Florida Department of Transportation

RON DESANTIS
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

KEVIN J. THIBAULT, P.E.
SECRETARY

August 8, 2019

Khoa Nguyen
Director, Office of Technical Services
Federal Highway Administration
3500 Financial Plaza, Suite 400
Tallahassee, Florida 32312

Re: State Specifications Office
Section: **995**
Proposed Specification: **9950000 Traffic Control Signal and Device Materials.**

Dear Mr. Nguyen:

We are submitting, for your approval, two copies of the above referenced Supplemental Specification.

The changes are proposed by Derek Vollmer of the State Traffic Engineering Research Lab (TERL) to create a new Section. Material requirements for vehicle detection systems were deleted from Section 660 and added in this new Section 995. Also included language for wrong way vehicle detection system.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to stefanie.maxwell@dot.state.fl.us.

If you have any questions relating to this specification change, please call me at 414-4140.

Sincerely,

Signature on file

Stefanie D. Maxwell, P.E.
Manager, Program Management Office

SM/dt
Attachment
cc: Florida Transportation Builders' Assoc.
State Construction Engineer

TRAFFIC CONTROL SIGNAL AND DEVICE MATERIALS.
(REV 5-20-196-20-196-27-198-2-19)

The following new Section is added after Section 994:

SECTION 995
TRAFFIC CONTROL SIGNAL AND DEVICE MATERIALS

995-1 Description.
This Section governs the requirements for all permanent traffic control signals and devices.

995-2 Vehicle Detection Systems.
995-2.1 General: ~~Vehicle detection systems shall meet the following requirements:~~
~~**995-2.1.1 Approved Products List (APL);**~~ All vehicle detection systems shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.
~~**995-2.1.2 Mechanical Requirements for all Detectors:**~~ All equipment shall be permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number. All parts shall be constructed of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal and all fasteners exposed to the elements are Type 304 or 316 passivated stainless steel.
~~**995-2.1.3 Environmental Requirements for all Detectors:**~~ Detectors shall meet the environmental requirements of NEMA TS-2-2016.
995-2.2 Inductive Loop Detector Units: Rack mount inductive loop detector units shall meet the requirements of NEMA TS-2-2016. Shelf mount detector units shall meet the requirements of NEMA TS-1-1989.
995-2.3 Video Vehicle Detection System (VVDS).
995-2.3.1 Configuration and Management: The VVDS shall be provided with software that allows local and remote configuration and monitoring. The system shall be capable of displaying detection zones and detection activations overlaid on live video inputs. The VVDS shall meet the following criteria:

1. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.
2. Retains its programming in nonvolatile memory. The detection system configuration data shall be capable of being saved to a computer and restored from a saved file. All communication addresses shall be user programmable.
3. Offers an open Application Programming Interface (API) and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.3.2 Detection Camera: Camera shall be ~~furnished or~~ approved by the video detection system manufacturer and listed with the detection system on the APL.
995-2.3.3 Machine Vision Processor: The VVDS shall include a machine vision processor that allows video analysis, presence detection, data collection, and interfaces for inputs and outputs as well as storage and reporting of collected vehicle detection data.

995-2.3.4 Communications: The VVDS shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. Serial interface and connectors shall conform to Telecommunications Industry Association (TIA)-232 standards. Ensure that the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).
2. Wired Ethernet interfaces shall provide a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.
3. Wireless communications shall be secure and wireless devices shall be Federal Communications Commission (FCC) certified. The FCC identification number shall be displayed on an external label and all detection system devices shall operate within their FCC frequency allocation.
4. Cellular communications devices shall be compatible with the cellular carrier used by the agency responsible for system operation and maintenance.
5. The system shall be configured and monitored via one or more communications interface.

995-2.3.5 Video Inputs and Outputs: Analog video inputs and outputs shall utilize BNC connectors.

995-2.3.6 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2016, 6.5.2.26.

995-2.3.7 Electrical Requirements: The system shall operate using a nominal input voltage of 120 V of alternating current (V_{AC}) and with an input voltage ranging from 89 to 135 V_{AC}. If a system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

995-2.4 Microwave Vehicle Detection System (MVDS): Sidefire MVDS sensors shall have a minimum 200 foot range and the capability to detect a minimum of 8 lanes of traffic.

995-2.4.1 Configuration and Management: The MVDS shall be provided with software that allows local and remote configuration and monitoring. The system software shall be capable of displaying detection zones and detection activations in a graphical format. The MVDS shall meet the following criteria:

1. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.
2. Retains its programming in nonvolatile memory. Ensure that the detection system configuration data can be saved to a computer and restored from a saved file. Ensure that all communication addresses are user programmable.
3. Detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.4.2 Communications: Major components of the detection system (such as the sensor and any separate hardware used for contact closures) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria:

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provide a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

995-2.4.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2016, 6.5.2.26.

995-2.4.4 Electrical Requirements: The microwave detector shall operate with a nominal input voltage of 12 V_{DC} and with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

The detector shall be FCC certified and has been granted authorization to operate within a frequency range established and approved by the FCC. The FCC identification number shall be displayed on an external label.

995-2.5 Wireless Magnetometer Detection System (WMDS):

995-2.5.1 Configuration and Management: The detection system shall be provided with software that allows local and remote configuration and monitoring and shall meet the following criteria.

1. Allows a user to edit previously defined configuration parameters.

2. Retains its programming in nonvolatile memory and the detection system configuration data can be saved to a computer and restored from a saved file. All communication addresses shall be user programmable.

3. The detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.5.2 Communications: Components of the detection system (such as sensors, access points, and contact closure cards) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provide a 10/100 Base TX connection and all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.

4. Cellular communications devices are e-compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

995-2.5.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2016, 6.5.2.26.

995-2.5.4 Electrical Requirements: The WDMS shall operate with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

995-2.6 Automatic Vehicle Identification (AVI):

995-2.6.1 Configuration and Management: The detection system shall be provided with software that allows local and remote configuration and monitoring.

995-2.6.2 Communications: Components of the detection system (such as sensors, controllers, and processing hardware) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provide a 10/100 Base TX connection and all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

995-2.6.3 Probe Data Detector Requirements:

1. Transponder Readers shall be compatible with multiple tag protocols, including Allegro and the protocol defined in ISO18000-6B.

2. Bluetooth Readers shall be capable of operating using either solar power or AC power.

3. License Plate Readers shall not require the use of visible strobes or other visible supplemental lighting.

995-2.6.4 Electrical Requirements: The AVI shall operate with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied. For solar powered devices, the detection system must operate for 5 days without solar assistance.

