle's trip packet to the active vehicle list.
d) Remove the trip packet from the enroute vehicle list.
e) Update the active vehicle list on the operator's CRT screen. Show vehicle ID, weight and pull-in/bypass status. Highlight vehicles that are in violation and show the reason. Also highlight differently those vehicles that have been cleared to bypass.

Compliance AVI Reade r The Compliance AVI Reader communicates tag, violat to the WSHC. The WSHC is responsible for downloading configuration data to the Compliance AVI Reader. The WSHC is also responsible for periodically synchronizing date and time with the Compliance AVI Reader.

The messages sent from the WSHC are:

a) Download configuration data.
b) Request configuration data.
c) Request status of reader and associated classifier.
d) Set date and time.
e) Set message string for transmit to in-vehicle device over RS232 port.
f) Read message string received from in-vehicle device.

The trip data packets received from the Compliance AVI Reader provide data for statistics on unauthorized bypasses. Unauthorized bypasses by enrolled vehicles will automatically trigger the Compliance Reader to extract information on the violating vehicle and print it out to aid in enforcement. Packets can be sent to the weigh station host computer for both enrolled and non-enrolled vehicles for statistics gathering purposes.

The WSHC receiving the trip data packet processes it as follows:

a) If an enrolled vehicle is in violation for unauthorized bypass, display and highlight details of the truck to the operator (i.e. carrier, make, model, color, license number etc.).
b) Calculate statistics based on data received from the Compliance AVI Reader.
c) Discard trip data packets for non-enrolled vehicles.
d) Copy the trip data packet of an enrolled vehicle to the outgoing communications buffer.
e) Copy the trip data packet of an enrolled vehicle to the vehicle history list.

Ramp Sorter AVI Reader The Ramp Sorter AVI Reader communicates tag, v data to the WSHC. The WSHC is responsible for downloading configuration data to the Ramp Sorter AVI Reader and for periodically synchronizing date and time with the Ramp Sorter AVI Reader.

The messages sent from the WSHC are:

a) Clear enrolled vehicle list.
b) Add or replace vehicle data in enrolled vehicle list.
c) Delete vehicle from enrolled vehicle list.
d) Request vehicle data from enrolled vehicle list.
e) Download configuration data.
f) Request configuration data.
g) Request status of reader and associated scale.
h) Set data & time.
i) Set message string for transmit to in-vehicle device over RS232 port.
j) Read message string received from in-vehicle device.

Trip data packets received from the Ramp Sorter AVI Reader provide updated weight and bypass status of vehicles that were directed into the weigh station by the Advance AVI Reader. Packets may

include both enrolled and non-enrolled vehicles for statistics gathering purposes as controlled by the AVI configuration file.

The WSHC receiving the data packet processes it as follows:

a) Calculate statistics based on data received from the Ramp Sorter AVI Reader.
b) Discard trip data packets for non-enrolled vehicles.
c) Update the active vehicle list on the operator's CRT screen. Display updated weight from the Ramp Sorter AVI Reader. Highlight vehicles that are being directed to the scales and show the reason.

Exit AVI Reader The Exit AVI Reader communicates tag, violation and status data to The WSHC is responsible for downloading configuration data to the Exit AVI Reader and for periodically synchronizing date and time with the Exit AVI Reader.

The messages sent from the WSHC are:

a) Download configuration data.
b) Request configuration data.
c) Download correlated tag id and weight data.
d) Request status of reader and associated classifier.
e) Set date and time.
f) Set message string for transmit to in-vehicle device over RS232 port.
g) Read message string received from in-vehicle device.

Trip data packets received from the Exit AVI Reader notify the weigh station host computer that the enrolled vehicle has left the vicinity of the weigh station. Packets are only received for tagged vehicles since there is no facility for detection of vehicles without tags.

The WSHC receiving the data packet processes it as follows:

a) Calculate statistics on data received from the Exit AVI Reader.
b) Discard trip data packets for non-enrolled vehicles.
c) Copy the trip data packets to the outgoing communications buffer.
d) Copy the vehicle's data to the vehicle history list.
e) Delete the vehicle's trip data packet from the active vehicle list.

