Florida Department of Transportation

RON DESANTIS
GOVERNOR

605 Suwannee Street
Tallahassee, FL 32399-0450

JARED W. PERDUE, P.E.
SECRETARY

October 4, 2023

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: **9950201 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 to add requirements for systems using LiDAR, update warranty requirements, and update internal/external publication references.

Please review and transmit your comments, if any, within two weeks (10 business days). Comments should be sent via email daniel.strickland@dot.state.fl.us.

If you have any questions relating to this specification change, please call me at (850) 414-4130.

Sincerely,

Signature on File

Daniel Strickland, P.E.
State Specifications Engineer

DS/dh
Attachment
cc: Florida Transportation Builders' Assoc.
State Construction Engineer

TRAFFIC CONTROL SIGNAL AND DEVICE MATERIALS.
(REV 8-2-23)

ARTICLE 995-2 is deleted and the following substituted:

995-2 Vehicle Detection Systems.

995-2.1 General: All parts shall be constructed of corrosion-resistant materials, such as UV stabilized or UV resistant plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. All fasteners exposed to the elements shall be Type 304 or 316 passivated stainless steel.

If the assembly includes a cabinet, meet the requirements of Section 676.

Detectors shall meet the environmental requirements of NEMA TS 2-2021.

995-2.2 Inductive Loop Detector Units: Rack mount inductive loop detector units shall meet the requirements of NEMA NEMA TS 2-2021 and CALTRANS TEES 2020. 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 recommended by the video detection system manufacturer. Cameras that are integrated and included in a VVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

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 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 TS 2-2021, 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.

6. Cameras that are integrated and included in a MVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications

and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

995-2.4.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2021, 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 ~~c~~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 TS2-2021, 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 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 interface~~s~~ 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. The SunGuide software requirements are listed in supplemental requirement SR-995-2.7.2-01, Supplemental Wrong Way Vehicle Detection System SunGuide HTTP Protocol, as published on the Department's State Traffic Engineering and Operations Office website at the following https://www.fdot.gov/traffic/Traf-Sys/Product-Specifications.shtm.

7. For WWVDS installed on ramps, the device shall:

a. Send an alert to the SunGuide® software when the wrong-way vehicle is detected.

b. Send 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.

c. Activate all highlighted signs associated with the WWVDS.

8. For WWVDS installed on mainline lanes, the device shall send an alert to the SunGuide® software when the wrong-way vehicle is detected.

9. Cameras that are integrated and included in a WWVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

995-2.7.3 Electrical Specifications: Equipment shall operate on solar power or with an input voltage ranging from 89 to 135 V_{AC}. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter. Solar powered systems shall be designed to operate for minimum of 5 activations per day and provide 10 days of operation without sunlight.

995-2.8 Light Detection and Ranging (LiDAR) Vehicle Detection System:

995-2.8.1 Configuration and Management: LiDAR systems 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 on superimposed on live images of the point cloud data produced by the system. The LiDAR system shall meet the following criteria:

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

995-2.8.2 LiDAR sensors: System sensors shall be recommended by the system manufacturer as part of the engineered LiDAR system solution. Detection range must extend up to at least 200 feet from the sensor. Multiple sensors shall be used to reduce occlusion and generate an accurate point cloud representation of the installation environment and detected objects.

995-2.8.3 Perception Software and Processor: The LiDAR system shall include a processor that combines data from multiple LiDAR sensors into a single point cloud for object detection, classification, presence detection, and data collection. The processor shall be a rugged industrial PC with CPU, memory, storage, a commercially available host operating system, and all software required for system operation. The processor shall include physical interfaces for connection of sensors, system inputs, and outputs.

995-2.8.4 Communications: All major system components shall include an Ethernet communications interface that provides a 10/100 Base TX connection. All unshielded twisted pair/shielded twisted pair network cables and connectors shall comply with TIA-568.

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.

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

995-2.8.5 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS 2-2021, 6.5.2.26.

995-2.8.6 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.~~8~~9 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 TS2-2021, 6.5.2.17.

995-2.~~8~~9.1 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 995-2.

Table 995-2
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~~9.2 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.

With~~I~~in the equation in 995-2.~~8~~9.2.1, "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~~9.2.1 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 995-2 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~~9.2.2, "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 off-peak, etc.).

995-2.~~8~~9.2.2 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~~9.2.3.

995-2.~~8~~9.2.3 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~~10 Traffic Data Detection System Acceptance Requirements:

995-2.~~9~~10.1 Data Accuracy: The vehicle detection system shall be capable of meeting the minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer.

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 995-2.

995-2.~~9~~10.2 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~~10.2.1, “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 off-peak, 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
VA = Volume accuracy

995-2.910.2.1 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 995-2.910.2.2, "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 off-peak, etc.).

995-2.910.2.2 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 995-2.910.2.3.

995-2.910.2.3 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

995-2.910.3 Calculation of Speed 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 995-2.910.3.1 represents the ground truth average speed computation procedure for a particular lane during a specific time period. The equation in 995-2.910.3.2 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 995-2.910.3.1 and 995-2.910.3.2, 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~~10.3.1 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~~10.3.2 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~~10.3.3, "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 off-peak, etc.).

995-2.~~9~~10.3.3 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~~10.3.3, over all lanes.

In the equation in 995-2.~~9~~10.3.4, "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 off-peak, etc.).

995-2.~~9~~10.3.4 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~~10.3.5.

995-2.~~9~~10.3.5 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~~ 11 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 match rate of 5% for probe data detection systems that match upstream and downstream detection of the same vehicle

2. 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~~11.1 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~~11.1.1 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~~ 12 Wrong Way Vehicle ~~(WWVDS)~~ Detection System Accuracy ~~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 FDOT 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.~~To verify conformance with the accuracy requirements in this Section and as a precondition for listing on the APL, sample data collected from the WWVDS 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).

WWVDS accuracy testing shall be performed under controlled conditions at the TERL facility. The wrong way vehicle detection system must be capable of meeting a true positive detection accuracy of 100% using a sample size of 100 wrong way vehicle runs. Sample data shall be collected over several time periods under a variety of conditions. System operation will be monitored for 72 hours. The wrong way vehicle detection system shall not exceed one false positive per 24-hours during the monitoring period.

995-2.12.1 Calculation of WWVDS) System Accuracy: Determine true positive detection accuracy by dividing the number of valid wrong way vehicle detections by the number of vehicles.

995-2.12.1.1 Wrong Way Vehicle Detection System Accuracy expressed as a Percentage:

$$TPDA = \frac{WWVD}{N}\ x\ 100$$

Where:

TPDA = True Positive Detection Accuracy

WWVD = Number of Wrong Way Detections reported by system

N = Total number of wrong way vehicle runs

SUBARTICLE 995-4.2.7 is deleted and the following substituted:

995-4.2.7 Backplates: Backplates may be constructed of either aluminum or plastic. Minimum thickness for aluminum backplates is 0.060 inch and the minimum thickness for plastic backplates is 0.120 inch. Backplate thickness measurement must not include the retroreflective sheeting thickness. The ~~required~~ width of the top, bottom, and sides of backplates must measure between five to six inches. Color of backplates must be black in accordance with 995-4.2.5.~~Backplate thickness measurement must not include the retroreflective sheetinthickness.~~

If backplates are mechanically attached, provide a minimum of four corner mounting attachment points per signal section (for example, a three-section signal assembly would have 12 mounting points). Attachment points must not interfere with the operation of traffic signal section doors. Backplate outside corners must be rounded and all edges must be de-burred.

If louvers are provided, louver orientation must be vertical on sides and horizontal on top and bottom of the backplate and must be at least 1/2 inch from the inner and outer edge of the backplate panel. Universal backplates must fit all traffic signals listed on the APL.

Mount the backplate securely to the signal assembly with Type 316 or 304 passivated stainless steel installation hardware. Backplates, if mechanically attached, must be marked in accordance with 995-1, on the long sides of the backplate.

Backplates must include retroreflective borders using Type IV yellow retroreflective sheeting listed on the APL. Place a 2-inch border on the entire outer perimeter of the backplate panel, no closer than 1/2 inch from any louvers.

All materials must be designed for exterior use and be UV stable.

995-4.2.7.1 Flexible Backplates: Flexible backplates must allow the entire length of longer portions of the backplate to flex 90 degrees, or until the backplate width is reduced to 2.5 inches or less, when influenced by high wind conditions, and return to zero degrees after the wind conditions subside. Flexible backplates must maintain visibility of the retroreflective border to approaching traffic, with up to 40 mph winds.

SUBARTICLE 995-6.4 is deleted and the following substituted:

995-6.4 Cabinets, Housings, and Hardware: Cabinets used as part of the midblock crosswalk enhancement assembly must be currently listed on the APL or meet the requirements of Section 676.

All housings other than approved cabinets must be powder coat painted dull black per SAE AMS-STD-595A~~FED-STD-595-37038)~~ with a reflectance value not exceeding 25 percent as measured by ASTM E1347. Cabinets and housings must prevent unauthorized access.

Pole-mount assemblies shall allow installation on 4-1/2 inch outer diameter posts.

Ensure all assembly hardware, including nuts, bolts, external screws, and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel. Stainless steel bolts, screws, and studs must meet ASTM F593. Stainless steel nuts must meet ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized. Carbon steel bolts, studs, and threaded rod must meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

SUBARTICLE 995-6.6 is deleted and the following substituted:

995-6.6 Environmental Specifications: All electronic assemblies shall operate as specified during and after being subjected to the transients, temperature, voltage, humidity, vibration, and shock tests described in NEMA TS2-2021, 2.2.7, 2.2.8, and 2.2.9. Electronics must meet FCC Title 47, Subpart B, Section 15. The optical portion of the housing shall be sealed to provide an IP 67 rating.

SUBARTICLE 995-8.3 is deleted and the following substituted:

995-8.3 Preemption System Cabinet Electronics: The priority and preemption system must be compatible with NEMA TS 1, NEMA TS 2, Type 170, and Type 2070 traffic signal controllers and their respective cabinets.

The system must be able to provide calls to the controller via input file and detector rack. The system must include two channel or four channel detector card units ~~compatible with NEMA TS 2-2003 v02.06~~. The system must include a shelf mount option.

The system must be able to provide emergency preemption (high priority) and transit signal (low priority) preemption calls to the controller. Detectors must include programmable timers that allow the operator to configure detector call extension as well as limit the length of channel output calls.

Channel outputs must deliver a constant signal while emergency vehicles are detected for high priority preemption activation. Channel outputs must deliver a pulsed output for low priority preemption activation. Inputs and outputs must be optically isolated.

995-8.3.1 Serial Interface: Ensure that the serial ports support data rates up to 115 kbps; error detection procedures utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2). Serial interface ports may utilize RJ-45 connectors, D-sub connectors, or screw terminals.

995-8.3.2 Network Interface: Ensure that LAN connections support the requirements detailed in the IEEE 802.3 Standard for 10/100 Ethernet Connections. Ensure that the connector complies with applicable TIA requirements.

SUBARTICLE 995-8.8 is deleted and the following substituted:

995-8.8 Environmental Specifications: Ensure system electronics perform all required functions during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9. Detectors and detector connections that are exposed to the elements must be weatherproof and designed for outdoor use.

ARTICLE 995-10 is deleted and the following substituted:

995-10 Traffic Controllers.

Traffic controllers must meet the industry standards in Table 995-6.

Table 995-6 Traffic Controller Standards	
Device	Standard
NEMA TS2 Controller	NEMA TS2-2021
Model 2070 Controller	CALTRANS TEES, 2020
Note: All controllers must meet AASHTO/ITE/NEMA ATC 5201, v06.25.	

All controllers must provide functionality that meets or exceeds operational characteristics, including NTCIP support, as described in NEMA TS2-2021.

All controllers must:

1.Capture all mandatory event-based data elements listed in supplemental requirement SR-671-2, Supplemental Traffic Controller High Resolution Data Logging Requirements, as published on the Department's State Traffic Engineering and Operations Office website at the following URL: https://www.fdot.gov/traffic/Traf-Sys/Product-Specifications.shtm.

2. Provide and make Management Information Bases (MIBs) available for Traffic Signal Controller Broadcast Messages (TSCBM) to local agencies and FDOT that are compatible with SAE J2735~~-2016-03~~.

3. Support programming of destination Internet Protocol (IP) addresses via controller front panel for interface with Roadside Units (RSU) and other devices or systems.

SUBARTICLE 995-11.1 is deleted and the following substituted:

995-11 Traffic Cabinets.

995-11.1 General: Cabinets must be permanently marked with a label including the manufacturer's name or trademark, model/part number, and the year and month of manufacture. Place the label on the inside of the main door using a water-resistant method. The label must be visible after installation.

Painted and unpainted cabinets must meet the applicable requirements in Aluminum Cabinets, NEMA TS-2--2021~~16, 7.7.2~~.