995-2.7 Wrong Way Vehicle Detection Systems (WWVDS):

995-2.7.1 Configuration and Management: The WWVDS shall be provided with software that allows local and remote configuration and monitoring. That the system shall have the capability to display detection zones and detection activations. The WWVDS shall meet the following criteria:

1. WWVDS controllers shall support either an on-board real-time clock/calendar with on-board battery backup, or the controller's internal time clock can be configured to synchronize to a time server using the network time protocol (NTP) in order to maintain the current local date/time information. For NTP, the synchronization frequency must be user configurable and permit polling intervals from once per minute to once per week in one-

minute increments. For NTP, the controller must allow the user to define the NTP server by internet protocol (IP) address.

2. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.

3. Retains its programming in nonvolatile memory. The detection system configuration data shall be capable of being saved to a computer and restored from a saved file. All communication addresses shall be user programmable.

4. Offers an open Application Programming Interface (API) or software development kit available to the Department at no cost for integration with third party software and systems.

995-2.7.2 Communications: Major components of the WWVDS (such as the sensor and any separate hardware used for contact closures) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria:

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provides, at a minimum, a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all WWVDS devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

6. The WWVDS is compatible with the Department's SunGuide® software at the time of installation. For WWVDS installed on ramps, the device shall send an alert and a sequence of images for up to ten seconds to the SunGuide® software that covers a configurable time before and after the wrong-way vehicle detection.

995-2.8 Vehicle Presence Detection System Performance Requirements: Presence detectors shall provide a minimum detection accuracy of 98% and shall meet the requirements for modes of operation in NEMA TS2-2016, 6.5.2.17.

995-2.8.1 Vehicle Presence Detection Accuracy: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the vehicle detection system will be compared against ground truth data collected during the same time by human observation or by another method approved by the FDOT Traffic Engineering Research Laboratory (TERL). Ensure sample data is collected over several time periods under a variety of traffic conditions. Weight each data sample to represent the predominant conditions over the course of a 24-hour period. Samples will consist of 15- and 30-minute data sets collected at various times of the day. Representative data periods and their assigned weights are provided in Table 995-1.

Table 995-1
Data Collection Periods

Period	Intended To Represent	Duration	Weight

Early morning (predawn) [EM]	12:30 a.m. – 6:30 a.m.	15 minutes	24
Dawn [DA]	6:30 a.m. – 7:00 a.m.	30 minutes	2
AM Peak [AMP]	7:00 a.m. – 8:00 a.m.	15 minutes	4
Late AM Off-Peak [LAOP]	8:00 a.m. – 12:00 p.m.	15 minutes	16
Noon [NO]	12:00 p.m. – 1:00 p.m.	15 minutes	4
Afternoon Off-Peak [AOP]	1:00 p.m. – 5:00 p.m.	15 minutes	16
PM Peak [PMP]	5:00 p.m. – 6:00 p.m.	15 minutes	4
Dusk [DU]	6:00 p.m. - 6:30 p.m.	30 minutes	2
Night [NI]	6:30 p.m. - 12:30 a.m.	15 minutes	24
Total Sum of Weights			96

For example, the sample gathered for the Late AM Off-Peak period is intended to represent typical traffic conditions between 8:00 a.m. and 12:00 p.m. Since the sample period's duration is 15 minutes and the actual period of time represented is 4 hours, the multiplication factor or weight assigned is 16, the number of 15-minute intervals in a 4 hour period.

995-2.8.2 Calculation of Vehicle Presence Detection Accuracy: Determine individual lane presence detection accuracy per period by subtracting from 100 percent the absolute difference of the total time monitored and the cumulative error time, divided by total time, expressed as a percentage.

In the equation in 995-2.8.2.1, "EM" represents the early morning period. The variable "i" represents a detector or detection zone and could vary from 1,…, N, where "N" is the total number of detectors observed. Substitute other detector numbers and periods as necessary to determine accuracy for all detectors during each period (i.e., dawn, AM peak, late AM off peak, etc.).

Variables used in the following equations are identified as follows:

PA = Presence detection accuracy

TT = Total time

CET = Cumulative Error Time (duration of all false and missed calls)

N=Total number of detectors observed

995-2.8.2.1 Early Morning Vehicle Presence Detection Accuracy for a Single Detector Expressed as a Percentage:

$$PA_{EM,\det_i} = 100 - \frac{\left|TT_{EM,\det_i} - CET_{EM,\det_i}\right|}{TT_{EM,\det_i}} x100$$

where:

$PA_{EM,\det_i}$ = Presence detection accuracy of detector *i* during the early morning period.

$TT_{EM,\det_i}$ = Total time that detector *i* was monitored (for instance, the 15-minute minimum duration specified in Table 995-1 for the early morning period).

$CET_{EM,\det_i}$ = Cumulative time that detector *i* was in an error state (indicating a detection with no vehicle present or not indicating a detection when vehicle present) during the monitoring period using human observation or another method approved by the Engineer.

The period accuracy will be the arithmetic mean of all individual detector accuracies.

In the equation in 995-2.8.2.2, "EM" represents the early morning period and "*N*" is the total number of detectors tested. Substitute other periods as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.8.2.2 Early Morning Vehicle Presence Detection Accuracy for All Detectors Expressed as a Percentage:

$$PA_{EM} = \left(\frac{\sum_{i=1}^{N} PA_{EM,\det_i}}{N} \right)$$

Where:

PA_{EM} = Average accuracy of all detectors during the early morning.

$PA_{EM,\det_i}$ = Accuracy of detector *i* during early morning.

Calculate the roadway segment accuracy over all periods using the equation in 995-2.7.2.3.