Description Of The Gateway Computer Subsystem

Components of the subsystem:

- Sun SPARC station 20 Model 71

- External mass storage SCSI device
- 20” SVGA Color Monitor
- Hayes compatible modem (external - 9600 bps minimum)
- Parallel printer
- Smart UPS 900 VA 120 V with RS-232 9 pin female connector
- Sun SPARCstation 20 Model 50
- External mass storage SCSI device
- 17” SVGA Color Monitor
- Hayes compatible modem (external - 9600 bps minimum)
- Parallel printer
- Smart UPS 900 VA 120 V with RS-232 9 pin female connector
- Solaris UNIX operating system

The gateway computer’s primary roles are:

- Carrier enrollment maintenance and distribution
- Corridor time synchronization
- Collection and maintenance of system statistics

The “Gateway” computer subsystem actually consists of two computer systems. The main “gateway” computer (the first six component bullets and UNIX) performs the functions listed above. In addition, a second computer system, referred to as the “Operations Computer” (the second six bullets and UNIX), serves as the primary source of access to gateway computer information by all outside parties and for the day-to-day work of Operations Center personnel.

The connection between the weigh station host and gateway computers is supplied over the X.25 network running a virtual Internet address schema above it. Networking SQL products will be used to provide the machine to machine query and record transfer capability. A generic file transfer utility will be supported, such as FTP, for non-SQL file transfers. The gateway computer periodically updates the weigh station’s authorized vehicle sub-list and archives operational and systems information from the weigh stations.

Statistics collection and report generation are the two functions that will be used the most by the Operations Center management and staff. One can refer to pages 95-96 for further enumeration of the specific statistics gathered and reports that can be generated.