SUBARTICLE 995-11.2 is deleted and the following substituted:

995-11.2 NEMA Traffic Signal Controller Cabinets: Provide NEMA traffic signal controller cabinets with all terminals and facilities necessary for traffic signal control meeting the following requirements:

NEMA TS1 Controller Cabinet~~——~~……NEMA TS-1--1989

NEMA TS2 Controller Cabinet……~~——~~NEMA TS-2-~~-2016~~2021

995-11.2.1 Documentation: Provide four paper copies of the cabinet wiring diagram with each cabinet. The nomenclature of signal heads, vehicular movements and pedestrian movements on the wiring diagram must be in accordance with the signal operating plan.

Documentation must include a list identifying the termination points of cables used for vehicular and pedestrian signal heads, detector loop lead-ins, and pedestrian pushbutton wires.

A heavy duty, resealable plastic opaque bag must be mounted on the backside of main cabinet door for storing cabinet documentation.

995-11.2.2 Police Switches: Provide the following police switches with Type 3 and larger controller cabinets. The switches must be mounted on the police panel and identified as to their function.

1. AUTO-FLASH: When this switch is in the FLASH position, all signal indications must immediately transfer to the flashing mode. AC power shall be removed from the load switches and stop timing applied to the controller unit. When this switch is placed in the AUTO position the controller unit must operate in accordance with the appropriate specification.

2. MANUAL ON-OFF: When this switch is in the on position, a logic ground must be applied to the manual control enable input of the controller unit.

3. MANUAL JACK: Install a manual jack on the police panel. The jack must mate with a three circuit, 1/4 inch diameter phone plug. Connect the tip and ring (middle) circuits of the jack to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground must be connected to the interval advance input of the controller unit.

Provide a manual pushbutton with Type 3 and larger cabinets. The pushbutton cord must have a minimum length of six feet with a 1/4 inch diameter three circuit plug connected to one end and a hand held manual pushbutton at the other end. With the exception of the vehicular yellow and all red clearance intervals, a complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval that is active. Cycling the push-button during the vehicular yellow or all red clearance intervals must not terminate the timing of those intervals.

995-11.2.3 Service Switches: Service switches must be mounted on the service panel or other locations approved by the Department and identified as to their functions. Provide the following service switches with Type 3 and larger cabinets.

1. SIGNALS ON-OFF: When this switch is in the off position, AC power shall be removed from all signal heads. The SIGNALS ON-OFF switch must be connected to the control input of a contactor (displacement relay). Current supplied to the switch must not exceed five amperes (amps) total. Do not directly route the main signal head power bus and cabinet power through the service or police switches.

2. AUTO-FLASH: When this switch is in the FLASH position, all signal indications must transfer to the flashing mode in accordance with the Uniform Code Flash (UCF) requirements. AC power shall be removed from the load switches when the signal indications transfer to the flashing mode. The controller unit must operate in accordance with appropriate specifications during the flashing mode. When the switch is placed in the AUTO position, transfer from the flash mode to normal operation shall be made in accordance with UCF requirements.

3. CONTROLLER ON-OFF: When this switch is in the off position, AC power shall be removed from the controller.

4. AUX POWER ON-OFF: When this switch is in the off position, AC power shall be removed from all circuits of the cabinet except for the duplex receptacle, cabinet light and ventilation fan.

5. VEHICLE DETECTORS: A detector test switch must be provided for each phase of the controller unit. Detector test switches must include a position for normal

operation (phase receives calls from detectors), a position that provides a constant call, and a position that provides a momentary call.

995-11.2.4 Doors and Locks: Provide Type 3 and larger cabinets with a hinged, rain tight and dust tight police door which allows access to the police switches and manual jack.

Locate the police door in the bottom half of the main door for Type 3 and 4 pole mount cabinets. Locate the police door in the upper half of the main door for Type 4 and larger base mount cabinets.

Hinges and hinge pins must be constructed of stainless steel and prevent the door (main or police) from sagging. Hinges for the main and police doors must be 14 gauge and be located on the right side (viewed from the front).

Type 3 and larger cabinets must be furnished with a three point draw roller latching system consisting of the following latching points:

1. Center of the cabinet (lock)
2. Top of the cabinet--controlled by the door handle
3. Bottom of the cabinet--controlled by the door handle

The latching points on the top and bottom of the cabinet must remain in the locked position until the main cabinet door lock is unlocked. The locking mechanism must be equipped with nylon rollers to secure the top and bottom of the door.

Type 3 and larger cabinets must be furnished with a door stop which retains the main door open in a 90 degree and 120 degree position.

995-11.2.5 Police and Service Panels: Provide a police service panel with Type 3 and larger cabinets. The panels may be constructed of either sheet aluminum or cast aluminum. Locate the police panel behind the police door attached to the main door. The service panel must be mounted on the back side of the police panel. The police panel must have the following minimum dimensions:

1. Height – 4 inches
2. Width – 8 inches
3. Depth – 2-1/2 inches

995-11.2.6 Ventilation: Type 1 and 2 cabinets must be vented to allow dissipation of the heat generated by the equipment housed inside the cabinet.

Type 3 and larger cabinets must have dual, UL listed, thermostatically controlled fans, rated for continuous duty with a service life of at least ~~three~~ 3 years. Mount thermostats on the inside top of the cabinet. Thermostats must be user adjustable to allow temperature settings ranging from a minimum of 70°F to a maximum of 140°F and capable of activating the fans within plus or minus 5 degrees of the set temperature. The intake vent must be rain tight, located on the bottom half of the cabinet, and covered with a removable filter.

995-11.2.7 Shelves: Type 2 cabinets must be furnished with one shelf. Type 3 and larger cabinets must be furnished with two adjustable shelves. Shelves must be adjustable in a maximum of 2-inch increments from the top of the load panel to 12 inches from the top of the controller cabinet.

995-11.2.8 Mounting Hardware: Type 1, 2, and 3 cabinets must be supplied with hardware for attaching the top and bottom half of the cabinet onto a flat or round surface. Optional wall or pole mount hardware must be provided for mounting Type 4 cabinets in specific installations.

Type 4 cabinets must have rigid tabs attached to the bottom of the cabinet. Type 5 cabinets must have rigid brackets attached to the bottom of the cabinet. Rigid brackets and tabs must be constructed of the same material used for the cabinet.

Type 4 and larger cabinets must be provided with one of the following alternatives for fastening to a concrete base:

1. Galvanized anchor bolts, nuts, lock washers, and flat washers in accordance with ASTM A153. The anchor bolts must be at least 1/2 inch in diameter, seven inches in vertical length with at least three inch horizontal, or

2. Heavy duty machine bolt anchors, flat washers, lock washers and machine screws with at least 1/2 inch thread diameter.

995-11.2.9 Electrical: Fabricate ground busbars of copper or aluminum alloy material compatible with copper wire and provide at least two positions where No. 2 AWG stranded copper wire can be attached.

Mount a ground busbar on the side of the cabinet wall adjacent to the power panel for the connection of AC neutral wires and chassis ground wires.

If more than one ground busbar is used in a cabinet, a minimum of a No. 10 AWG copper wire must be used to interconnect them.

995-11.2.9.1 Wiring: All wiring must be laced. All conductors in the cabinet must be stranded copper.

All inputs and outputs must be terminated on terminal strips. A connector harnesses for the controller, conflict monitor, vehicle detectors, and other controller accessory equipment must be furnished and wired into the cabinet circuitry.

A vehicle detector harness or rack must be furnished with the cabinet. Terminal strip circuits must be provided for connection of the loop lead-in cable.

995-11.2.9.2 Terminal Strips: The voltage and current rating of terminal strips must be greater than the voltage and current rating of the wire which is terminated on the terminal strip.

Conductors must be terminated on terminal strips with insulated terminal lugs. A calibrated ratchet crimping tool must be used to terminate the conductor in the terminal lug.

When two or more conductors are terminated on field wiring terminal strip screws, a terminal ring lug shall be used for termination of those conductors. All terminal strip circuits must be numbered.

995-11.2.9.3 Cabinet Light and Receptacle: For Type 3 and larger cabinets, provide one or more light fixtures that illuminate the entire interior of the cabinet. All lighting fixtures must automatically turn on when the cabinet doors are opened and off when the doors are closed.

Mount and wire a three-wire 115 V_{AC} duplex receptacle in all cabinets. The receptacle must be protected by a 15A circuit breaker. Do not mount the receptacle on the main cabinet door or police and service switch panels.

995-11.2.9.4 Main Circuit Breaker: Provide a 15A circuit breaker with Type 1 and 2 cabinets, and a 30A circuit breaker with Type 3 and larger cabinets.

The main circuit breaker must turn off all power to the cabinet and shall not be used for the power switch located in the service panel.

995-11.2.9.5 Radio Interference Suppression: A radio interference suppressor must be provided in series with the AC power before it is distributed to any

equipment inside the cabinet. The suppressor must provide a minimum attenuation of 50 decibels over a frequency range of 200 kHz to 75 MHz when used with normal installations and shall be hermetically sealed in a metal case.

The radio interference suppressor must have the same minimum current rating as the main circuit breaker.

The ground connection of the radio interference suppressor must be connected only to AC neutral and shall not be connected to earth ground directly.

995-11.2.9.6 Optically Isolated Inputs: The Opto common input is the common reference pin for four optically isolated inputs.

The Opto inputs are intended to provide optical isolation for pedestrian detector and remote interconnect inputs. The Opto inputs are intended to connect through external 27 K ohm, 1 W resistors for 120 V_{AC} operation and are intended for direct connection to 12 V_{AC} from the cabinet power supply for pedestrian detector applications. These inputs may alternatively be used for low-true DC applications when the Opto common pin is connected to the 24 V supply.

The Opto inputs shall provide electrical isolation of 10 megohms minimum resistance and 1000 V_{AC} RMS minimum breakdown to all connector pins except the Opto common pin. These inputs shall exhibit nominal impedance to the Opto common pin of 5 K ohm, plus or minus 10 percent, and shall require 2.4 mA, plus or minus 10 percent, from a nominal 12 V_{AC} supply. The Opto inputs shall not recognize 3 V_{AC} RMS or less relative to the common input and recognize 6 V_{AC} RMS or more relative to the common input. Any steady state voltage applied between an Opto input and the Opto common shall not exceed 35 V_{AC} RMS. Opto inputs shall not be acknowledged when active for 25 ms or less, and shall be acknowledged when active for 50 ms or more.

995-11.2.9.7 Load Resistors: A load resistor or capacitor must be installed between the AC (common) and each signal field wiring terminal for the yellow, green and walk indication. All load resistors and capacitors must be on the front side of any panel used in the cabinet.

995-11.2.9.8 Surge Protection: Furnish surge protective devices (SPDs) for the main AC power input, all signal head field wiring terminals, interconnect cable terminals and loop lead-in cable terminals which are located in the cabinet. SPDs must be unobstructed and accessible from the front side of any panel used in the cabinet. Cabinets utilizing Din rail mounted SPDs must be grounded with a conductor to the cabinet busbar.

The SPD for the main AC power input of the cabinet must be connected on the load side of the cabinet circuit breaker.

SPDs for signal and interconnect cable field wiring terminals must meet the following:

1. Clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected.

2. Withstand a surge current of 1000A with an 8 by 20 µs waveform six times (at 1 second intervals between surges) without damage to the suppressor.

SPDs for loop lead-in cables must be designed in accordance with the following requirements:

1. Protect the detector unit loop inputs against differential (between the loop lead) surges, and against common mode (between loop leads and ground) surges.

2. Clamp the surge voltage to 25 V or less when subjected to repetitive 300A surges.

3. Withstand repetitive 400A surges with an 8 by 20 µs waveform without damage.

SPDs must be installed according to the SPD manufacturer's instructions and not affect the operation of detectors. SPD leads must be kept as short as possible.

SUBARTICLE 995-11.3 is deleted and the following substituted:

995-11.3 Type 170 Traffic Signal Controller Cabinets: Provide Type 170 traffic signal controller cabinets with all terminals and facilities necessary for traffic signal control and meeting the following requirements:

Model 332, 334 and 336S Cabinets…….

CALTRANS TEES 2009

Model 336S cabinet must incorporate input surge protection mounted on a fold-down termination panel at the input file.

Model 332 cabinets must incorporate a lower input termination panel. Model 332 and 334 cabinets must be base mounted. The Model 332 cabinet must have an auxiliary MODEL 420 output file, and be configured for 8 vehicle, 4 pedestrian, and 4 overlaps.

Model 552A designation is given to Model 332 cabinet assemblies that include a swing-out EIA 19-inch rack cage.

Model 662 designation is given to Model 552A cabinets with a 66 inch height.

Cabinets must comply with figures for traffic control signals and devices available on the Department's State Traffic Engineering and Operations Office website at the following URL:
https://www.fdot.gov/traffic/Traf_Sys/Product-Specifications.shtm.

All terminals and facilities on panels must be clearly identified using permanent silk-screened text.

995-11.3.1 Base Plate and Mounting Brackets: Provide cabinets with a standard base mounting bolt pattern and a minimum of two aluminum plates welded inside for anchoring to a concrete or composite base.

995-11.3.2 Output File: Fabricate the output file using a "hard wired" harness. Printed board circuit boards are not acceptable.