995-2.8.2.3 Total Vehicle Presence Detection Accuracy for All Detectors Expressed as a Percentage:

$$PA_{Total} = \frac{\left[PA_{EM}x24 + PA_{DA}x2 + PA_{AMP}x4 + PA_{LAOP}x16 + PA_{NO}x4 + PA_{AOP}x16 + PA_{PMP}x4 + PA_{DU}x2 + PA_{NI}x24\right]}{96}$$

Where:

PA_{Total} =Accuracy for all detectors for all periods

PA_{EM} = Accuracy of all detectors during early morning traffic conditions

PA_{DA} = Accuracy of all detectors during dawn traffic conditions

PA_{AMP} = Accuracy of all detectors during AM peak traffic conditions

PA_{LAOP} = Accuracy of all detectors during late AM off-peak traffic conditions

PA_{NO} = Accuracy of all detectors during noon traffic conditions

PA_{AOP} = Accuracy of all detectors during afternoon off-peak traffic conditions

PA_{PMP} = Accuracy of all detectors during PM peak traffic conditions

PA_{DU} = Accuracy of all detectors during dusk traffic conditions

PA_{NI} = Accuracy of all detectors during night traffic conditions

995-2.9 Traffic Data Detection System Acceptance Requirements:

995-2.9.1 Data Accuracy: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the vehicle detection system will be compared against ground truth data collected during the same time by human observation or by another method approved by the TERL. Sample data shall be collected over several time periods under a variety of traffic conditions. Weight each data sample to represent the predominant conditions over the course of a 24-hour period. Samples shall consist of 15- and 30-minute data sets collected at various times of the day. Representative data periods and their assigned weights are provided in Table 995-1.

995-2.9.2 Calculation of Volume Accuracy: Determine individual lane volume accuracy per period by subtracting from 100 percent the absolute difference of the total volume measured by the detector and the ground truth volume measurement, divided by the ground truth volume measurement, expressed as a percentage.

In the equation in 995-2.9.2.1, "EM" represents the early morning period. The subscript "*i*" represents a lane at the detection zone on the roadway segment and could vary from 1,…, N, where "N" is the maximum number of lanes being detected. Substitute other lane numbers and periods as necessary to determine the accuracy for each lane during each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

Variables and subscripts used in the equations below are identified as follows:

VT = Total volume

VD = Vehicle detection data (in this case, count data)

GT = Ground truth measurement utilizing a reliable method approved by the Engineer.

VA = Volume accuracy

995-2.9.2.1 Early Morning Volume Accuracy for a Lane Expressed as a Percentage:

$$VA_{EM,\ln_i} = 100 - \frac{\left|VT_{EM,VD,\ln_i} - VT_{EM,GT,\ln_i}\right|}{VT_{EM,GT,\ln_i}} x100$$

Where:

VA_{EM,ln_i} = Volume accuracy for early morning traffic conditions in the i^{th} lane.

VT_{EM,VD,ln_i} = Total volume for the 15-minute early morning period using the vehicle detector in the i^{th} lane.

VT_{EM,GT,ln_i} = Total volume for the 15-minute early morning period in the i^{th} lane using human observation or another method approved by the Engineer.

The period volume accuracy will be the arithmetic mean of the lane volume accuracy over all lanes.

In the equation in 995-2.9.2.2, "EM" represents the early morning period and "*N*" is the total number of lanes of detection on the roadway segment under test.

Substitute other periods as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.9.2.2 Early Morning Volume Accuracy Expressed as a Percentage:

$$VA_{EM} = \left(\frac{\sum_{i=1}^{N} VA_{EM,\ln_i}}{N} \right)$$

Where:

VA_{EM} = Average volume accuracy for early morning traffic conditions for all lanes.

VA_{EM,ln_i} = Volume accuracy for early morning traffic conditions in the i^{th} lane.

Calculate the total volume accuracy over all periods using the equation in 995-2.8.2.3.

995-2.9.2.3 Total Volume Accuracy Expressed as a Percentage:

$$VA_{Total} = \frac{[VA_{EM}x24 + VA_{DA}x2 + VA_{AMP}x4 + VA_{LAOP}x16 + VA_{NO}x4 + VA_{AOP}x16 + VA_{PMP}x4 + VA_{DU}x2 + VA_{NI}x24]}{96}$$

Where:

VA_{Total} = Volume accuracy for all lanes for all periods

VA_{EM} = Volume accuracy for early morning traffic conditions

VA_{DA} = Volume accuracy for dawn traffic conditions

VA_{AMP} = Volume accuracy for AM peak traffic conditions

VA_{LAOP} = Volume accuracy for late AM off-peak traffic conditions

VA_{NO} = Volume accuracy for noon traffic conditions

VA_{AOP} = Volume accuracy for afternoon off-peak traffic conditions

VA_{PMP} = Volume accuracy for PM peak traffic conditions

VA_{DU} = Volume accuracy for dusk traffic conditions

VA_{NI} = Volume accuracy for night traffic conditions

995-2.9.3 Calculation of Speed and Occupancy Accuracy: For computing the accuracy of the detector speed measurement, the average speed readings obtained from the detection system are compared to ground truth values.

The equation in 995-2.9.3.1 represents the ground truth average speed computation procedure for a particular lane during a specific time period. The equation in 995-2.9.3.2 represents the average speed computation procedure for a particular lane during a specific time period using data gathered from the detection system.

In the equations in 995-2.9.3.1 and 995-2.9.3.2, the time period described is the early morning period, represented by “EM”, and the subscript “k” represents a vehicle traveling on the roadway and could vary from 1,…, K, where “K” is the total number of vehicles in lane i during the time period under consideration. The subscript “i” represents a lane in a roadway and could vary from 1,…, N, where "N" is the total number of lanes of detection on the roadway segment. Substitute other lanes and periods as necessary and compute the accuracy for each lane for all time periods.

Variables and subscripts used in the equations below are identified as follows:

SA = Speed accuracy

S = Speed of an individual vehicle

K= Total number of vehicles in lane during time period

veh = Vehicle

995-2.9.3.1 Early Morning Average Ground Truth Speed:

$$S_{Avg,EM,GT,\ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,GT,\ln_i,veh_k}$$

Where:

SA_{Avg,EM,GT,ln_i} represents the average ground truth vehicle speed for the i^{th} lane during the early morning period.

S_{EM,GT,ln_i,veh_k} represents the ground truth speed for the k^{th} vehicle in the i^{th} lane during the early morning period using human observation or another method approved by the Engineer.

995-2.9.3.2 Early Morning Average Vehicle Detector Speed:

$$S_{Avg,EM,VD,\ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,VD,\ln_i,veh_k}$$

Where:

S_{Avg,EM,VD,ln_i} represents the average speed recorded by the vehicle detector for the i^{th} lane during the early morning period.

S_{EM,VD,ln_i,veh_k} represents the speed for the k^{th} vehicle in the i^{th} lane during the early morning period using the vehicle detector.

Determine lane speed accuracy per period by subtracting from 100 percent the absolute difference of the average lane speed measured by the detector and the average lane ground truth speed, divided by the average lane ground truth speed, expressed as a percent.