Appendix 2: MACS System Diagrams

Figure 2. A Representative Weigh Station Layout

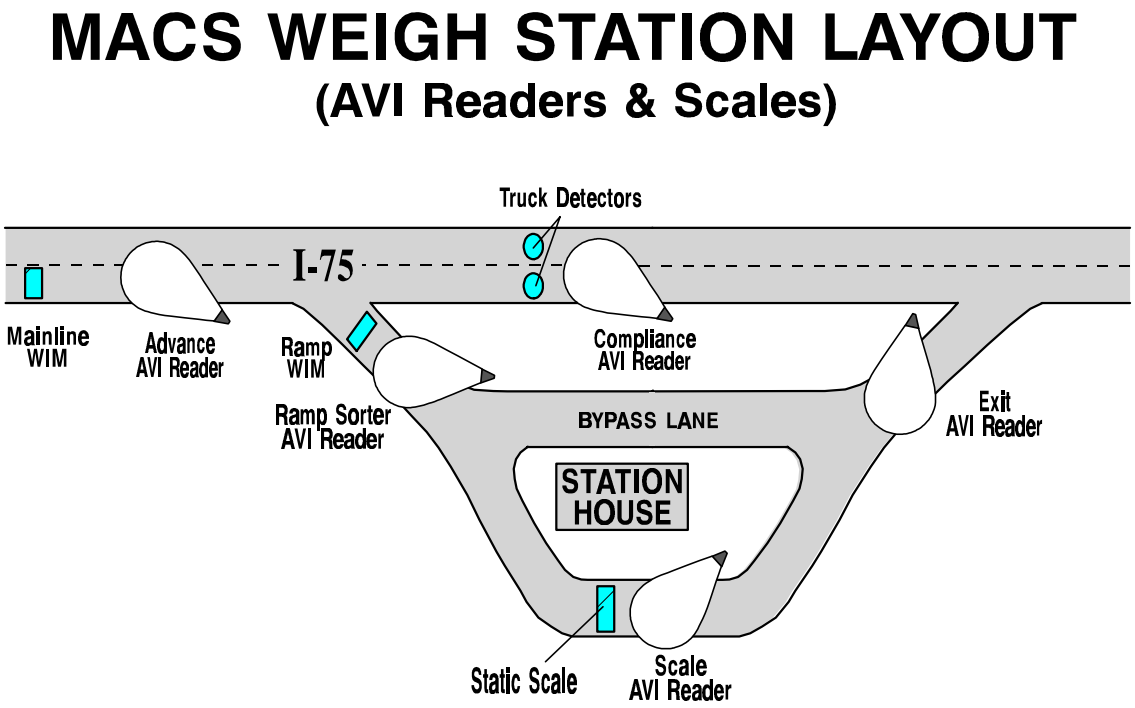