995-11.3.3 Shelf: Provide an aluminum shelf with storage compartment in the rack below the controller (for remote secondary monitor/lap top computer use). The storage compartment must have telescoping drawer guides for full extension. The compartment top must have a non-slip plastic laminate attached. Provide an RS-232 connector for communications to the C2S port.

995-11.3.4 Loads: Provide dummy loads consisting of 4.7k resistors rated at five watts minimum for Greens, Peds, and Yellows. The dummy loads must be mounted on a terminal block in the rear of the output file or other approved location. Wire one side of each dummy load to AC return in a manner that allows a technician to easily attach the load to outputs from selected load switches.

995-11.3.5 Cabinet Light: Provide one or more light fixtures that illuminate the entire interior of the cabinet. All lighting fixtures must automatically turn on when the cabinet doors are opened and off when the doors are closed.

995-11.3.6 Surge Protection: Provide each cabinet with devices to protect equipment from surges. Surge protector termination panels must be attached to the cabinet rack assembly and allow sufficient space for connections, access, and surge protector replacement. AC isolation terminals must be on the same side of the cabinet as the AC service inputs. DC terminals and loop detector terminals must be installed on the opposite side of the cabinet from the AC power lines.

Surge protection for 332A cabinets must be mounted on the lower input termination panel.

Surge protection for 336S cabinets must be mounted on a custom fold down termination panel at the input file.

Under no circumstance (normal operation or short-circuit condition) shall the amperage capacity of the internal wiring and printed circuit board traces be less than the protecting threshold of circuit breakers and surge protectors provided.

995-11.3.6.1 Power Distribution Assembly Protection: The power distribution assembly (PDA) SPD must be a two-stage series/parallel device that meets or exceeds the following:

1. Maximum AC line voltage: 140 V_{AC}
2. 20 pulses of peak current, each of which will rise in 8 microseconds and fall in 20 microseconds to one-half the peak: 20kA.
3. The protector must include the following terminals:
    a. Main line (AC Line first stage terminal)
    b. Main Neutral (AC Neutral input terminals)
    c. Equipment Line Out (AC Line second stage output terminal, 10A)
    d. Equipment Neutral Out (Neutral terminal to protected equipment)
    e. Ground (Earth connection)
4. The main AC line in and the equipment line outer terminals must be separated by a 200 microhenry (minimum) inductor rated to handle 10A AC service
5. The first stage clamp shall be between Main Line and ground terminals
6. The second stage clamp shall be between Equipment Line Out and Equipment Neutral
7. The protector for the first and second stage clamp must have a metal oxide varistor (MOV) or similar solid state device, rated 20 kA.

The main neutral and equipment neutral output shall be connected together internally and shall have an MOV (or similar solid state device, or gas discharge tubes) rated at 20 kA between main neutral and ground terminals.

The PDA SPD must have a peak clamp voltage of 250V at 20 kA (voltage measured between equipment line out and equipment neutral out terminals, current applied between main line and ground terminals with ground and main neutral terminals externally tied together).

The PDA SPD must have a maximum let through voltage not exceeding 500 Vpk using an 8 by 20 µs/1.2 by 50 µs; 6 kV, 3 kA surge. The SPD must either be epoxy-encapsulated in a flame retardant material or utilize thermally protected varistors and be designed for continuous service current of 10A at 120 V_{AC} RMS. Power to the Type 170E controller and to the 24V power supply must be provided from the equipment line out terminal of the PDA SPD.

995-11.3.6.2 Inductive Loop Detector Protection: Protect each inductive loop detector input channel with an external SPD that meets or exceeds the following:

1. The SPD must be a three-terminal device, two of which shall be connected across the signal inputs of the detector. The third terminal shall be connected to chassis ground to protect against common mode damage.

2.The SPD must instantly clamp differential mode surges (induced voltage across the loop detector input terminals) via a semiconductor array. The array shall be designed to appear as a very low capacitance to the detector.

3. The SPD must clamp common mode surges (induced voltage between the loop leads and ground) via solid state clamping devices.

4. Peak Surge Current
    a. Differential Mode: 400A (8 by 20 µs)
    b. Common Mode: 1000A (8 by 20 µs)
    c. Estimated Occurrences: 500 @ 200A
5. Response Time: 40 ns
6. Input Capacitance 35 pF typical
7. Clamp Voltage
    a. 30V max @ 400A (Differential Mode)
    b. 30V max @1000A (Common Mode)

995-11.3.6.3 Signal Load Switch Protection: The outputs of each load switch in the output file shall be provided with a MOV connected from the AC positive field terminal to the chassis ground. The MOV must be rated 150 V_{AC} and shall be a V150LA20A (or approved equal).

995-11.3.6.4 Communication Input Protection: Each low voltage communication input must be protected as it enters the cabinet with a hybrid two-stage SPD that meets or exceeds the following:

1. The SPD must be a dual pair (four-wire) module with a double-sided, gold-plated printed circuit board connector.

2. The SPD must be installed in a ten-circuit card edge terminal block (PCB1B10A).

3. The SPD must be utilized as two independent signal pairs. The data circuits must pass through the SPD in a serial fashion.

4. Peak Surge Current
    a. 10kA (8 by 20 µs)
    b. Occurrences at 2000A: greater than 100
5. Response Time: less than 1 ns
6. Clamp Voltage: 30V maximum
7. Series Resistance: greater than 15 ohms per line
8. Primary Protector: 3 element gas tube

9. Secondary Protector: Solid state clamp (1.5 kW minimum)

The line side of the SPD must be connected to the communication field wires, the load side connected to the communication connector of the controller, and the ground terminal connected to chassis ground.

995-11.3.6.5 Low Voltage DC input protection: Each DC input must be protected by an SPD that meets or exceeds the following:

(a) The SPD must be a 5 terminal device. Two terminals must be connected to the line side of the low voltage pair, two terminals must be connected to the input file side, and the fifth terminal connected to chassis ground.

(b)Peak Surge Current

2 kA (8 by 20 µs)

Occurrences at peak current: 100 (typical)

(c) Response Time: 5-30 ns

(d) Shock: Must withstand 10-foot drop on concrete

(e) Clamp Voltage: 30V

(f) Series Resistance: greater than 15 ohms each conductor

995-11.3.6.6 Preemption and 115V AC signal input protection: Each preemption or AC signaling input channel must be protected by an external SPD that meets or exceeds the following requirements:

(a) The SPD must be a 3 terminal device

(b) Peak Surge Current

2000A (8 b 20 µs)

Occurrences at peak current: 25 (minimum)

(c) Response Time: less than 200 ns

(d) Peak Surge Trip Point: less than 890V nominal

~~**995-11.3.7 Model 210 Conflict Monitor with Absence of Red Monitoring:** The conflict monitor must be a Model 210 "PLUS" conflict monitor capable of detecting fault sequencing of signals on a per channel basis (i.e., short or absence of yellow interval and/or simultaneous dual indications). All integrated circuits having 14 pins or more must be socket mounted.~~

~~**995-11.3.7.1 Absence of Red Monitoring:** The conflict monitor must be capable of monitoring for the absence of voltage on all of the inputs of a channel (defined here as red, yellow, and green). If an output is not present on at least one input of a channel at all times, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the unit shall not trigger. If this condition exists for more than 1000 milliseconds, the unit shall trigger as if a conflict had occurred, causing the intersection to transfer immediately into a flashing mode, and "stop-time" to be applied to the controller. A red signal shall require the presence of a minimum of 60 $V_{AC,}$ plus or minus 10 $V_{AC,}$ to satisfy the requirements of a red indication. The red input signals shall be brought into the conflict monitor through an auxiliary connector on the monitor's front panel. Provide a similar connector on the output file, with a removable harness connecting the two. Provide an indicator on the front panel of the monitor to identify the triggering of the monitor in response to the absence of red condition.~~

995-11.3.7~~.2~~ Red Monitor Harness: A connector and terminal assembly designated as P20 for monitoring the absence of red, shall be an integral part of the output file. The connector must terminate, and be compatible with, the cable and connector of a

Type 170 conflict monitor unit (CMU), capable of monitoring the absence of red. Provide the pin assignments of the P20 connector and terminal assembly with the cabinet plans. The P20 connector shall be physically like the cable and connector of a Type 170 CMU to prevent the absence of red cable connector from being inserted into the P20 connector 180 degrees out of alignment.

995-11.3.7.~~3~~ 1 Programming of Unused Red Channels: Provide all cabinet assemblies with a means of programming unused red channels by installing jumpers from red monitor inputs to 115 V_{AC}. The connecting terminals for the jumpers must be accessible and located in the same terminal block for all 16 channels to assure full compatibility of all cabinet assemblies with "210 Plus" conflict monitor units.

995-11.3.8 Police Door and Panel: Provide cabinets with police doors and panels. The police panel must include text informing officers that yellow and all-red clearance intervals are timed internally.

Police switch panels must include a manual jack. The jack must mate with a three circuit, 1/4-inch diameter phone plug. Connect the tip and ring (middle) circuits of the jack to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground must be connected to the interval advance input of the controller unit.

The pushbutton cord must have a minimum length of six feet with a 1/4-inch diameter three circuit plug connected to one end and a hand held manual pushbutton at the other end. With the exception of the vehicular yellow and all red clearance intervals, a complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval that is active. Cycling the push-button during the vehicular yellow or all red clearance intervals must not terminate the timing of those intervals.

995-11.3.9 Technician Service Panel: Provide cabinets with a technician service panel which is mounted on the back side of the police panel (inside the main cabinet front door).

There must be two switches located on the technician service panel, clearly labeled according to the following functions:

(a) UCF – This toggle switch shall:

Place the intersection into Flashing Operation.

After meeting requirements for Flashing Operations, all power shall be removed immediately from signal load switches.

(b) Signal On/Off – This toggle switch shall disconnect all power to the signal lights through the use of a 60A contact switch placed in series with the load switch packs.

Labels must be silk screened directly on the panel.

995-11.3.10 Swing-out Rack Assembly: Provide 552-A cabinets with a pullout and rotatable rack assembly as well as an interface panel mounted on the top of the rack assembly and attached to the top shelf. The rack assembly must be constructed to house components designed to be installed in a standard EIA 19-inch rack and shall house the Controller, Input File, Output File No. 1, PDA No. 2, and a storage compartment.

Construct the rack and slide/hinged mounting brackets so that when the rack assembly (fully loaded) can be pulled out with one hand with complete ease of operation including rotation of the assembly.

The rack assembly must have a spring-loaded latch mechanism to secure the rack assembly inside the cabinet while in the "rest" position. When pulled out of the cabinet

at any point from its resting position (inside cabinet) to its full extension and rotation, the fully loaded rack assembly shall not cause any member of the assembly to bend, warp or bind. The rack must be made of one-inch square aluminum tubing with welded joints and extend and retract smoothly without noticeable friction or stress on roller guides, extension brackets, or other mechanical components. Maximum deflection of the entire rack assembly (with all equipment installed) shall not exceed 1/8 inch.

The rack assembly must have 12 technician test switches mounted to the interface frame assembly. Technician test switches must be of the momentary type and shall have eight vehicle and four pedestrian inputs.

The front of the rack assembly must be tapped with 10-30 threads with EIA universal spacing for 19-inch electrical equipment racks.

The rack assembly must be attached to the left cabinet wall through combination slide/hinged mounting brackets.

The slide/hinged mounting brackets must be fabricated from aluminum and/or stainless steel only.

Mounting bracket guides must utilize 7/8-inch stainless steel ball bearing rollers and allow extension and retraction of a loaded rack with minimal effort.

The rack assembly must be capable of rotating 210 degrees from its rest position after full extension from the cabinet.

The rack assembly must have a minimum 7/16-inch diameter aluminum rack stop rod attached to the inside left cabinet wall from the left side of the rack assembly to lock the rack into final position.

All cabinet harnesses must be long enough to maintain cabinet connections and functionality when the rack assembly is fully extended and rotated to its maximum limit. Harnesses must not bind or crimp when the rack is fully retracted, extended, or in motion.

995-11.3.11 Service Panels for 552A: The 552A cabinet must include a field service panel, auxiliary field service panel, and interface panel, all constructed of aluminum with a 1/8-inch minimum thickness. All components must be accessible from the front of the panels. Do not mount components or attach wires behind panels.

995-11.3.11.1 Field Service Panel: The field service panel must consist of terminal strips, circuit breakers, transient protection devices, load resistors, capacitors, cable tie mounts and associated wiring for making all field wiring connections. Mount the field service panel in the cabinet on the lower right exterior cabinet wall.

The field service panel must provide the necessary interconnecting junction points between the rack assembly and cabinet for the field service wires. The panel must be grouped for internal connections (jumpers) between terminals boards, wiring from the panel to the rack assembly, and wiring from the panel to the cabinet.