In the equation in 995-2.9.3.3, "EM" represents the early morning period. The subscript "*i*" represents a lane of detection on a roadway and could vary from 1,…,N, where "N" is the total number of lanes of detection on the roadway segment. Substitute other lanes as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.9.3.3 Early Morning Lane Speed Accuracy Expressed as a Percentage:

$$SA_{Avg,EM,\ln_i} = 100 - \frac{\left|S_{Avg,EM,VD,\ln_i} - S_{Avg,EM,GT,\ln_i}\right|}{S_{Avg,EM,GT,\ln_i}} \times 100$$

Where:

SA_{Avg,EM,ln_i} represents the average speed accuracy during early morning traffic conditions for all vehicles that traveled in lane i of the roadway segment.

The period speed accuracy will be the arithmetic mean of the lane speed accuracy, computed using the equation in 995-2.9.3.3, over all lanes.

In the equation in 995-2.9.3.4, “EM” represents the early morning period. The subscript “i” represents a lane of detection on a roadway and could vary from 1,…, N, where “N” is the maximum number of lanes on the roadway segment. Substitute data as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.9.3.4 Early Morning Speed Accuracy Expressed as a Percentage:

$$SA_{EM} = \left(\frac{\sum_{i=1}^{N} SA_{Avg,EM,\ln_i}}{N} \right)$$

Where:

SA_{EM} represents the average speed accuracy during early morning traffic conditions for all lanes of detection on the roadway segment.

Calculate detector speed accuracy for the roadway segment over all periods using the equation in 995-2.9.3.5.

995-2.9.3.5 Total Roadway Segment Accuracy Expressed as a Percentage:

$$SA_{Total} = \frac{[SA_{EM}x24 + SA_{DA}x2 + SA_{AMP}x4 + SA_{LAOP}x16 + SA_{NO}x4 + SA_{AOP}x16 + SA_{PMP}x4 + SA_{DU}x2 + SA_{NI}x24]}{96}$$

Where:

SA_{Total} = Speed accuracy for all lanes for all periods

SA_{EM} = Speed accuracy for early morning traffic conditions

SA_{DA} = Speed accuracy for dawn traffic conditions

SA_{AMP} = Speed accuracy for AM peak traffic conditions

SA_{LAOP} = Speed accuracy for late AM off-peak traffic conditions

SA_{NO} = Speed accuracy for noon traffic conditions

SA_{AOP} = Speed accuracy for afternoon off-peak traffic conditions

SA_{PMP} = Speed accuracy for PM peak traffic conditions

SA_{DU} = Speed accuracy for dusk traffic conditions

SA_{NI} = Speed accuracy for night traffic conditions

995-2.10 Probe Data Detection System Performance Requirements: Probe data detectors shall establish a unique and consistent identifier for each vehicle detected and the time and location that the vehicle was detected and shall provide the following:

1. A minimum penetration rate of 75%.

2. A minimum match rate of 5% for probe data detection systems that match upstream and downstream detection of the same vehicle

3. A minimum total roadway segment speed and travel time accuracy level of 90%. Verify system performance over several time periods under a variety of traffic conditions as described in 995-2.9.1.

995-2.10.1 Calculation of Penetration Rate: Penetration rate is defined as the volume of vehicles detected, identified, and time stamped divided by the number of qualified vehicles that passed within the detection area of the probe detector.

995-2.10.1.1 Early Morning Penetration Rate Expressed as a Percentage:

$$PR_{EM} = 100 - \frac{\left| R_{EM,VD} - V_{EM,GT} \right|}{V_{EM,GT}} \times 100$$

Where:

PR_{EM} = Penetration Rate for early morning.

$R_{EM,VD}$ = Number of unique vehicle records captured by the vehicle detector.

$V_{EM,GT}$ = Total volume of vehicles that pass the detection area for the 15-minute early morning period using human observation or another method approved by the Engineer.

995-2.10.2 Calculation of Match Rate: Match rate is the percentage of the total vehicle population of a road segment that is detected and matched at consecutive probe data detection sites.

995-2.10.2.1 Early Morning Match Rate Expressed as a Percentage:

$$MR_{EM} = 100 - \frac{\left| M_{EM,VD} - V_{EM,GT} \right|}{V_{EM,GT}} \times 100$$

Where:

MR_{EM} = Match Rate for early morning.

$M_{EM,VD}$ = Number of matched detections between two probe vehicle detection sites (typically a pair of sites at each end of a roadway segment) during early morning.

$V_{EM,GT}$ = Total volume of vehicles that pass the detection area for the 15-minute early morning period using human observation or another method approved by the Engineer.

995-2.11 Wrong Way Vehicle (WWVDS) Detection System Performance Requirements: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, the wrong way detection system will be evaluated at the State Traffic Engineering Research Lab (TERL). Under controlled conditions at the TERL facility, the wrong way detection system must be capable of meeting the detection accuracy of 100% and zero false positive readings, using a sample size of 200 vehicles.

995-3 Loop Sealant.

Loop sealant shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

Loop sealant shall be furnished in a premeasured two-part formulation and meet the following requirements:

1. Sealant shall be self-leveling when applied and designed to be installed flush with the roadway surface. Sealant shall not run out of unlevel slots when tested for viscosity in accordance with ASTM D562 at 77°F. Sealant shall be tack free in a maximum of two hours from time of application and cured when tested for tack free time in accordance with ASTM C679 at 77°F.

2. When installed in a 3/8 inch by 3 inch saw cut and cured for two weeks at 77°F:

    a. using visual inspection, sealant shall securely adhere to concrete and asphalt .

    b. sealant shall show no visible signs of shrinkage after curing when tested for shrinkage using a dimensional measurement.

3. Sealant shall resist weather, oils, gasoline, antifreeze, and brake fluid when tested for absorption for water, No. 3 oil, gasoline, antifreeze, and brake fluid for 24 hours in accordance with ASTM D570. Sealant shall resist penetration of foreign materials when tested for durometer hardness for 24 hours in accordance with ASTM D2240 Shore A.

4. Sealant shall resist cracking caused by expansion and contraction due to temperature changes when tested for tensile strength and elongation in accordance with ASTM D412.

5. Sealant shall not become brittle with age or temperature extremes when tested for weight loss, cracking, and chalking in accordance with ASTM C1246.

6. Sealant shall have a minimum shelf life of 12 months when stored in accordance with the manufacturer recommendations.

7. Sealant containers shall be clearly labeled with name or trademark of the manufacturer, model number, date of manufacture or manufacturer's batch number, and installation instructions.