Figure 3. MACS System Diagram

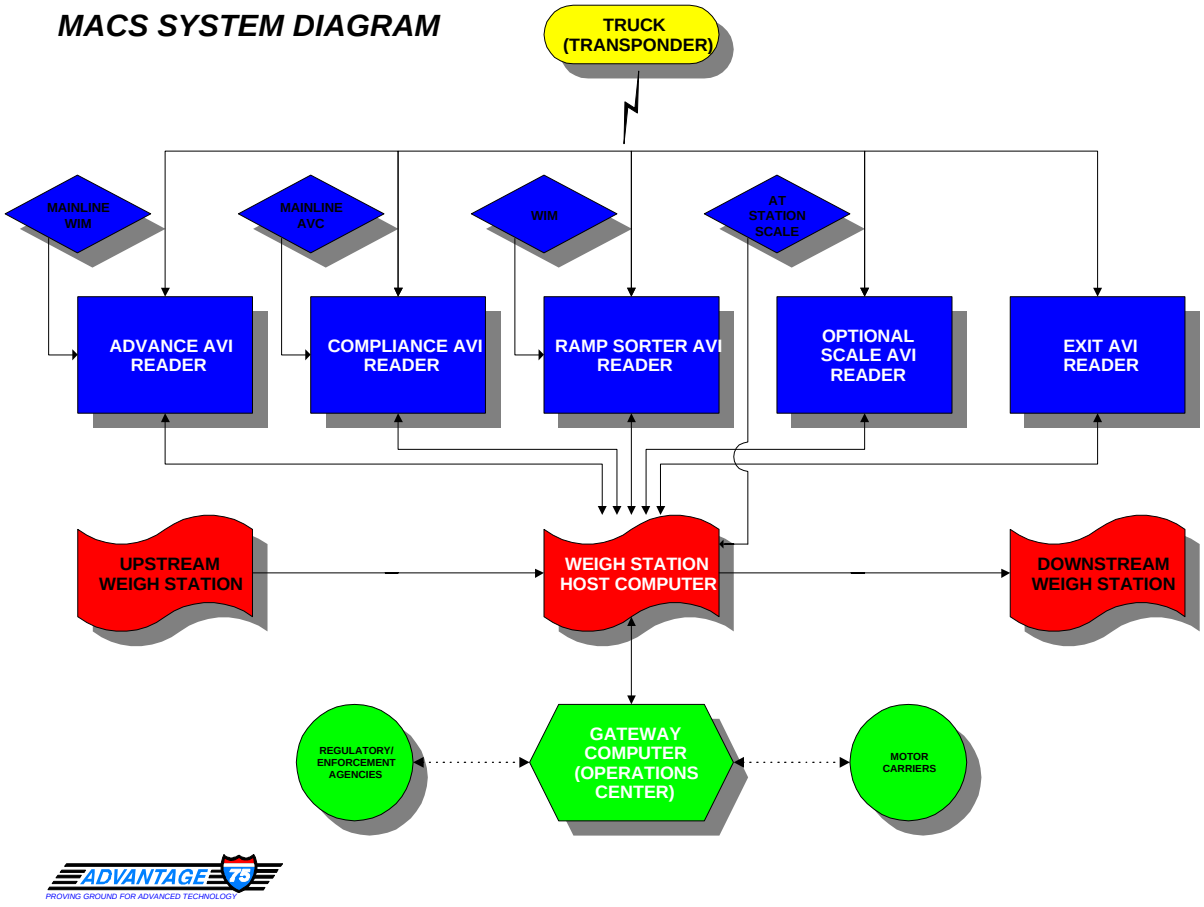


Figure 4. Advance AVI Reader Subsystem Reader Subsystem