The field service panel wiring harness must have flexible wire covered by a flexible non-metallic conduit from the field service panel to the PDA, output file, and interface panel. The harness must have a metal clamp with a rubber grommet center attached to the field service panel to secure the harness to the panel for proper orientation of the harness with the rack assembly. Terminal strips for the panel shall be as listed below:

1. TBS1 - Terminal Block, Deadfront type, 3 position, No. 4 to No. 14 AWG wire range, 70A, 600V.

2. TBS2 - Terminal Block, Barrier, 16 position, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No. 16 AWG (max), 15A, 250V.

3. TBS3 - Terminal Block, Barrier, 20 position, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No 16 AWG (max), 15A, 250V.

4. TBS4 &TBS5 - Terminal Block, Barrier, 12 position, .438 Density, 6-32 x 1/4 BH Screw, Open Bottom, Double Row, No. 14 AWG (max), 20A, 250V.

The panel must have a main cabinet circuit breaker rated at 30A and a cabinet accessory circuit breaker rated at 15A for cabinet fans and light. Mount the circuit breakers near the back cabinet door on the panel.

The panel must include load resistors for all Walk, Green, Green Arrow, Yellow and Yellow Arrow Switch Pack outputs to prevent the conflict-voltage monitor from going into "Flash" due to a failed signal lamp. Load resistors must be 2K, 10 watt.

MOVs must be physically tied to one side of each terminal on TBS4 and TBS5 and be physically secured to the field service panel with a 6-32 screw.

995-11.3.11.2 Auxiliary Field Service Panel: The auxiliary field service panel must be mounted on the lower left interior cabinet wall and consist of a minimum of four terminal strips, 18 detector surge protectors and one pedestrian button isolation board assembly. The 18 surge protectors must be a three-terminal device, two of which are connected across the signal inputs of the detector for differential mode protection and the third terminal is grounded to protect against common mode damage. Mount the pedestrian button isolation board on the auxiliary field service panel. Terminal strips for the panel shall be Terminal Block, Barrier, 12 position, .438 Density, 6-32 x 1/4 BH Screw, Open Bottom, Double Row, No. 14 AWG (max), 20A, 250V.

Install a four-button pedestrian isolation board on the auxiliary field service panel to provide for the connection of the pedestrian buttons on phases 2, 4, 6 and 8. The board must provide electrical isolation of the field wiring to the internal cabinet wiring. The inputs to this isolation board shall be wired to terminal block TBA5 for connection to field wiring. The outputs of this board shall be carried through the harness to the input file to the proper wires that go to the interface extension panel of the controller.

The pedestrian button isolation board must include a PC board mounted on an aluminum panel with the following minimum dimensions:

Height: 2 inches
Width: 8 inches
Thickness: 1/8 to 3/16 inch

995-11.3.11.3 Interface Panel: The interface panel must consist of eight terminal strips, one telephone line suppressor and mounting fixture, two 24 V_{DC} relays and mounting fixtures, and all associated wiring for connecting the required interface equipment modules.

The front of the panel must be covered by a 1/4-inch clear plexiglass sheet, supported from the panel by four 1-1/2 inch standoffs. Secure the panels and cover using wing nuts that are removable without the use of tools. The plexiglass cover shall have 1/2-inch slot, centered over each of the terminal strips. All covers and panels must be interchangeable.

The panel wiring must provide the necessary interconnecting junction points between interface equipment cable harnesses and controller cabinet input and

output signal. The panel wiring provides the functional wiring information for connecting the interface equipment in the cabinet.

The panel wiring must be grouped for internal connections (jumpers between terminal boards) as well as wiring from the controller and related cabinet functions to the terminal boards on the interface panel.

Ground wires must be No. 14 AWG wire, minimum. The internal harnesses must be located between TB1, TB2 and TB3. The external and internal wiring must be located outside of TB1 and TB4, between TB2 and TB3.

Terminal strips shall be Barrier type, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No. 16 AWG (max), 15A, 250V. Terminals must use nickel/cadmium plated brass screws. All terminals and facilities on panels must be clearly identified using permanent silk-screened

The K1P and K2F relays shall be 15A miniature relays with polycarbonate cover, 2 form C (CO) contact arrangement, DC coil input, socket mount, .187 inch quick connect/solder terminals, AgCdO (15A) contacts, and 24 V_{AC} coil voltage with matching socket and hold down spring. All screws on the relay socket must be brass with nickel/cadmium plating.

995-11.3.12 Storage Compartment: Mount an aluminum storage compartment in the rack assembly. The storage compartment must have telescoping drawer guides for full extension of drawer from rack assembly and have a continuous front lip for opening the compartment top for storage. The top of the compartment must be non-slip plastic laminate.

Install a communication port on the right hand side of the drawer at the front for connecting to the communications port of the controller unit via the cabinet harness.

995-11.3.13 Cabinet Rails: Provide the cabinet with four cabinet rails for mounting wiring panels and various brackets. Rails must be keyhole design with slots 2 inches on center with a top opening diameter of 5/8 inch to allow the insertion of a 5/8 inch by 1 inch carriage bolt. The rails must be approximately 1-1/2 to 2 inches wide by 1/2 inch deep. Do not use unistruts or other rails.

995-11.3.14 Electrical: Do not use printed circuit boards in any controller cabinet subsystem file or panel, including but not limited to the output file (except for the red monitor program board), service panel, interface panel, and input file.

995-11.3.14.1 Wiring: Cut all wires to the proper length and neatly laced into cables with nylon lacing. No wire shall be doubled back to take up slack. Cables in the cabinet must not interfere with the routing and connection of field wiring. Cables must be secured with nylon cable clamps, unless specified otherwise. The position of cables between the components must be such that when the door is closed, it does not press against the cables or force the cables against the various components inside the controller cabinet.

Fabricate ground busbars of a copper or aluminum alloy material compatible with copper wire and provide at least two positions where a No. 2 AWG stranded copper wire can be attached. Mount a 6 inch ground busbar with screw terminals on the bottom flange on each side of the cabinet for connection of AC neutral wires and chassis ground. Attach a flexible ground strap between the left side ground busbar and the left side bottom rear of the rack assembly. Wiring harnesses must be covered by a flexible non-metallic conduit. Panel wire size must be a minimum of No. 18 AWG unless otherwise specified.

995-11.3.14.2 Terminals: Terminal connections must be soldered or constructed using a calibrated ratchet type crimping tool. Wiring must be traceable and without entanglement.

SUBARTICLE 995-11.5.7 is deleted and the following substituted:

995-11.5.7 Ventilation: Provide ventilation through the use of a louvered vent at the bottom of the door. Vent depth must not exceed 0.25 inch. Provide an air filter a minimum of 192 square inches and 1 inch thick behind the vent. The filter must be removable and held firmly in place so that all intake air is filtered.

Provide a bottom trough and a spring-loaded upper clamp to hold the filter in place. The bottom trough must drain any accumulated moisture to the outside of the field cabinet.

ITS field cabinets must have dual thermostatically controlled fans, with one thermostat per fan, rated for continuous duty with a service life of at least ~~three~~ 3 years. Mount thermostats on the inside top of the cabinet. Thermostats must be user adjustable to allow temperature settings ranging from a minimum of 70°F to a maximum of 140°F and capable of activating the fans within plus or minus 5 degrees of the set temperature. Use UL listed exhaust fans having a minimum air flow rating of 100 cubic feet per minute. Electric fan motors must have ball or roller bearings. Vent the exhaust air from openings in the roof of the field cabinet.

SUBARTICLE 995-11.7 is deleted and the following substituted:

995-11.7 Small Equipment Enclosures: Small equipment enclosures must be a minimum NEMA 3R rated and smaller than 16 inches wide by 24 inches tall by 12 inches deep. The enclosure must be constructed of aluminum or non-metallic materials. Enclosures must include a safe means of removing power from the installed equipment for servicing and replacement, such as a switch, fuse, or breaker. Discrete markings, such as manufacturer name and model, are permitted on the outside of small enclosures.

All fasteners less than 5/8 inch exposed to the elements must be Type 304 or 316 stainless steel.

Construct aluminum enclosures of 5052 sheet aluminum alloy with a minimum thickness of 0.090 inch. Aluminum enclosures must have a uniform natural finish or be powder coat painted in accordance with AAMA-2603-02 specifications. All welds, bends, and seams must be neatly formed and free of cracks, blow holes and other irregularities. All inside and outside edges of the enclosure must be free of burrs, rivet holes, visible scratches, and gouges and have a smooth, uniform finish.

Non-metallic enclosures must be ~~UL 508A listed, be rated~~designed for outdoor use, and resist chemicals, corrosion, and ultraviolet rays.

Enclosure doors must include a vandal resistant hinge and be secured with a locking latch or a minimum of two quick-release Type 304 or 316 stainless steel latches with padlock hasps. Removal of the hinge or hinge pin must not be possible while the enclosure is closed. Provide two sets of keys with each lock.

Enclosures may be vented. Holes larger than 1/8 inch must be covered by heavy duty screen.

Post mounted enclosures must be supplied with mounting hardware for attaching the enclosure to a 4-1/2 inch (OD) aluminum post.

SUBARTICLE 995-12.1 is deleted and the following substituted:

995-12 Traffic Controller Accessories.

995-12.1 General: Traffic controller accessories must meet the industry standards in Table 995-8 as well as the environmental requirements of those standards.

Table 995-8
Traffic Controller Accessory Standards

Device	Standard
Conflict Monitor	NEMA TS1-1989, Section 6
Malfunction Management Unit	NEMA TS2-2021, Section 4
Power Supply	NEMA TS2-2021, Section 5.3.5
Load Switch	NEMA TS2-2021, Section 6.2
Flasher	NEMA TS2-2021, Section 6.3
Bus Interface Unit	NEMA TS2-2021, Section 8
Model 206L Power Supply Unit	CALTRANS TEES, 2020, 3.4
Model 208 Monitor Unit	CALTRANS TEES, 2020, 3.5
Model 210 Monitor Unit	CALTRANS TEES, 2020, 3.6
Power Distribution Assembly	CALTRANS TEES, 2020, 6.4.3
Input File	CALTRANS TEES, 2020, 6.4.4

ARTICLE 995-12 is expanded by the following new Subarticle:

995-1~~1~~2.3.~~7~~ Model 210 Conflict Monitor with Absence of Red Monitoring: The conflict monitor must be a Model 210 "PLUS" conflict monitor capable of detecting fault sequencing of signals on a per channel basis (i.e., short or absence of yellow interval and/or simultaneous dual indications). All integrated circuits having 14 pins or more must be socket mounted.

995-1~~1~~2.3.~~7.~~1 Absence of Red Monitoring: The conflict monitor must be capable of monitoring for the absence of voltage on all of the inputs of a channel (defined here as red, yellow, and green). If an output is not present on at least one input of a channel at all times, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the unit shall not trigger. If this condition exists for more than 1000 milliseconds, the unit shall trigger as if a conflict had occurred, causing the intersection to transfer immediately into a flashing mode, and "stop-time" to be applied to the controller. A red signal shall require the presence of a minimum of 60 $V_{AC,}$ plus or minus 10 $V_{AC,}$ to satisfy the requirements of a red indication. The red input signals shall be brought into the conflict monitor through an auxiliary connector on the monitor's front panel. Provide a similar connector on the output file, with a removable harness connecting the two. Provide an indicator on the front panel of the monitor to identify the triggering of the monitor in response to the absence of red condition.

SUBARTICLE 995-14.3 is deleted and the following substituted:

995-14.3 Luminance: The sign face must be illuminated evenly across the entire surface. Contrast ratio between the background and legend ~~must be established by the lowest and the highest color retroreflective measurement and~~ shall be at least 4:1.~~Measure the retroreflectivity in accordance with ASTM D4956~~

995-14.3.1 Background Luminance: Minimum luminance for the legend portion of the street sign face must be no less than 87.5 lux. The luminance must be determined by averaging a minimum of seven readings. Four of the readings must be taken near the midpoint of a line that would span between the outside corners of the background and the outside corners of the legend. One reading must be taken near the midpoint of a line that would connect the top corner readings. One reading must be taken near the midpoint of a line that would connect the bottom corner readings. One reading must be taken near the vertical and horizontal midpoint of the sign.

995-14.3.2 Border and Lettering Luminance: Minimum luminance of the legend and border must be 350 lux. The luminance must be determined by averaging a minimum of 17 readings. There must be a minimum of one reading from each letter in the legend. Readings within the legend must alternate between the top, middle and bottom portion of each letter. Readings within top and bottom of the border must be perpendicular to the top and bottom readings in the background. Readings within the sides of the border must be taken parallel to the readings taken within each letter.

SUBARTICLE 995-14.7 is deleted and the following substituted:

995-14.7 Warranty: Internally illuminated signs must have a manufacturer's warranty covering defects for ~~five~~ 5 years from the date of final acceptance ~~by the Engineer in accordance with 5-11 and Section 608~~.

SUBARTICLE 995-15.7 is deleted and the following substituted:

995-15.7 Warranty: Highlighted signs must have a manufacturer's warranty covering defects for ~~three~~ 3 years from the date of final acceptance ~~by the Engineer in accordance with 5-11 and Section 608~~.