TRAFFIC CONTROL SIGNAL AND DEVICE MATERIALS.
(REV 8-2-19)

The following new Section is added after Section 994:

SECTION 995
TRAFFIC CONTROL SIGNAL AND DEVICE MATERIALS

995-1 Description.
This Section governs the requirements for all permanent traffic control signals and devices.

995-2 Vehicle Detection Systems.
995-2.1 General: All vehicle detection systems shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

All equipment shall be permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number. All parts shall be constructed of corrosion-resistant materials, such as plastic, stainless steel, anodized aluminum, brass, or gold-plated metal and all fasteners exposed to the elements are Type 304 or 316 passivated stainless steel.

Detectors shall meet the environmental requirements of NEMA TS-2-2016.

995-2.2 Inductive Loop Detector Units: Rack mount inductive loop detector units shall meet the requirements of NEMA TS-2-2016. Shelf mount detector units shall meet the requirements of NEMA TS-1-1989.

995-2.3 Video Vehicle Detection System (VVDS).

995-2.3.1 Configuration and Management: The VVDS shall be provided with software that allows local and remote configuration and monitoring. The system shall be capable of displaying detection zones and detection activations overlaid on live video inputs. The VVDS shall meet the following criteria:

1. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.
2. Retains its programming in nonvolatile memory. The detection system configuration data shall be capable of being saved to a computer and restored from a saved file. All communication addresses shall be user programmable.
3. Offers an open Application Programming Interface (API) and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.3.2 Detection Camera: Camera shall be approved by the video detection system manufacturer and listed with the detection system on the APL.

995-2.3.3 Machine Vision Processor: The VVDS shall include a machine vision processor that allows video analysis, presence detection, data collection, and interfaces for inputs and outputs as well as storage and reporting of collected vehicle detection data.

995-2.3.4 Communications: The VVDS shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. Serial interface and connectors shall conform to Telecommunications Industry Association (TIA)-232 standards. Ensure that the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces shall provide a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications shall be secure and wireless devices shall be Federal Communications Commission (FCC) certified. The FCC identification number shall be displayed on an external label and all detection system devices shall operate within their FCC frequency allocation.

4. Cellular communications devices shall be compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system shall be configured and monitored via one or more communications interface.

995-2.3.5 Video Inputs and Outputs: Analog video inputs and outputs shall utilize BNC connectors.

995-2.3.6 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2016, 6.5.2.26.

995-2.3.7 Electrical Requirements: The system shall operate using a nominal input voltage of 120 V of alternating current (V_{AC}) and with an input voltage ranging from 89 to 135 V_{AC}. If a system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

995-2.4 Microwave Vehicle Detection System (MVDS): Sidefire MVDS sensors shall have a minimum 200 foot range and the capability to detect a minimum of 8 lanes of traffic.

995-2.4.1 Configuration and Management: The MVDS shall be provided with software that allows local and remote configuration and monitoring. The system software shall be capable of displaying detection zones and detection activations in a graphical format. The MVDS shall meet the following criteria:

1. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.

2. Retains its programming in nonvolatile memory. Ensure that the detection system configuration data can be saved to a computer and restored from a saved file. Ensure that all communication addresses are user programmable.

3. Detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.4.2 Communications: Major components of the detection system (such as the sensor and any separate hardware used for contact closures) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria:

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provide a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

995-2.4.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2016, 6.5.2.26.

995-2.4.4 Electrical Requirements: The microwave detector shall operate with a nominal input voltage of 12 V_{DC} and with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

The detector shall be FCC certified and has been granted authorization to operate within a frequency range established and approved by the FCC. The FCC identification number shall be displayed on an external label.

995-2.5 Wireless Magnetometer Detection System (WMDS):

995-2.5.1 Configuration and Management: The detection system shall be provided with software that allows local and remote configuration and monitoring and shall meet the following criteria.

1. Allows a user to edit previously defined configuration parameters.

2. Retains its programming in nonvolatile memory and the detection system configuration data can be saved to a computer and restored from a saved file. All communication addresses shall be user programmable.

3. The detection system software offers an open API and software development kit available to the Department at no cost for integration with third party software and systems.

995-2.5.2 Communications: Components of the detection system (such as sensors, access points, and contact closure cards) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provide a 10/100 Base TX connection and all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.

4. Cellular communications devices are e-compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

995-2.5.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2016, 6.5.2.26.

995-2.5.4 Electrical Requirements: The WDMS shall operate with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied.

995-2.6 Automatic Vehicle Identification (AVI):

995-2.6.1 Configuration and Management: The detection system shall be provided with software that allows local and remote configuration and monitoring.

995-2.6.2 Communications: Components of the detection system (such as sensors, controllers, and processing hardware) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria.

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).
2. Wired Ethernet interfaces provide a 10/100 Base TX connection and all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.
3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all detection system devices operate within their FCC frequency allocation.
4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.
5. The system can be configured and monitored via one or more communications interface.

995-2.6.3 Probe Data Detector Requirements:

1. Transponder Readers shall be compatible with multiple tag protocols, including Allegro and the protocol defined in ISO18000-6B.
2. Bluetooth Readers shall be capable of operating using either solar power or AC power.
3. License Plate Readers shall not require the use of visible strobes or other visible supplemental lighting.

995-2.6.4 Electrical Requirements: The AVI shall operate with an input voltage ranging from 89 to 135 V_{AC}. If any system device requires operating voltages other than 120 V_{AC}, a voltage converter shall be supplied. For solar powered devices, the detection system must operate for 5 days without solar assistance.

995-2.7 Wrong Way Vehicle Detection Systems (WWVDS):

995-2.7.1 Configuration and Management: The WWVDS shall be provided with software that allows local and remote configuration and monitoring. That the system shall have the capability to display detection zones and detection activations. The WWVDS shall meet the following criteria:

1. WWVDS controllers shall support either an on-board real-time clock/calendar with on-board battery backup, or the controller’s internal time clock can be configured to synchronize to a time server using the network time protocol (NTP) in order to maintain the current local date/time information. For NTP, the synchronization frequency must be user configurable and permit polling intervals from once per minute to once per week in one-minute increments. For NTP, the controller must allow the user to define the NTP server by internet protocol (IP) address.

2. Allows a user to edit previously defined configuration parameters, including size, placement, and sensitivity of detection zones.

3. Retains its programming in nonvolatile memory. The detection system configuration data shall be capable of being saved to a computer and restored from a saved file. All communication addresses shall be user programmable.