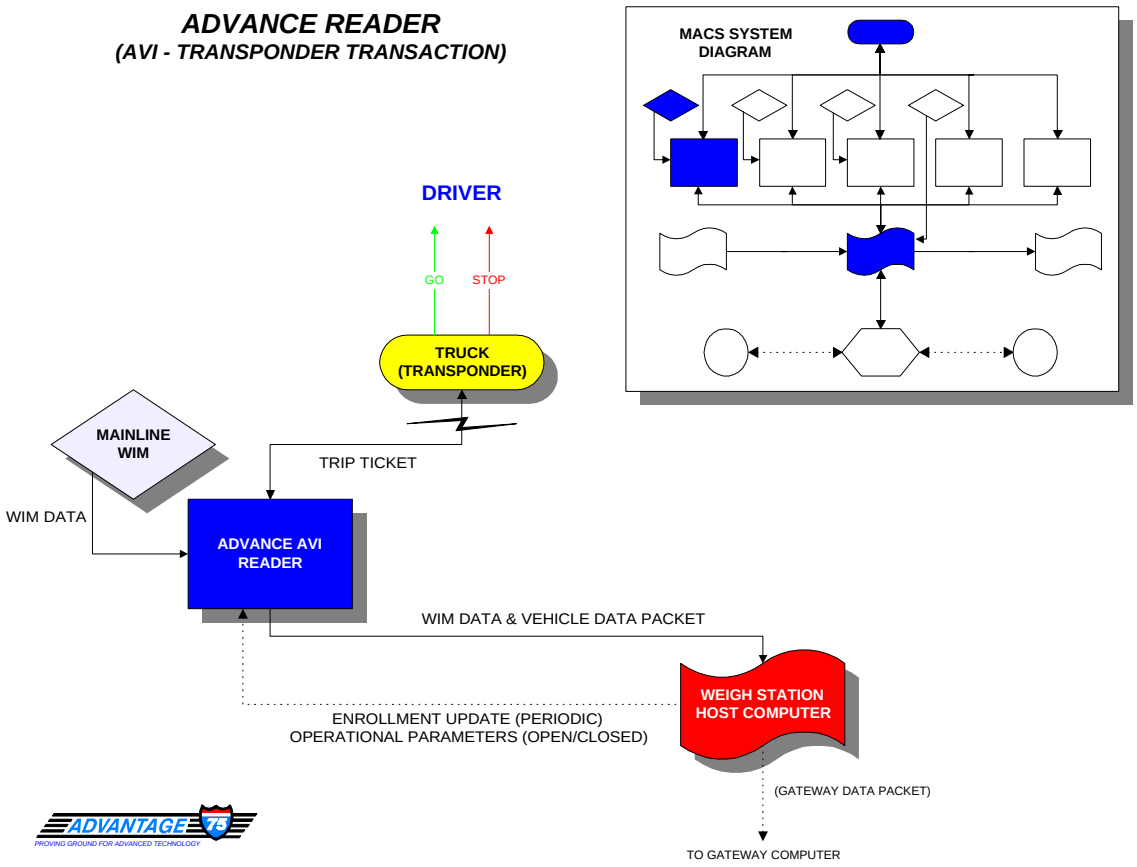


Figure 5. Compliance AVI Reader Subsystem

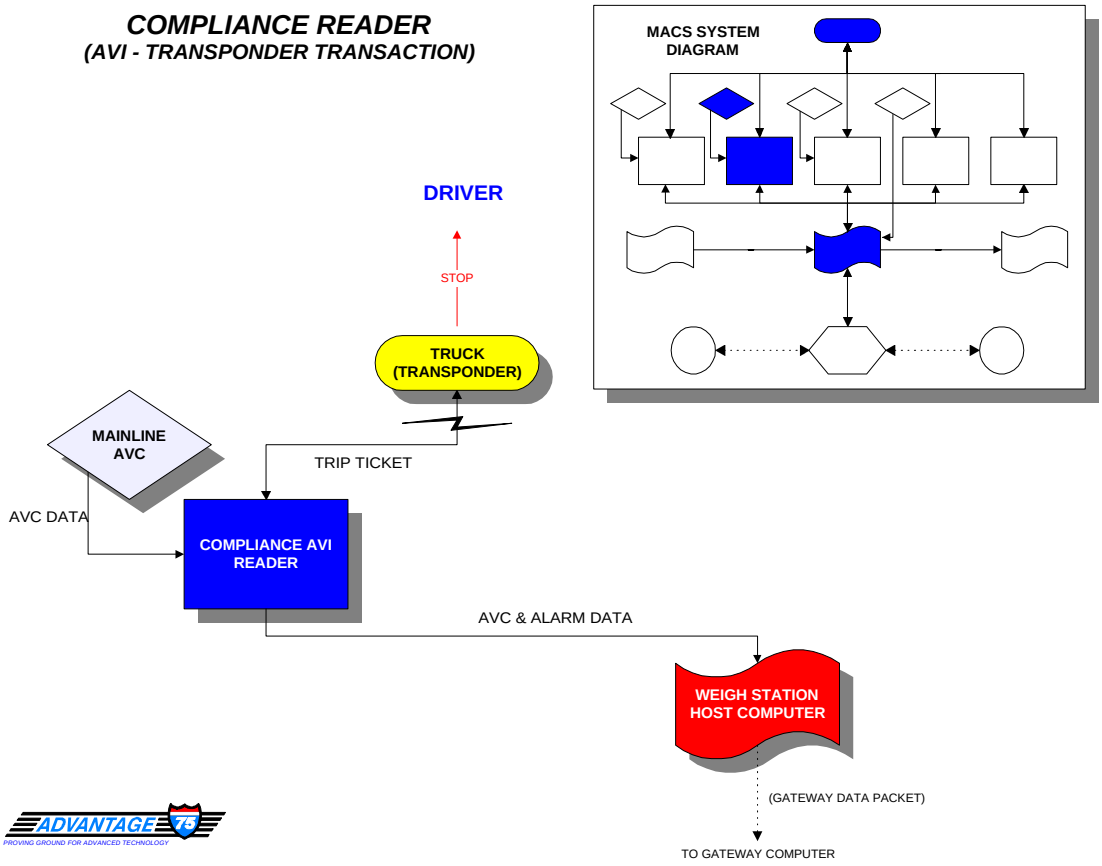


Figure 6. Ramp Sorter Reader Subsystem