SUBARTICLE 995-16.8.3 is deleted and the following substituted:

995-16.8.3 Display System Hardware: The sign must utilize a system data interface circuit for communications between the sign controller and display modules. Except for embedded DMS, the following components must reside inside the sign housing: sign controller ~~(master or slave)~~, display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, EIA-232 null modem cables (minimum of ~~four~~ 4 ~~-~~feet long for connecting laptop computer to sign controller), and surge protective devices.

SUBARTICLE 995-16.8.4 is deleted and the following substituted:

995-16.8.4 Control Cabinet: A control cabinet that meets the requirements of Section 676 shall be provided. The minimum height of the cabinet must be 46 inches.

A ground control cabinet that includes the following assemblies and components: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming, a ~~four~~ 4~~-~~ foot long cable to connect laptop computers, a workspace for a laptop computer, and duplex outlets shall be provided.

All telephone, data, control, power, and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors shall be provided.

SUBARTICLE 995-16.13 is deleted and the following substituted:

995-16.13 Warranty: The DMS system and equipment must have a manufacturer's warranty covering defects for a minimum of ~~five~~ 5~~-~~ years from the date of final acceptance~~ by the Engineer in accordance with 5-11 and Section 608~~.

SUBARTICLE 995-17.2.16 is deleted and the following substituted:

995-17.2.16 Warranty: The EDS systems and equipment furnished must have a manufacturer's warranty covering defects ~~in assembly, fabrication, and materials~~ for a minimum of ~~three~~ 3~~-~~ years from the date of final acceptance.

SUBARTICLE 995-18.5 is deleted and the following substituted:

995-18.5 Warranty: Ensure all flashing beacons have a manufacturer's warranty covering defects for a minimum of ~~three~~ 3~~-~~ years from the date of final acceptance~~ in accordance with 5-11 and Section 608~~. Ensure the manufacturer will furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or maintaining agency within 30 calendar days of notification.

TRAFFIC CONTROL SIGNAL AND DEVICE MATERIALS.
(REV 8-2-23)

ARTICLE 995-2 is deleted and the following substituted:

995-2 Vehicle Detection Systems.

995-2.1 General: All parts shall be constructed of corrosion-resistant materials, such as UV stabilized or UV resistant plastic, stainless steel, anodized aluminum, brass, or gold-plated metal. All fasteners exposed to the elements shall be Type 304 or 316 passivated stainless steel.

If the assembly includes a cabinet, meet the requirements of Section 676.

Detectors shall meet the environmental requirements of NEMA TS 2-2021.

995-2.2 Inductive Loop Detector Units: Rack mount inductive loop detector units shall meet the requirements of NEMA NEMA TS 2-2021 and CALTRANS TEES 2020. 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 recommended by the video detection system manufacturer. Cameras that are integrated and included in a VVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

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 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 TS 2-2021, 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.

6. Cameras that are integrated and included in a MVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

995-2.4.3 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS2-2021, 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 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 TS2-2021, 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 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 interface 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. The SunGuide software requirements are listed in supplemental requirement SR-995-2.7.2-01, Supplemental Wrong Way Vehicle Detection System SunGuide HTTP Protocol, as published on the Department's State Traffic Engineering and Operations Office website at the following https://www.fdot.gov/traffic/Traf-Sys/Product-Specifications.shtm.

7. For WWVDS installed on ramps, the device shall:

a. Send an alert to the SunGuide® software when the wrong-way vehicle is detected.

b. Send 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.

c. Activate all highlighted signs associated with the WWVDS.

8. For WWVDS installed on mainline lanes, the device shall send an alert to the SunGuide® software when the wrong-way vehicle is detected.

9. Cameras that are integrated and included in a WWVDS shall be compliant with the Code of Federal Regulations Section 200.216 Prohibition on certain telecommunications and video surveillance services or equipment https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-C/section-200.216.

995-2.7.3 Electrical Specifications: Equipment shall operate on solar power or with an input voltage ranging from 89 to 135 V_{AC}. If the device requires operating voltages of less than 120 V_{AC}, supply the appropriate voltage converter. Solar powered systems shall be designed to operate for minimum of 5 activations per day and provide 10 days of operation without sunlight.

995-2.8 Light Detection and Ranging (LiDAR) Vehicle Detection System:

995-2.8.1 Configuration and Management: LiDAR systems 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 on superimposed on live images of the point cloud data produced by the system. The LiDAR system shall meet the following criteria:

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

995-2.8.2 LiDAR sensors: System sensors shall be recommended by the system manufacturer as part of the engineered LiDAR system solution. Detection range must extend up to at least 200 feet from the sensor. Multiple sensors shall be used to reduce occlusion and generate an accurate point cloud representation of the installation environment and detected objects.

995-2.8.3 Perception Software and Processor: The LiDAR system shall include a processor that combines data from multiple LiDAR sensors into a single point cloud for object detection, classification, presence detection, and data collection. The processor shall be a rugged industrial PC with CPU, memory, storage, a commercially available host operating system, and all software required for system operation. The processor shall include physical interfaces for connection of sensors, system inputs, and outputs.

995-2.8.4 Communications: All major system components shall include an Ethernet communications interface that provides a 10/100 Base TX connection. All unshielded twisted pair/shielded twisted pair network cables and connectors shall comply with TIA-568.

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.

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

995-2.8.5 Solid State Detection Outputs: Outputs shall meet the requirements of NEMA TS 2-2021, 6.5.2.26.

995-2.8.6 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.

995-2.9 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 TS2-2021, 6.5.2.17.

995-2.9.1 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 995-2.

Table 995-2
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.

995-2.9.2 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.

Within the equation in 995-2.9.2.1, "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

995-2.9.2.1 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 995-2 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 995-2.9.2.2, "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 off-peak, etc.).

995-2.9.2.2 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 995-2.9.2.3.

995-2.9.2.3 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

995-2.10 Traffic Data Detection System Acceptance Requirements:

995-2.10.1 Data Accuracy: The vehicle detection system shall be capable of meeting the minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer.

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 995-2.

995-2.10.2 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 995-2.10.2.1, “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 off-peak, 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
VA = Volume accuracy

995-2.10.2.1 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 995-2.10.2.2, "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 off-peak, etc.).

995-2.10.2.2 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 995-2.10.2.3.

995-2.10.2.3 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

995-2.10.3 Calculation of Speed 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 995-2.10.3.1 represents the ground truth average speed computation procedure for a particular lane during a specific time period. The equation in 995-2.10.3.2 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 995-2.10.3.1 and 995-2.10.3.2, 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

995-2.10.3.1 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.

995-2.10.3.2 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 ith 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 995-2.10.3.3, "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 off-peak, etc.).

995-2.10.3.3 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 995-2.10.3.3, over all lanes.

In the equation in 995-2.10.3.4, "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 off-peak, etc.).

995-2.10.3.4 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 995-2.10.3.5.

995-2.10.3.5 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

995-2.11 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 match rate of 5% for probe data detection systems that match upstream and downstream detection of the same vehicle
2. 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.

995-2.11.1 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.

995-2.11.1.1 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.

995-2.12 Wrong Way Vehicle Detection System 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 WWVDS 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).

WWVDS accuracy testing shall be performed under controlled conditions at the TERL facility. The wrong way vehicle detection system must be capable of meeting a true positive detection accuracy of 100% using a sample size of 100 wrong way vehicle runs. Sample data shall be collected over several time periods under a variety of conditions. System operation will be monitored for 72 hours. The wrong way vehicle detection system shall not exceed one false positive per 24-hours during the monitoring period.

995-2.12.1 Calculation of WWVDS) System Accuracy: Determine true positive detection accuracy by dividing the number of valid wrong way vehicle detections by the number of vehicles.

995-2.12.1.1 Wrong Way Vehicle Detection System Accuracy expressed as a Percentage:

$$TPDA = \frac{WWVD}{N}\ x\ 100$$

Where:

TPDA = True Positive Detection Accuracy

WWVD = Number of Wrong Way Detections reported by system

N = Total number of wrong way vehicle runs

SUBARTICLE 995-4.2.7 is deleted and the following substituted:

995-4.2.7 Backplates: Backplates may be constructed of either aluminum or plastic. Minimum thickness for aluminum backplates is 0.060 inch and the minimum thickness for plastic backplates is 0.120 inch. Backplate thickness measurement must not include the retroreflective sheeting thickness. The width of the top, bottom, and sides of backplates must

measure between five to six inches. Color of backplates must be black in accordance with 995-4.2.5.

If backplates are mechanically attached, provide a minimum of four corner mounting attachment points per signal section (for example, a three-section signal assembly would have 12 mounting points). Attachment points must not interfere with the operation of traffic signal section doors. Backplate outside corners must be rounded and all edges must be de-burred.

If louvers are provided, louver orientation must be vertical on sides and horizontal on top and bottom of the backplate and must be at least 1/2 inch from the inner and outer edge of the backplate panel. Universal backplates must fit all traffic signals listed on the APL.

Mount the backplate securely to the signal assembly with Type 316 or 304 passivated stainless steel installation hardware. Backplates, if mechanically attached, must be marked in accordance with 995-1, on the long sides of the backplate.

Backplates must include retroreflective borders using Type IV yellow retroreflective sheeting listed on the APL. Place a 2-inch border on the entire outer perimeter of the backplate panel, no closer than 1/2 inch from any louvers.

All materials must be designed for exterior use and be UV stable.

995-4.2.7.1 Flexible Backplates: Flexible backplates must allow the entire length of longer portions of the backplate to flex 90 degrees, or until the backplate width is reduced to 2.5 inches or less, when influenced by high wind conditions, and return to zero degrees after the wind conditions subside. Flexible backplates must maintain visibility of the retroreflective border to approaching traffic, with up to 40 mph winds.

SUBARTICLE 995-6.4 is deleted and the following substituted:

995-6.4 Cabinets, Housings, and Hardware: Cabinets used as part of the midblock crosswalk enhancement assembly must be currently listed on the APL or meet the requirements of Section 676.

All housings other than approved cabinets must be powder coat painted dull black per SAE AMS-STD-595A with a reflectance value not exceeding 25 percent as measured by ASTM E1347. Cabinets and housings must prevent unauthorized access.

Pole-mount assemblies shall allow installation on 4-1/2 inch outer diameter posts.

Ensure all assembly hardware, including nuts, bolts, external screws, and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel. Stainless steel bolts, screws, and studs must meet ASTM F593. Stainless steel nuts must meet ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter must be galvanized. Carbon steel bolts, studs, and threaded rod must meet ASTM A307. Structural bolts must meet ASTM F3125, Grade A325.

SUBARTICLE 995-6.6 is deleted and the following substituted:

995-6.6 Environmental Specifications: All electronic assemblies shall operate as specified during and after being subjected to the transients, temperature, voltage, humidity, vibration, and shock tests described in NEMA TS2-2021, 2.2.7, 2.2.8, and 2.2.9. Electronics

must meet FCC Title 47, Subpart B, Section 15. The optical portion of the housing shall be sealed to provide an IP 67 rating.

SUBARTICLE 995-8.3 is deleted and the following substituted:

995-8.3 Preemption System Cabinet Electronics: The priority and preemption system must be compatible with NEMA TS 1, NEMA TS 2, Type 170, and Type 2070 traffic signal controllers and their respective cabinets.

The system must be able to provide calls to the controller via input file and detector rack. The system must include two channel or four channel detector card units . The system must include a shelf mount option.

The system must be able to provide emergency preemption (high priority) and transit signal (low priority) preemption calls to the controller. Detectors must include programmable timers that allow the operator to configure detector call extension as well as limit the length of channel output calls.

Channel outputs must deliver a constant signal while emergency vehicles are detected for high priority preemption activation. Channel outputs must deliver a pulsed output for low priority preemption activation. Inputs and outputs must be optically isolated.

995-8.3.1 Serial Interface: Ensure that the serial ports support data rates up to 115 kbps; error detection procedures utilizing parity bits (i.e., none, even, and odd); and stop bits (1 or 2). Serial interface ports may utilize RJ-45 connectors, D-sub connectors, or screw terminals.

995-8.3.2 Network Interface: Ensure that LAN connections support the requirements detailed in the IEEE 802.3 Standard for 10/100 Ethernet Connections. Ensure that the connector complies with applicable TIA requirements.

SUBARTICLE 995-8.8 is deleted and the following substituted:

995-8.8 Environmental Specifications: Ensure system electronics perform all required functions during and after being subjected to the environmental testing procedures described in NEMA TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9. Detectors and detector connections that are exposed to the elements must be weatherproof and designed for outdoor use.

ARTICLE 995-10 is deleted and the following substituted:

995-10 Traffic Controllers.

Traffic controllers must meet the industry standards in Table 995-6.

Table 995-6
Traffic Controller Standards

Device	Standard
NEMA TS2 Controller	NEMA TS2-2021
Model 2070 Controller	CALTRANS TEES, 2020
Note: All controllers must meet AASHTO/ITE/NEMA ATC 5201, v06.25.	

All controllers must provide functionality that meets or exceeds operational characteristics, including NTCIP support, as described in NEMA TS2-2021.