4. Offers an open Application Programming Interface (API) or software development kit available to the Department at no cost for integration with third party software and systems.

995-2.7.2 Communications: Major components of the WWVDS (such as the sensor and any separate hardware used for contact closures) shall include a minimum of one serial or Ethernet communications interface and shall meet the following criteria:

1. The serial interface and connector conforms to TIA-232 standards and the serial ports support data rates up to 115200 bps; error detection utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2).

2. Wired Ethernet interfaces provides, at a minimum, a 10/100 Base TX connection. Verify that all unshielded twisted pair/shielded twisted pair network cables and connectors comply with TIA-568.

3. Wireless communications are secure and that wireless devices are FCC certified. The FCC identification number is displayed on an external label and all WWVDS devices operate within their FCC frequency allocation.

4. Cellular communications devices are compatible with the cellular carrier used by the agency responsible for system operation and maintenance.

5. The system can be configured and monitored via one or more communications interface.

6. The WWVDS is compatible with the Department's SunGuide® software at the time of installation. For WWVDS installed on ramps, the device shall send an alert and a sequence of images for up to ten seconds to the SunGuide® software that covers a configurable time before and after the wrong-way vehicle detection.

995-2.8 Vehicle Presence Detection System Performance Requirements: Presence detectors shall provide a minimum detection accuracy of 98% and shall meet the requirements for modes of operation in NEMA TS2-2016, 6.5.2.17.

995-2.8.1 Vehicle Presence Detection Accuracy: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the vehicle detection system will be compared against ground truth data collected during the same time by human observation or by another method approved by the FDOT Traffic Engineering Research Laboratory (TERL). Ensure sample data is collected over several time periods under a variety of traffic conditions. Weight each data sample to represent the predominant conditions over the course of a 24-hour period. Samples will consist of 15- and 30-minute data sets collected at various times of the day. Representative data periods and their assigned weights are provided in Table 995-1.

Table 995-1
Data Collection Periods

Period	Intended To Represent	Duration	Weight
Early morning (predawn) [EM]	12:30 a.m. – 6:30 a.m.	15 minutes	24

Dawn [DA]	6:30 a.m. – 7:00 a.m.	30 minutes	2
AM Peak [AMP]	7:00 a.m. – 8:00 a.m.	15 minutes	4
Late AM Off-Peak [LAOP]	8:00 a.m. – 12:00 p.m.	15 minutes	16
Noon [NO]	12:00 p.m. – 1:00 p.m.	15 minutes	4
Afternoon Off-Peak [AOP]	1:00 p.m. – 5:00 p.m.	15 minutes	16
PM Peak [PMP]	5:00 p.m. – 6:00 p.m.	15 minutes	4
Dusk [DU]	6:00 p.m. - 6:30 p.m.	30 minutes	2
Night [NI]	6:30 p.m. - 12:30 a.m.	15 minutes	24
Total Sum of Weights			96

For example, the sample gathered for the Late AM Off-Peak period is intended to represent typical traffic conditions between 8:00 a.m. and 12:00 p.m. Since the sample period's duration is 15 minutes and the actual period of time represented is 4 hours, the multiplication factor or weight assigned is 16, the number of 15-minute intervals in a 4 hour period.

995-2.8.2 Calculation of Vehicle Presence Detection Accuracy: Determine individual lane presence detection accuracy per period by subtracting from 100 percent the absolute difference of the total time monitored and the cumulative error time, divided by total time, expressed as a percentage.

In the equation in 995-2.8.2.1, "EM" represents the early morning period. The variable "i" represents a detector or detection zone and could vary from 1,…, N, where "N" is the total number of detectors observed. Substitute other detector numbers and periods as necessary to determine accuracy for all detectors during each period (i.e., dawn, AM peak, late AM off peak, etc.).

Variables used in the following equations are identified as follows:

PA = Presence detection accuracy
TT = Total time
CET = Cumulative Error Time (duration of all false and missed calls)
N=Total number of detectors observed

995-2.8.2.1 Early Morning Vehicle Presence Detection Accuracy for a Single Detector Expressed as a Percentage:

$$PA_{EM,\det_i} = 100 - \frac{\left|TT_{EM,\det_i} - CET_{EM,\det_i}\right|}{TT_{EM,\det_i}} x100$$

where:

$PA_{EM,\det_i}$ = Presence detection accuracy of detector *i* during the early morning period.

$TT_{EM,\det_i}$ = Total time that detector *i* was monitored (for instance, the 15-minute minimum duration specified in Table 995-1 for the early morning period).

$CET_{EM,\det_i}$ = Cumulative time that detector *i* was in an error state (indicating a detection with no vehicle present or not indicating a detection when vehicle present) during the monitoring period using human observation or another method approved by the Engineer.

The period accuracy will be the arithmetic mean of all individual detector accuracies.

In the equation in 995-2.8.2.2, "EM" represents the early morning period and "*N*" is the total number of detectors tested. Substitute other periods as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.8.2.2 Early Morning Vehicle Presence Detection Accuracy for All Detectors Expressed as a Percentage:

$$PA_{EM} = \left(\frac{\sum_{i=1}^{N} PA_{EM,\det_i}}{N} \right)$$

Where:

PA_{EM} = Average accuracy of all detectors during the early morning.

$PA_{EM,\det_i}$ = Accuracy of detector *i* during early morning.

Calculate the roadway segment accuracy over all periods using the equation in 995-2.7.2.3.

995-2.8.2.3 Total Vehicle Presence Detection Accuracy for All Detectors Expressed as a Percentage:

$$PA_{Total} = \frac{\left[PA_{EM}x24 + PA_{DA}x2 + PA_{AMP}x4 + PA_{LAOP}x16 + PA_{NO}x4 + PA_{AOP}x16 + PA_{PMP}x4 + PA_{DU}x2 + PA_{NI}x24\right]}{96}$$

Where:

PA_{Total} =Accuracy for all detectors for all periods

PA_{EM} = Accuracy of all detectors during early morning traffic conditions

PA_{DA} = Accuracy of all detectors during dawn traffic conditions

PA_{AMP} = Accuracy of all detectors during AM peak traffic conditions

PA_{LAOP} = Accuracy of all detectors during late AM off-peak traffic conditions

PA_{NO} = Accuracy of all detectors during noon traffic conditions

PA_{AOP} = Accuracy of all detectors during afternoon off-peak traffic conditions

PA_{PMP} = Accuracy of all detectors during PM peak traffic conditions

PA_{DU} = Accuracy of all detectors during dusk traffic conditions

PA_{NI} = Accuracy of all detectors during night traffic conditions

995-2.9 Traffic Data Detection System Acceptance Requirements:

995-2.9.1 Data Accuracy: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the vehicle detection system will be compared against ground truth data collected during the same time by human observation or by another method approved by the TERL. Sample data shall be collected over several time periods under a variety of traffic conditions. Weight each data sample to represent the predominant conditions over the course of a 24-hour period. Samples shall consist of 15- and 30-minute data sets collected at various times of the day. Representative data periods and their assigned weights are provided in Table 995-1.