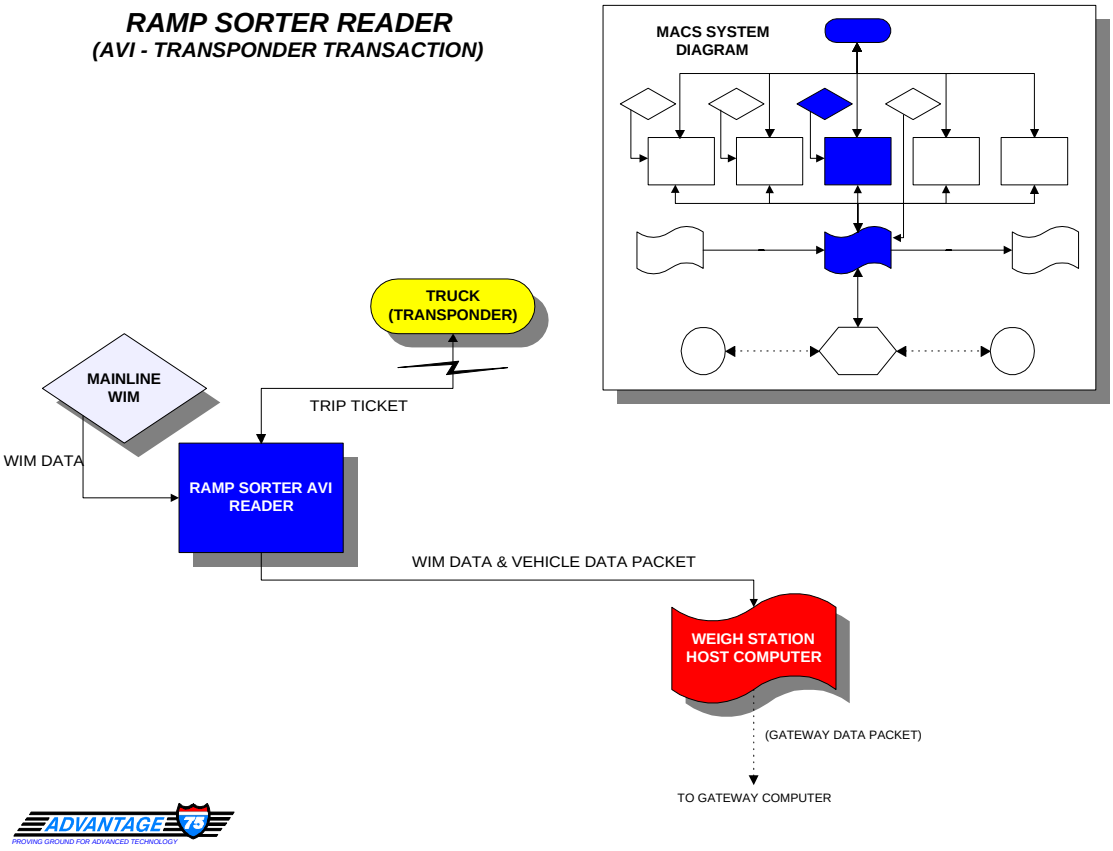


Figure 7. Optional Slow Roll-Over Scale or Static Scale

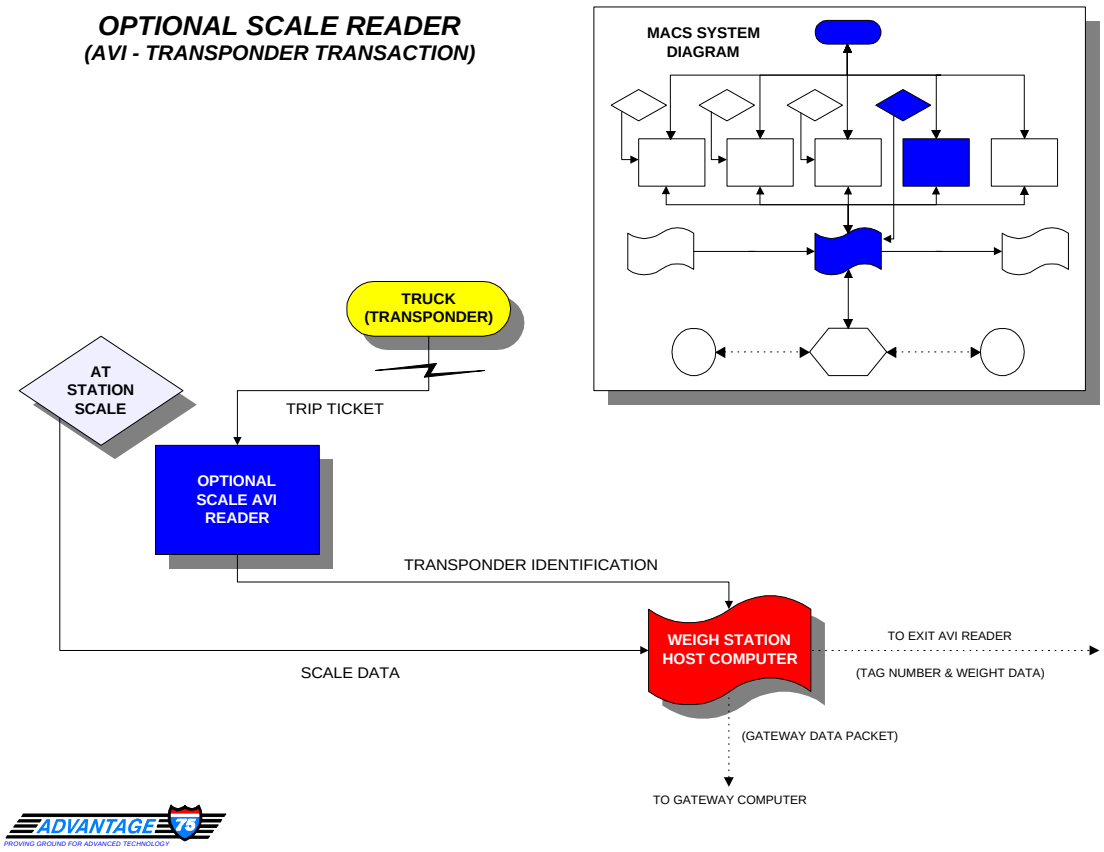