All controllers must:

1.Capture all mandatory event-based data elements listed in supplemental requirement SR-671-2, Supplemental Traffic Controller High Resolution Data Logging Requirements, as published on the Department's State Traffic Engineering and Operations Office website at the following URL: https://www.fdot.gov/traffic/Traf-Sys/Product-Specifications.shtm.

2. Provide and make Management Information Bases (MIBs) available for Traffic Signal Controller Broadcast Messages (TSCBM) to local agencies and FDOT that are compatible with SAE J2735.

3. Support programming of destination Internet Protocol (IP) addresses via controller front panel for interface with Roadside Units (RSU) and other devices or systems.

SUBARTICLE 995-11.1 is deleted and the following substituted:

995-11 Traffic Cabinets.

995-11.1 General: Cabinets must be permanently marked with a label including the manufacturer's name or trademark, model/part number, and the year and month of manufacture. Place the label on the inside of the main door using a water-resistant method. The label must be visible after installation.

Painted and unpainted cabinets must meet the applicable requirements in Aluminum Cabinets, NEMA TS2-2021.

SUBARTICLE 995-11.2 is deleted and the following substituted:

995-11.2 NEMA Traffic Signal Controller Cabinets: Provide NEMA traffic signal controller cabinets with all terminals and facilities necessary for traffic signal control meeting the following requirements:

NEMA TS1 Controller Cabinet……NEMA TS1-1989
NEMA TS2 Controller Cabinet……..NEMA TS2-2021

995-11.2.1 Documentation: Provide four paper copies of the cabinet wiring diagram with each cabinet. The nomenclature of signal heads, vehicular movements and pedestrian movements on the wiring diagram must be in accordance with the signal operating plan.

Documentation must include a list identifying the termination points of cables used for vehicular and pedestrian signal heads, detector loop lead-ins, and pedestrian pushbutton wires.

A heavy duty, resealable plastic opaque bag must be mounted on the backside of main cabinet door for storing cabinet documentation.

995-11.2.2 Police Switches: Provide the following police switches with Type 3 and larger controller cabinets. The switches must be mounted on the police panel and identified as to their function.

1. AUTO-FLASH: When this switch is in the FLASH position, all signal indications must immediately transfer to the flashing mode. AC power shall be removed from the

load switches and stop timing applied to the controller unit. When this switch is placed in the AUTO position the controller unit must operate in accordance with the appropriate specification.

2. MANUAL ON-OFF: When this switch is in the on position, a logic ground must be applied to the manual control enable input of the controller unit.

3. MANUAL JACK: Install a manual jack on the police panel. The jack must mate with a three circuit, 1/4 inch diameter phone plug. Connect the tip and ring (middle) circuits of the jack to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground must be connected to the interval advance input of the controller unit.

Provide a manual pushbutton with Type 3 and larger cabinets. The pushbutton cord must have a minimum length of six feet with a 1/4 inch diameter three circuit plug connected to one end and a hand held manual pushbutton at the other end. With the exception of the vehicular yellow and all red clearance intervals, a complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval that is active. Cycling the push-button during the vehicular yellow or all red clearance intervals must not terminate the timing of those intervals.

995-11.2.3 Service Switches: Service switches must be mounted on the service panel or other locations approved by the Department and identified as to their functions. Provide the following service switches with Type 3 and larger cabinets.

1. SIGNALS ON-OFF: When this switch is in the off position, AC power shall be removed from all signal heads. The SIGNALS ON-OFF switch must be connected to the control input of a contactor (displacement relay). Current supplied to the switch must not exceed five amperes (amps) total. Do not directly route the main signal head power bus and cabinet power through the service or police switches.

2. AUTO-FLASH: When this switch is in the FLASH position, all signal indications must transfer to the flashing mode in accordance with the Uniform Code Flash (UCF) requirements. AC power shall be removed from the load switches when the signal indications transfer to the flashing mode. The controller unit must operate in accordance with appropriate specifications during the flashing mode. When the switch is placed in the AUTO position, transfer from the flash mode to normal operation shall be made in accordance with UCF requirements.

3. CONTROLLER ON-OFF: When this switch is in the off position, AC power shall be removed from the controller.

4. AUX POWER ON-OFF: When this switch is in the off position, AC power shall be removed from all circuits of the cabinet except for the duplex receptacle, cabinet light and ventilation fan.

5. VEHICLE DETECTORS: A detector test switch must be provided for each phase of the controller unit. Detector test switches must include a position for normal operation (phase receives calls from detectors), a position that provides a constant call, and a position that provides a momentary call.

995-11.2.4 Doors and Locks: Provide Type 3 and larger cabinets with a hinged, rain tight and dust tight police door which allows access to the police switches and manual jack.

Locate the police door in the bottom half of the main door for Type 3 and 4 pole mount cabinets. Locate the police door in the upper half of the main door for Type 4 and larger base mount cabinets.

Hinges and hinge pins must be constructed of stainless steel and prevent the door (main or police) from sagging. Hinges for the main and police doors must be 14 gauge and be located on the right side (viewed from the front).

Type 3 and larger cabinets must be furnished with a three point draw roller latching system consisting of the following latching points:

1. Center of the cabinet (lock)
2. Top of the cabinet--controlled by the door handle
3. Bottom of the cabinet--controlled by the door handle

The latching points on the top and bottom of the cabinet must remain in the locked position until the main cabinet door lock is unlocked. The locking mechanism must be equipped with nylon rollers to secure the top and bottom of the door.

Type 3 and larger cabinets must be furnished with a door stop which retains the main door open in a 90 degree and 120 degree position.

995-11.2.5 Police and Service Panels: Provide a police service panel with Type 3 and larger cabinets. The panels may be constructed of either sheet aluminum or cast aluminum. Locate the police panel behind the police door attached to the main door. The service panel must be mounted on the back side of the police panel. The police panel must have the following minimum dimensions:

1. Height – 4 inches
2. Width – 8 inches
3. Depth – 2-1/2 inches

995-11.2.6 Ventilation: Type 1 and 2 cabinets must be vented to allow dissipation of the heat generated by the equipment housed inside the cabinet.

Type 3 and larger cabinets must have dual, UL listed, thermostatically controlled fans, rated for continuous duty with a service life of at least 3 years. Mount thermostats on the inside top of the cabinet. Thermostats must be user adjustable to allow temperature settings ranging from a minimum of 70°F to a maximum of 140°F and capable of activating the fans within plus or minus 5 degrees of the set temperature. The intake vent must be rain tight, located on the bottom half of the cabinet, and covered with a removable filter.

995-11.2.7 Shelves: Type 2 cabinets must be furnished with one shelf. Type 3 and larger cabinets must be furnished with two adjustable shelves. Shelves must be adjustable in a maximum of 2-inch increments from the top of the load panel to 12 inches from the top of the controller cabinet.

995-11.2.8 Mounting Hardware: Type 1, 2, and 3 cabinets must be supplied with hardware for attaching the top and bottom half of the cabinet onto a flat or round surface. Optional wall or pole mount hardware must be provided for mounting Type 4 cabinets in specific installations.

Type 4 cabinets must have rigid tabs attached to the bottom of the cabinet. Type 5 cabinets must have rigid brackets attached to the bottom of the cabinet. Rigid brackets and tabs must be constructed of the same material used for the cabinet.

Type 4 and larger cabinets must be provided with one of the following alternatives for fastening to a concrete base:

1. Galvanized anchor bolts, nuts, lock washers, and flat washers in accordance with ASTM A153. The anchor bolts must be at least 1/2 inch in diameter, seven inches in vertical length with at least three inch horizontal, or

2. Heavy duty machine bolt anchors, flat washers, lock washers and machine screws with at least 1/2 inch thread diameter.

995-11.2.9 Electrical: Fabricate ground busbars of copper or aluminum alloy material compatible with copper wire and provide at least two positions where No. 2 AWG stranded copper wire can be attached.

Mount a ground busbar on the side of the cabinet wall adjacent to the power panel for the connection of AC neutral wires and chassis ground wires.

If more than one ground busbar is used in a cabinet, a minimum of a No. 10 AWG copper wire must be used to interconnect them.

995-11.2.9.1 Wiring: All wiring must be laced. All conductors in the cabinet must be stranded copper.

All inputs and outputs must be terminated on terminal strips. A connector harnesses for the controller, conflict monitor, vehicle detectors, and other controller accessory equipment must be furnished and wired into the cabinet circuitry.

A vehicle detector harness or rack must be furnished with the cabinet. Terminal strip circuits must be provided for connection of the loop lead-in cable.

995-11.2.9.2 Terminal Strips: The voltage and current rating of terminal strips must be greater than the voltage and current rating of the wire which is terminated on the terminal strip.

Conductors must be terminated on terminal strips with insulated terminal lugs. A calibrated ratchet crimping tool must be used to terminate the conductor in the terminal lug.

When two or more conductors are terminated on field wiring terminal strip screws, a terminal ring lug shall be used for termination of those conductors. All terminal strip circuits must be numbered.

995-11.2.9.3 Cabinet Light and Receptacle: For Type 3 and larger cabinets, provide one or more light fixtures that illuminate the entire interior of the cabinet. All lighting fixtures must automatically turn on when the cabinet doors are opened and off when the doors are closed.

Mount and wire a three-wire 115 V_{AC} duplex receptacle in all cabinets. The receptacle must be protected by a 15A circuit breaker. Do not mount the receptacle on the main cabinet door or police and service switch panels.

995-11.2.9.4 Main Circuit Breaker: Provide a 15A circuit breaker with Type 1 and 2 cabinets, and a 30A circuit breaker with Type 3 and larger cabinets.

The main circuit breaker must turn off all power to the cabinet and shall not be used for the power switch located in the service panel.

995-11.2.9.5 Radio Interference Suppression: A radio interference suppressor must be provided in series with the AC power before it is distributed to any equipment inside the cabinet. The suppressor must provide a minimum attenuation of 50 decibels over a frequency range of 200 kHz to 75 MHz when used with normal installations and shall be hermetically sealed in a metal case.

The radio interference suppressor must have the same minimum current rating as the main circuit breaker.

The ground connection of the radio interference suppressor must be connected only to AC neutral and shall not be connected to earth ground directly.

995-11.2.9.6 Optically Isolated Inputs: The Opto common input is the common reference pin for four optically isolated inputs.

The Opto inputs are intended to provide optical isolation for pedestrian detector and remote interconnect inputs. The Opto inputs are intended to connect through external 27 K ohm, 1 W resistors for 120 V_{AC} operation and are intended for direct connection to 12 V_{AC} from the cabinet power supply for pedestrian detector applications. These inputs may alternatively be used for low-true DC applications when the Opto common pin is connected to the 24 V supply.

The Opto inputs shall provide electrical isolation of 10 megohms minimum resistance and 1000 V_{AC} RMS minimum breakdown to all connector pins except the Opto common pin. These inputs shall exhibit nominal impedance to the Opto common pin of 5 K ohm, plus or minus 10 percent, and shall require 2.4 mA, plus or minus 10 percent, from a nominal 12 V_{AC} supply. The Opto inputs shall not recognize 3 V_{AC} RMS or less relative to the common input and recognize 6 V_{AC} RMS or more relative to the common input. Any steady state voltage applied between an Opto input and the Opto common shall not exceed 35 V_{AC} RMS. Opto inputs shall not be acknowledged when active for 25 ms or less, and shall be acknowledged when active for 50 ms or more.

995-11.2.9.7 Load Resistors: A load resistor or capacitor must be installed between the AC (common) and each signal field wiring terminal for the yellow, green and walk indication. All load resistors and capacitors must be on the front side of any panel used in the cabinet.

995-11.2.9.8 Surge Protection: Furnish surge protective devices (SPDs) for the main AC power input, all signal head field wiring terminals, interconnect cable terminals and loop lead-in cable terminals which are located in the cabinet. SPDs must be unobstructed and accessible from the front side of any panel used in the cabinet. Cabinets utilizing Din rail mounted SPDs must be grounded with a conductor to the cabinet busbar.

The SPD for the main AC power input of the cabinet must be connected on the load side of the cabinet circuit breaker.

SPDs for signal and interconnect cable field wiring terminals must meet the following:

1. Clamp the surge voltage to a level no greater than twice the peak operating voltage of the circuit being protected.

2. Withstand a surge current of 1000A with an 8 by 20 µs waveform six times (at 1 second intervals between surges) without damage to the suppressor.

SPDs for loop lead-in cables must be designed in accordance with the following requirements:

1. Protect the detector unit loop inputs against differential (between the loop lead) surges, and against common mode (between loop leads and ground) surges.

2. Clamp the surge voltage to 25 V or less when subjected to repetitive 300A surges.

3. Withstand repetitive 400A surges with an 8 by 20 µs waveform without damage.

SPDs must be installed according to the SPD manufacturer's instructions and not affect the operation of detectors. SPD leads must be kept as short as possible.

SUBARTICLE 995-11.3 is deleted and the following substituted:

995-11.3 Type 170 Traffic Signal Controller Cabinets: Provide Type 170 traffic signal controller cabinets with all terminals and facilities necessary for traffic signal control and meeting the following requirements:

Model 332, 334 and 336S Cabinets…….CALTRANS TEES 2009

Model 336S cabinet must incorporate input surge protection mounted on a fold-down termination panel at the input file.