995-2.9.2 Calculation of Volume Accuracy: Determine individual lane volume accuracy per period by subtracting from 100 percent the absolute difference of the total volume measured by the detector and the ground truth volume measurement, divided by the ground truth volume measurement, expressed as a percentage.

In the equation in 995-2.9.2.1, “EM” represents the early morning period. The subscript “*i*” represents a lane at the detection zone on the roadway segment and could vary from 1,…, N, where “N” is the maximum number of lanes being detected. Substitute other lane numbers and periods as necessary to determine the accuracy for each lane during each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

Variables and subscripts used in the equations below are identified as follows:

VT = Total volume

VD = Vehicle detection data (in this case, count data)

GT = Ground truth measurement utilizing a reliable method approved by the Engineer.

VA = Volume accuracy

995-2.9.2.1 Early Morning Volume Accuracy for a Lane Expressed as a Percentage:

$$VA_{EM,\ln_i} = 100 - \frac{\left| VT_{EM,VD,\ln_i} - VT_{EM,GT,\ln_i} \right|}{VT_{EM,GT,\ln_i}} x100$$

Where:

VA_{EM,ln_i} = Volume accuracy for early morning traffic conditions in the *i* th lane.

VT_{EM,VD,ln_i} = Total volume for the 15-minute early morning period using the vehicle detector in the *i* th lane.

VT_{EM,GT,ln_i} = Total volume for the 15-minute early morning period in the *i* th lane using human observation or another method approved by the Engineer.

The period volume accuracy will be the arithmetic mean of the lane volume accuracy over all lanes.

In the equation in 995-2.9.2.2, “EM” represents the early morning period and “*N*” is the total number of lanes of detection on the roadway segment under test. Substitute other periods as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.9.2.2 Early Morning Volume Accuracy Expressed as a Percentage:

$$VA_{EM} = \left(\frac{\sum_{i=1}^{N} VA_{EM,\ln_i}}{N} \right)$$

Where:

VA_{EM} = Average volume accuracy for early morning traffic conditions for all lanes.

$VA_{EM,\ln_i}$ = Volume accuracy for early morning traffic conditions in the i th lane.

Calculate the total volume accuracy over all periods using the equation in 995-2.8.2.3.

995-2.9.2.3 Total Volume Accuracy Expressed as a Percentage:

$$VA_{Total} = \frac{\left[VA_{EM}\,x24 + VA_{DA}\,x2 + VA_{AMP}\,x4 + VA_{LAOP}\,x16 + VA_{NO}\,x4 + VA_{AOP}\,x16 + VA_{PMP}\,x4 + VA_{DU}\,x2 + VA_{NI}\,x24\right]}{96}$$

Where:

VA_{Total} = Volume accuracy for all lanes for all periods
VA_{EM} = Volume accuracy for early morning traffic conditions
VA_{DA} = Volume accuracy for dawn traffic conditions
VA_{AMP} = Volume accuracy for AM peak traffic conditions
VA_{LAOP} = Volume accuracy for late AM off-peak traffic conditions
VA_{NO} = Volume accuracy for noon traffic conditions
VA_{AOP} = Volume accuracy for afternoon off-peak traffic conditions
VA_{PMP} = Volume accuracy for PM peak traffic conditions
VA_{DU} = Volume accuracy for dusk traffic conditions
VA_{NI} = Volume accuracy for night traffic conditions

995-2.9.3 Calculation of Speed and Occupancy Accuracy: For computing the accuracy of the detector speed measurement, the average speed readings obtained from the detection system are compared to ground truth values.

The equation in 995-2.9.3.1 represents the ground truth average speed computation procedure for a particular lane during a specific time period. The equation in 995-2.9.3.2 represents the average speed computation procedure for a particular lane during a specific time period using data gathered from the detection system.

In the equations in 995-2.9.3.1 and 995-2.9.3.2, the time period described is the early morning period, represented by “EM”, and the subscript “k” represents a vehicle traveling on the roadway and could vary from 1,…, K, where “K” is the total number of vehicles in lane i during the time period under consideration. The subscript “i” represents a lane in a roadway and could vary from 1,…, N, where “N” is the total number of lanes of detection on the roadway segment. Substitute other lanes and periods as necessary and compute the accuracy for each lane for all time periods.

Variables and subscripts used in the equations below are identified as follows:

SA = Speed accuracy
S = Speed of an individual vehicle
K= Total number of vehicles in lane during time period
veh = Vehicle

995-2.9.3.1 Early Morning Average Ground Truth Speed:

$$S_{Avg,EM,GT,\ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,GT,\ln_i,veh_k}$$

Where:

SA_{Avg,EM,GT,ln_i} represents the average ground truth vehicle speed for the i th lane during the early morning period.

S_{EM,GT,ln_i,veh_k} represents the ground truth speed for the k^{th} vehicle in the i^{th} lane during the early morning period using human observation or another method approved by the Engineer.

995-2.9.3.2 Early Morning Average Vehicle Detector Speed:

$$S_{Avg,EM,VD,\ln_i} = \frac{1}{K}\sum_{k=1}^{K} S_{EM,VD,\ln_i,veh_k}$$

Where:

S_{Avg,EM,VD,ln_i} represents the average speed recorded by the vehicle detector for the i th lane during the early morning period.

S_{EM,VD,ln_i,veh_k} represents the speed for the k th vehicle in the i th lane during the early morning period using the vehicle detector.

Determine lane speed accuracy per period by subtracting from 100 percent the absolute difference of the average lane speed measured by the detector and the average lane ground truth speed, divided by the average lane ground truth speed, expressed as a percent.