Figure 8. Exit AVI Reader Subsystem

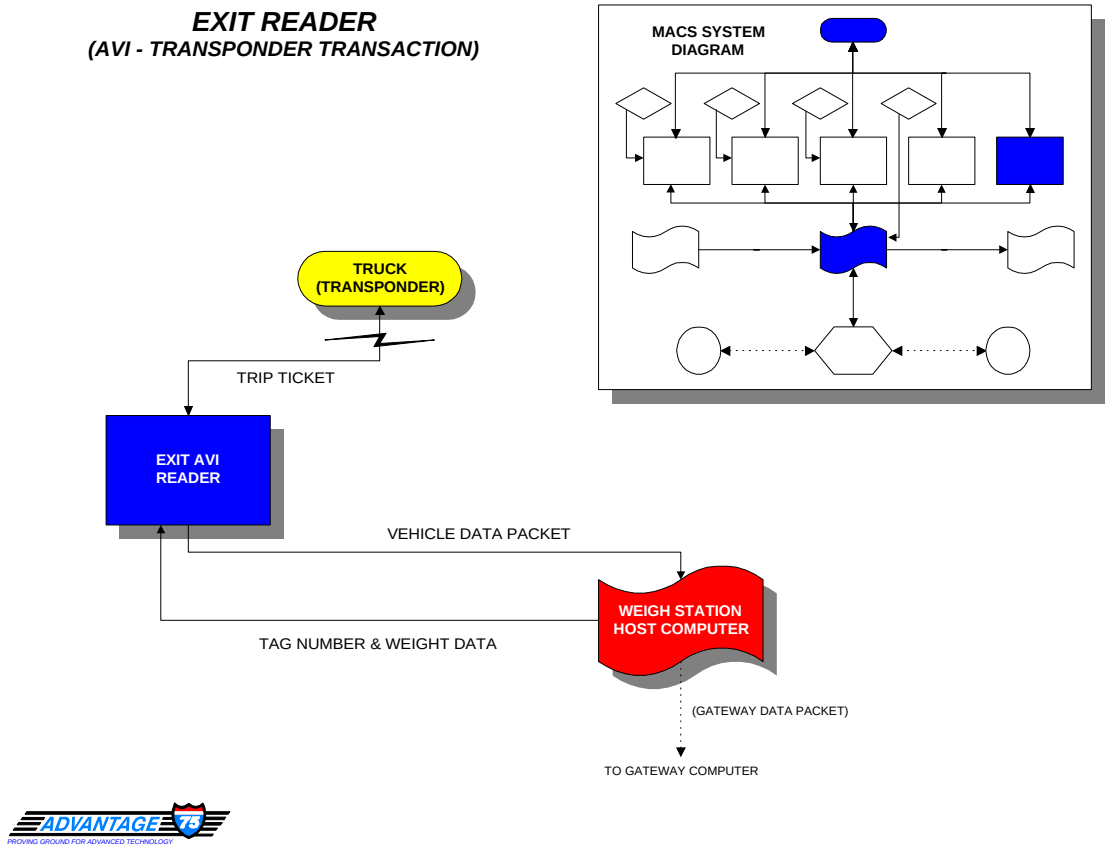


Figure 9. Weigh Station Transactions