Model 332 cabinets must incorporate a lower input termination panel. Model 332 and 334 cabinets must be base mounted. The Model 332 cabinet must have an auxiliary MODEL 420 output file, and be configured for 8 vehicle, 4 pedestrian, and 4 overlaps.

Model 552A designation is given to Model 332 cabinet assemblies that include a swing-out EIA 19-inch rack cage.

Model 662 designation is given to Model 552A cabinets with a 66 inch height.

Cabinets must comply with figures for traffic control signals and devices available on the Department's State Traffic Engineering and Operations Office website at the following URL:
https://www.fdot.gov/traffic/Traf_Sys/Product-Specifications.shtm.

All terminals and facilities on panels must be clearly identified using permanent silk-screened text.

995-11.3.1 Base Plate and Mounting Brackets: Provide cabinets with a standard base mounting bolt pattern and a minimum of two aluminum plates welded inside for anchoring to a concrete or composite base.

995-11.3.2 Output File: Fabricate the output file using a "hard wired" harness. Printed board circuit boards are not acceptable.

995-11.3.3 Shelf: Provide an aluminum shelf with storage compartment in the rack below the controller (for remote secondary monitor/lap top computer use). The storage compartment must have telescoping drawer guides for full extension. The compartment top must have a non-slip plastic laminate attached. Provide an RS-232 connector for communications to the C2S port.

995-11.3.4 Loads: Provide dummy loads consisting of 4.7k resistors rated at five watts minimum for Greens, Peds, and Yellows. The dummy loads must be mounted on a terminal block in the rear of the output file or other approved location. Wire one side of each dummy load to AC return in a manner that allows a technician to easily attach the load to outputs from selected load switches.

995-11.3.5 Cabinet Light: Provide one or more light fixtures that illuminate the entire interior of the cabinet. All lighting fixtures must automatically turn on when the cabinet doors are opened and off when the doors are closed.

995-11.3.6 Surge Protection: Provide each cabinet with devices to protect equipment from surges. Surge protector termination panels must be attached to the cabinet rack assembly and allow sufficient space for connections, access, and surge protector replacement. AC isolation terminals must be on the same side of the cabinet as the AC service inputs. DC terminals and loop detector terminals must be installed on the opposite side of the cabinet from the AC power lines.

Surge protection for 332A cabinets must be mounted on the lower input termination panel.

Surge protection for 336S cabinets must be mounted on a custom fold down termination panel at the input file.

Under no circumstance (normal operation or short-circuit condition) shall the amperage capacity of the internal wiring and printed circuit board traces be less than the protecting threshold of circuit breakers and surge protectors provided.

995-11.3.6.1 Power Distribution Assembly Protection: The power distribution assembly (PDA) SPD must be a two-stage series/parallel device that meets or exceeds the following:

1. Maximum AC line voltage: 140 V_{AC}
2. 20 pulses of peak current, each of which will rise in 8 microseconds and fall in 20 microseconds to one-half the peak: 20kA.
3. The protector must include the following terminals:
    a. Main line (AC Line first stage terminal)
    b. Main Neutral (AC Neutral input terminals)
    c. Equipment Line Out (AC Line second stage output terminal, 10A)
    d. Equipment Neutral Out (Neutral terminal to protected equipment)
    e. Ground (Earth connection)
4. The main AC line in and the equipment line outer terminals must be separated by a 200 microhenry (minimum) inductor rated to handle 10A AC service
5. The first stage clamp shall be between Main Line and ground terminals
6. The second stage clamp shall be between Equipment Line Out and Equipment Neutral
7. The protector for the first and second stage clamp must have a metal oxide varistor (MOV) or similar solid state device, rated 20 kA.

The main neutral and equipment neutral output shall be connected together internally and shall have an MOV (or similar solid state device, or gas discharge tubes) rated at 20 kA between main neutral and ground terminals.

The PDA SPD must have a peak clamp voltage of 250V at 20 kA (voltage measured between equipment line out and equipment neutral out terminals, current applied between main line and ground terminals with ground and main neutral terminals externally tied together).

The PDA SPD must have a maximum let through voltage not exceeding 500 Vpk using an 8 by 20 µs/1.2 by 50 µs; 6 kV, 3 kA surge. The SPD must either be epoxy-encapsulated in a flame retardant material or utilize thermally protected varistors and be designed for continuous service current of 10A at 120 V_{AC} RMS. Power to the Type 170E controller and to the 24V power supply must be provided from the equipment line out terminal of the PDA SPD.

995-11.3.6.2 Inductive Loop Detector Protection: Protect each inductive loop detector input channel with an external SPD that meets or exceeds the following:

1. The SPD must be a three-terminal device, two of which shall be connected across the signal inputs of the detector. The third terminal shall be connected to chassis ground to protect against common mode damage.

2.The SPD must instantly clamp differential mode surges (induced voltage across the loop detector input terminals) via a semiconductor array. The array shall be designed to appear as a very low capacitance to the detector.

3. The SPD must clamp common mode surges (induced voltage between the loop leads and ground) via solid state clamping devices.

4. Peak Surge Current
    a. Differential Mode: 400A (8 by 20 µs)
    b. Common Mode: 1000A (8 by 20 µs)
    c. Estimated Occurrences: 500 @ 200A
5. Response Time: 40 ns
6. Input Capacitance 35 pF typical
7. Clamp Voltage
    a. 30V max @ 400A (Differential Mode)
    b. 30V max @1000A (Common Mode)

995-11.3.6.3 Signal Load Switch Protection: The outputs of each load switch in the output file shall be provided with a MOV connected from the AC positive field terminal to the chassis ground. The MOV must be rated 150 V_{AC} and shall be a V150LA20A (or approved equal).

995-11.3.6.4 Communication Input Protection: Each low voltage communication input must be protected as it enters the cabinet with a hybrid two-stage SPD that meets or exceeds the following:

1. The SPD must be a dual pair (four-wire) module with a double-sided, gold-plated printed circuit board connector.

2. The SPD must be installed in a ten-circuit card edge terminal block (PCB1B10A).

3. The SPD must be utilized as two independent signal pairs. The data circuits must pass through the SPD in a serial fashion.

4. Peak Surge Current
    a. 10kA (8 by 20 µs)
    b. Occurrences at 2000A: greater than 100
5. Response Time: less than 1 ns
6. Clamp Voltage: 30V maximum
7. Series Resistance: greater than 15 ohms per line
8. Primary Protector: 3 element gas tube
9. Secondary Protector: Solid state clamp (1.5 kW minimum)

The line side of the SPD must be connected to the communication field wires, the load side connected to the communication connector of the controller, and the ground terminal connected to chassis ground.

995-11.3.6.5 Low Voltage DC input protection: Each DC input must be protected by an SPD that meets or exceeds the following:

(a) The SPD must be a 5 terminal device. Two terminals must be connected to the line side of the low voltage pair, two terminals must be connected to the input file side, and the fifth terminal connected to chassis ground.

(b)Peak Surge Current

2 kA (8 by 20 µs)

Occurrences at peak current: 100 (typical)

(c) Response Time: 5-30 ns

(d) Shock: Must withstand 10-foot drop on concrete

(e) Clamp Voltage: 30V

(f) Series Resistance: greater than 15 ohms each conductor

995-11.3.6.6 Preemption and 115V AC signal input protection: Each preemption or AC signaling input channel must be protected by an external SPD that meets or exceeds the following requirements:

(a) The SPD must be a 3 terminal device

(b) Peak Surge Current

2000A (8 b 20 µs)

Occurrences at peak current: 25 (minimum)

(c) Response Time: less than 200 ns

(d) Peak Surge Trip Point: less than 890V nominal

995-11.3.7 Red Monitor Harness: A connector and terminal assembly designated as P20 for monitoring the absence of red, shall be an integral part of the output file. The connector must terminate, and be compatible with, the cable and connector of a Type 170 conflict monitor unit (CMU), capable of monitoring the absence of red. Provide the pin assignments of the P20 connector and terminal assembly with the cabinet plans. The P20 connector shall be physically like the cable and connector of a Type 170 CMU to prevent the absence of red cable connector from being inserted into the P20 connector 180 degrees out of alignment.

995-11.3.7.1 Programming of Unused Red Channels: Provide all cabinet assemblies with a means of programming unused red channels by installing jumpers from red monitor inputs to 115 V_{AC}. The connecting terminals for the jumpers must be accessible and located in the same terminal block for all 16 channels to assure full compatibility of all cabinet assemblies with "210 Plus" conflict monitor units.

995-11.3.8 Police Door and Panel: Provide cabinets with police doors and panels. The police panel must include text informing officers that yellow and all-red clearance intervals are timed internally.

Police switch panels must include a manual jack. The jack must mate with a three circuit, 1/4-inch diameter phone plug. Connect the tip and ring (middle) circuits of the jack to the logic ground and the interval advance inputs of controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground must be connected to the interval advance input of the controller unit.

The pushbutton cord must have a minimum length of six feet with a 1/4-inch diameter three circuit plug connected to one end and a hand held manual pushbutton at the other end. With the exception of the vehicular yellow and all red clearance intervals, a complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval that is active. Cycling the push-button during the vehicular yellow or all red clearance intervals must not terminate the timing of those intervals.

995-11.3.9 Technician Service Panel: Provide cabinets with a technician service panel which is mounted on the back side of the police panel (inside the main cabinet front door).

There must be two switches located on the technician service panel, clearly labeled according to the following functions:

(a) UCF – This toggle switch shall:

Place the intersection into Flashing Operation.

After meeting requirements for Flashing Operations, all power shall be removed immediately from signal load switches.

(b) Signal On/Off – This toggle switch shall disconnect all power to the signal lights through the use of a 60A contact switch placed in series with the load switch packs.

Labels must be silk screened directly on the panel.

995-11.3.10 Swing-out Rack Assembly: Provide 552-A cabinets with a pullout and rotatable rack assembly as well as an interface panel mounted on the top of the rack assembly and attached to the top shelf. The rack assembly must be constructed to house components designed to be installed in a standard EIA 19-inch rack and shall house the Controller, Input File, Output File No. 1, PDA No. 2, and a storage compartment.

Construct the rack and slide/hinged mounting brackets so that when the rack assembly (fully loaded) can be pulled out with one hand with complete ease of operation including rotation of the assembly.

The rack assembly must have a spring-loaded latch mechanism to secure the rack assembly inside the cabinet while in the "rest" position. When pulled out of the cabinet at any point from its resting position (inside cabinet) to its full extension and rotation, the fully loaded rack assembly shall not cause any member of the assembly to bend, warp or bind. The rack must be made of one-inch square aluminum tubing with welded joints and extend and retract smoothly without noticeable friction or stress on roller guides, extension brackets, or other mechanical components. Maximum deflection of the entire rack assembly (with all equipment installed) shall not exceed 1/8 inch.

The rack assembly must have 12 technician test switches mounted to the interface frame assembly. Technician test switches must be of the momentary type and shall have eight vehicle and four pedestrian inputs.

The front of the rack assembly must be tapped with 10-30 threads with EIA universal spacing for 19-inch electrical equipment racks.

The rack assembly must be attached to the left cabinet wall through combination slide/hinged mounting brackets.

The slide/hinged mounting brackets must be fabricated from aluminum and/or stainless steel only.

Mounting bracket guides must utilize 7/8-inch stainless steel ball bearing rollers and allow extension and retraction of a loaded rack with minimal effort.

The rack assembly must be capable of rotating 210 degrees from its rest position after full extension from the cabinet.

The rack assembly must have a minimum 7/16-inch diameter aluminum rack stop rod attached to the inside left cabinet wall from the left side of the rack assembly to lock the rack into final position.

All cabinet harnesses must be long enough to maintain cabinet connections and functionality when the rack assembly is fully extended and rotated to its

maximum limit. Harnesses must not bind or crimp when the rack is fully retracted, extended, or in motion.

995-11.3.11 Service Panels for 552A: The 552A cabinet must include a field service panel, auxiliary field service panel, and interface panel, all constructed of aluminum with a 1/8-inch minimum thickness. All components must be accessible from the front of the panels. Do not mount components or attach wires behind panels.

995-11.3.11.1 Field Service Panel: The field service panel must consist of terminal strips, circuit breakers, transient protection devices, load resistors, capacitors, cable tie mounts and associated wiring for making all field wiring connections. Mount the field service panel in the cabinet on the lower right exterior cabinet wall.

The field service panel must provide the necessary interconnecting junction points between the rack assembly and cabinet for the field service wires. The panel must be grouped for internal connections (jumpers) between terminals boards, wiring from the panel to the rack assembly, and wiring from the panel to the cabinet.