In the equation in 995-2.9.3.3, “EM” represents the early morning period. The subscript “*i*” represents a lane of detection on a roadway and could vary from 1,…,N, where “N” is the total number of lanes of detection on the roadway segment. Substitute other lanes as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.9.3.3 Early Morning Lane Speed Accuracy Expressed as a Percentage:

$$SA_{Avg,EM,\ln_i} = 100 - \frac{\left|S_{Avg,EM,VD,\ln_i} - S_{Avg,EM,GT,\ln_i}\right|}{S_{Avg,EM,GT,\ln_i}} \times 100$$

Where:

SA_{Avg,EM,ln_i} represents the average speed accuracy during early morning traffic conditions for all vehicles that traveled in lane i of the roadway segment.

The period speed accuracy will be the arithmetic mean of the lane speed accuracy, computed using the equation in 995-2.9.3.3, over all lanes.

In the equation in 995-2.9.3.4, “EM” represents the early morning period. The subscript “i” represents a lane of detection on a roadway and could vary from 1,…, N, where “N” is the maximum number of lanes on the roadway segment. Substitute data as necessary to determine the accuracy for each period (i.e., dawn, AM peak, late AM offpeak-, etc.).

995-2.9.3.4 Early Morning Speed Accuracy Expressed as a Percentage:

$$SA_{EM} = \left(\frac{\sum_{i=1}^{N} SA_{Avg,EM,\ln_i}}{N} \right)$$

Where:

SA_{EM} represents the average speed accuracy during early morning traffic conditions for all lanes of detection on the roadway segment.

Calculate detector speed accuracy for the roadway segment over all periods using the equation in 995-2.9.3.5.

995-2.9.3.5 Total Roadway Segment Accuracy Expressed as a Percentage:

$$SA_{Total} = \frac{[SA_{EM}x24 + SA_{DA}x2 + SA_{AMP}x4 + SA_{LAOP}x16 + SA_{NO}x4 + SA_{AOP}x16 + SA_{PMP}x4 + SA_{DU}x2 + SA_{NI}x24]}{96}$$

Where:

SA_{Total} = Speed accuracy for all lanes for all periods
SA_{EM} = Speed accuracy for early morning traffic conditions
SA_{DA} = Speed accuracy for dawn traffic conditions
SA_{AMP} = Speed accuracy for AM peak traffic conditions
SA_{LAOP} = Speed accuracy for late AM off-peak traffic conditions
SA_{NO} = Speed accuracy for noon traffic conditions
SA_{AOP} = Speed accuracy for afternoon off-peak traffic conditions
SA_{PMP} = Speed accuracy for PM peak traffic conditions
SA_{DU} = Speed accuracy for dusk traffic conditions
SA_{NI} = Speed accuracy for night traffic conditions

995-2.10 Probe Data Detection System Performance Requirements: Probe data detectors shall establish a unique and consistent identifier for each vehicle detected and the time and location that the vehicle was detected and shall provide the following:

1. A minimum penetration rate of 75%.

2. A minimum match rate of 5% for probe data detection systems that match upstream and downstream detection of the same vehicle

3. A minimum total roadway segment speed and travel time accuracy level of 90%. Verify system performance over several time periods under a variety of traffic conditions as described in 995-2.9.1.

995-2.10.1 Calculation of Penetration Rate: Penetration rate is defined as the volume of vehicles detected, identified, and time stamped divided by the number of qualified vehicles that passed within the detection area of the probe detector.

995-2.10.1.1 Early Morning Penetration Rate Expressed as a Percentage:

$$PR_{EM} = 100 - \frac{\left|R_{EM,VD} - V_{EM,GT}\right|}{V_{EM,GT}} \times 100$$

Where:

PR_{EM} = Penetration Rate for early morning.

$R_{EM,VD}$ = Number of unique vehicle records captured by the vehicle detector.

$V_{EM,GT}$ = Total volume of vehicles that pass the detection area for the 15-minute early morning period using human observation or another method approved by the Engineer.

995-2.10.2 Calculation of Match Rate: Match rate is the percentage of the total vehicle population of a road segment that is detected and matched at consecutive probe data detection sites.

995-2.10.2.1 Early Morning Match Rate Expressed as a Percentage:

$$MR_{EM} = 100 - \frac{\left|M_{EM,VD} - V_{EM,GT}\right|}{V_{EM,GT}} \times 100$$

Where:

MR_{EM} = Match Rate for early morning.

$M_{EM,VD}$ = Number of matched detections between two probe vehicle detection sites (typically a pair of sites at each end of a roadway segment) during early morning.

$V_{EM,GT}$ = Total volume of vehicles that pass the detection area for the 15-minute early morning period using human observation or another method approved by the Engineer.

995-2.11 Wrong Way Vehicle (WWVDS) Detection System Performance Requirements: To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, the wrong way detection system will be evaluated at the State Traffic Engineering Research Lab (TERL). Under controlled conditions at the TERL facility, the wrong way detection system must be capable of meeting the detection accuracy of 100% and zero false positive readings, using a sample size of 200 vehicles.

995-3 Loop Sealant.

Loop sealant shall be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

Loop sealant shall be furnished in a premeasured two-part formulation and meet the following requirements:

1. Sealant shall be self-leveling when applied and designed to be installed flush with the roadway surface. Sealant shall not run out of unlevel slots when tested for viscosity in accordance with ASTM D562 at 77°F. Sealant shall be tack free in a maximum of two hours from time of application and cured when tested for tack free time in accordance with ASTM C679 at 77°F.
2. When installed in a 3/8 inch by 3 inch saw cut and cured for two weeks at 77°F:
    a. using visual inspection, sealant shall securely adhere to concrete and asphalt .
    b. sealant shall show no visible signs of shrinkage after curing when tested for shrinkage using a dimensional measurement.
3. Sealant shall resist weather, oils, gasoline, antifreeze, and brake fluid when tested for absorption for water, No. 3 oil, gasoline, antifreeze, and brake fluid for 24 hours in accordance with ASTM D570. Sealant shall resist penetration of foreign materials when tested for durometer hardness for 24 hours in accordance with ASTM D2240 Shore A.
4. Sealant shall resist cracking caused by expansion and contraction due to temperature changes when tested for tensile strength and elongation in accordance with ASTM D412.
5. Sealant shall not become brittle with age or temperature extremes when tested for weight loss, cracking, and chalking in accordance with ASTM C1246.
6. Sealant shall have a minimum shelf life of 12 months when stored in accordance with the manufacturer recommendations.
7. Sealant containers shall be clearly labeled with name or trademark of the manufacturer, model number, date of manufacture or manufacturer's batch number, and installation instructions.