The field service panel wiring harness must have flexible wire covered by a flexible non-metallic conduit from the field service panel to the PDA, output file, and interface panel. The harness must have a metal clamp with a rubber grommet center attached to the field service panel to secure the harness to the panel for proper orientation of the harness with the rack assembly. Terminal strips for the panel shall be as listed below:

1. TBS1 - Terminal Block, Deadfront type, 3 position, No. 4 to No. 14 AWG wire range, 70A, 600V.
2. TBS2 - Terminal Block, Barrier, 16 position, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No. 16 AWG (max), 15A, 250V.
3. TBS3 - Terminal Block, Barrier, 20 position, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No 16 AWG (max), 15A, 250V.
4. TBS4 &TBS5 - Terminal Block, Barrier, 12 position, .438 Density, 6-32 x 1/4 BH Screw, Open Bottom, Double Row, No. 14 AWG (max), 20A, 250V.

The panel must have a main cabinet circuit breaker rated at 30A and a cabinet accessory circuit breaker rated at 15A for cabinet fans and light. Mount the circuit breakers near the back cabinet door on the panel.

The panel must include load resistors for all Walk, Green, Green Arrow, Yellow and Yellow Arrow Switch Pack outputs to prevent the conflict-voltage monitor from going into "Flash" due to a failed signal lamp. Load resistors must be 2K, 10 watt.

MOVs must be physically tied to one side of each terminal on TBS4 and TBS5 and be physically secured to the field service panel with a 6-32 screw.

995-11.3.11.2 Auxiliary Field Service Panel: The auxiliary field service panel must be mounted on the lower left interior cabinet wall and consist of a minimum of four terminal strips, 18 detector surge protectors and one pedestrian button isolation board assembly. The 18 surge protectors must be a three-terminal device, two of which are connected across the signal inputs of the detector for differential mode protection and the third terminal is grounded to protect against common mode damage. Mount the pedestrian button isolation board on the auxiliary field service panel. Terminal strips for the panel shall be Terminal Block, Barrier, 12 position, .438 Density, 6-32 x 1/4 BH Screw, Open Bottom, Double Row, No. 14 AWG (max), 20A, 250V.

Install a four-button pedestrian isolation board on the auxiliary field service panel to provide for the connection of the pedestrian buttons on phases 2, 4, 6 and 8. The board must provide electrical isolation of the field wiring to the internal cabinet wiring. The inputs to this isolation board shall be wired to terminal block TBA5 for connection to field wiring. The outputs of this board shall be carried through the harness to the input file to the proper wires that go to the interface extension panel of the controller.

The pedestrian button isolation board must include a PC board mounted on an aluminum panel with the following minimum dimensions:

Height: 2 inches
Width: 8 inches
Thickness: 1/8 to 3/16 inch

995-11.3.11.3 Interface Panel: The interface panel must consist of eight terminal strips, one telephone line suppressor and mounting fixture, two 24 V_{DC} relays and mounting fixtures, and all associated wiring for connecting the required interface equipment modules.

The front of the panel must be covered by a 1/4-inch clear plexiglass sheet, supported from the panel by four 1-1/2 inch standoffs. Secure the panels and cover using wing nuts that are removable without the use of tools. The plexiglass cover shall have 1/2-inch slot, centered over each of the terminal strips. All covers and panels must be interchangeable.

The panel wiring must provide the necessary interconnecting junction points between interface equipment cable harnesses and controller cabinet input and output signal. The panel wiring provides the functional wiring information for connecting the interface equipment in the cabinet.

The panel wiring must be grouped for internal connections (jumpers between terminal boards) as well as wiring from the controller and related cabinet functions to the terminal boards on the interface panel.

Ground wires must be No. 14 AWG wire, minimum. The internal harnesses must be located between TB1, TB2 and TB3. The external and internal wiring must be located outside of TB1 and TB4, between TB2 and TB3.

Terminal strips shall be Barrier type, .375 Density, 5-40 x 3/16 BH Screw, Open Bottom, Double Row, No. 16 AWG (max), 15A, 250V. Terminals must use nickel/cadmium plated brass screws. All terminals and facilities on panels must be clearly identified using permanent silk-screened

The K1P and K2F relays shall be 15A miniature relays with polycarbonate cover, 2 form C (CO) contact arrangement, DC coil input, socket mount, .187 inch quick connect/solder terminals, AgCdO (15A) contacts, and 24 V_{AC} coil voltage with matching socket and hold down spring. All screws on the relay socket must be brass with nickel/cadmium plating.

995-11.3.12 Storage Compartment: Mount an aluminum storage compartment in the rack assembly. The storage compartment must have telescoping drawer guides for full extension of drawer from rack assembly and have a continuous front lip for opening the compartment top for storage. The top of the compartment must be non-slip plastic laminate.

Install a communication port on the right hand side of the drawer at the front for connecting to the communications port of the controller unit via the cabinet harness.

995-11.3.13 Cabinet Rails: Provide the cabinet with four cabinet rails for mounting wiring panels and various brackets. Rails must be keyhole design with slots 2 inches on center with a top opening diameter of 5/8 inch to allow the insertion of a 5/8 inch by 1 inch carriage bolt. The rails must be approximately 1-1/2 to 2 inches wide by 1/2 inch deep. Do not use unistruts or other rails.

995-11.3.14 Electrical: Do not use printed circuit boards in any controller cabinet subsystem file or panel, including but not limited to the output file (except for the red monitor program board), service panel, interface panel, and input file.

995-11.3.14.1 Wiring: Cut all wires to the proper length and neatly laced into cables with nylon lacing. No wire shall be doubled back to take up slack. Cables in the cabinet must not interfere with the routing and connection of field wiring. Cables must be secured with nylon cable clamps, unless specified otherwise. The position of cables between the components must be such that when the door is closed, it does not press against the cables or force the cables against the various components inside the controller cabinet.

Fabricate ground busbars of a copper or aluminum alloy material compatible with copper wire and provide at least two positions where a No. 2 AWG stranded copper wire can be attached. Mount a 6 inch ground busbar with screw terminals on the bottom flange on each side of the cabinet for connection of AC neutral wires and chassis ground. Attach a flexible ground strap between the left side ground busbar and the left side bottom rear of the rack assembly. Wiring harnesses must be covered by a flexible non-metallic conduit. Panel wire size must be a minimum of No. 18 AWG unless otherwise specified.

995-11.3.14.2 Terminals: Terminal connections must be soldered or constructed using a calibrated ratchet type crimping tool. Wiring must be traceable and without entanglement.

SUBARTICLE 995-11.5.7 is deleted and the following substituted:

995-11.5.7 Ventilation: Provide ventilation through the use of a louvered vent at the bottom of the door. Vent depth must not exceed 0.25 inch. Provide an air filter a minimum of 192 square inches and 1 inch thick behind the vent. The filter must be removable and held firmly in place so that all intake air is filtered.

Provide a bottom trough and a spring-loaded upper clamp to hold the filter in place. The bottom trough must drain any accumulated moisture to the outside of the field cabinet.

ITS field cabinets must have dual thermostatically controlled fans, with one thermostat per fan, rated for continuous duty with a service life of at least 3 years. Mount thermostats on the inside top of the cabinet. Thermostats must be user adjustable to allow temperature settings ranging from a minimum of 70°F to a maximum of 140°F and capable of activating the fans within plus or minus 5 degrees of the set temperature. Use UL listed exhaust fans having a minimum air flow rating of 100 cubic feet per minute. Electric fan motors must have ball or roller bearings. Vent the exhaust air from openings in the roof of the field cabinet.

SUBARTICLE 995-11.7 is deleted and the following substituted:

995-11.7 Small Equipment Enclosures: Small equipment enclosures must be a minimum NEMA 3R rated and smaller than 16 inches wide by 24 inches tall by 12 inches deep. The enclosure must be constructed of aluminum or non-metallic materials. Enclosures must include a safe means of removing power from the installed equipment for servicing and replacement, such as a switch, fuse, or breaker. Discrete markings, such as manufacturer name and model, are permitted on the outside of small enclosures.

All fasteners less than 5/8 inch exposed to the elements must be Type 304 or 316 stainless steel.

Construct aluminum enclosures of 5052 sheet aluminum alloy with a minimum thickness of 0.090 inch. Aluminum enclosures must have a uniform natural finish or be powder coat painted in accordance with AAMA-2603-02 specifications. All welds, bends, and seams must be neatly formed and free of cracks, blow holes and other irregularities. All inside and outside edges of the enclosure must be free of burrs, rivet holes, visible scratches, and gouges and have a smooth, uniform finish.

Non-metallic enclosures must be designed for outdoor use, and resist chemicals, corrosion, and ultraviolet rays.

Enclosure doors must include a vandal resistant hinge and be secured with a locking latch or a minimum of two quick-release Type 304 or 316 stainless steel latches with padlock hasps. Removal of the hinge or hinge pin must not be possible while the enclosure is closed. Provide two sets of keys with each lock.

Enclosures may be vented. Holes larger than 1/8 inch must be covered by heavy duty screen.

Post mounted enclosures must be supplied with mounting hardware for attaching the enclosure to a 4-1/2 inch (OD) aluminum post.

SUBARTICLE 995-12.1 is deleted and the following substituted:

995-12 Traffic Controller Accessories.

995-12.1 General: Traffic controller accessories must meet the industry standards in Table 995-8 as well as the environmental requirements of those standards.

Table 995-8
Traffic Controller Accessory Standards

Device	Standard
Conflict Monitor	NEMA TS1-1989, Section 6
Malfunction Management Unit	NEMA TS2-2021, Section 4
Power Supply	NEMA TS2-2021, Section 5.3.5
Load Switch	NEMA TS2-2021, Section 6.2
Flasher	NEMA TS2-2021, Section 6.3
Bus Interface Unit	NEMA TS2-2021, Section 8
Model 206L Power Supply Unit	CALTRANS TEES, 2020, 3.4
Model 208 Monitor Unit	CALTRANS TEES, 2020, 3.5
Model 210 Monitor Unit	CALTRANS TEES, 2020, 3.6
Power Distribution Assembly	CALTRANS TEES, 2020, 6.4.3

Input File	CALTRANS TEES, 2020, 6.4.4

ARTICLE 995-12 is expanded by the following new Subarticle:

995-12.3 Model 210 Conflict Monitor with Absence of Red Monitoring: The conflict monitor must be a Model 210 "PLUS" conflict monitor capable of detecting fault sequencing of signals on a per channel basis (i.e., short or absence of yellow interval and/or simultaneous dual indications). All integrated circuits having 14 pins or more must be socket mounted.

995-12.3.1 Absence of Red Monitoring: The conflict monitor must be capable of monitoring for the absence of voltage on all of the inputs of a channel (defined here as red, yellow, and green). If an output is not present on at least one input of a channel at all times, the unit shall begin timing the duration of this condition. If this condition exists for less than 700 milliseconds, the unit shall not trigger. If this condition exists for more than 1000 milliseconds, the unit shall trigger as if a conflict had occurred, causing the intersection to transfer immediately into a flashing mode, and "stop-time" to be applied to the controller. A red signal shall require the presence of a minimum of 60 $V_{AC,}$ plus or minus 10 $V_{AC,}$ to satisfy the requirements of a red indication. The red input signals shall be brought into the conflict monitor through an auxiliary connector on the monitor's front panel. Provide a similar connector on the output file, with a removable harness connecting the two. Provide an indicator on the front panel of the monitor to identify the triggering of the monitor in response to the absence of red condition.

SUBARTICLE 995-14.3 is deleted and the following substituted:

995-14.3 Luminance: The sign face must be illuminated evenly across the entire surface. Contrast ratio between the background and legend shall be at least 4:1.

995-14.3.1 Background Luminance: Minimum luminance for the legend portion of the street sign face must be no less than 87.5 lux. The luminance must be determined by averaging a minimum of seven readings. Four of the readings must be taken near the midpoint of a line that would span between the outside corners of the background and the outside corners of the legend. One reading must be taken near the midpoint of a line that would connect the top corner readings. One reading must be taken near the midpoint of a line that would connect the bottom corner readings. One reading must be taken near the vertical and horizontal midpoint of the sign.

995-14.3.2 Border and Lettering Luminance: Minimum luminance of the legend and border must be 350 lux. The luminance must be determined by averaging a minimum of 17 readings. There must be a minimum of one reading from each letter in the legend. Readings within the legend must alternate between the top, middle and bottom portion of each letter. Readings within top and bottom of the border must be perpendicular to the top and bottom readings in the background. Readings within the sides of the border must be taken parallel to the readings taken within each letter.

SUBARTICLE 995-14.7 is deleted and the following substituted:

995-14.7 Warranty: Internally illuminated signs must have a manufacturer's warranty covering defects for 5 years from the date of final acceptance.

SUBARTICLE 995-15.7 is deleted and the following substituted:

995-15.7 Warranty: Highlighted signs must have a manufacturer's warranty covering defects for 3 years from the date of final acceptance.

SUBARTICLE 995-16.8.3 is deleted and the following substituted:

995-16.8.3 Display System Hardware: The sign must utilize a system data interface circuit for communications between the sign controller and display modules. Except for embedded DMS, the following components must reside inside the sign housing: sign controller, display system interface circuits, display modules, power supplies, local and remote control switches, LED indicators, EIA-232 null modem cables (minimum of 4 feet long for connecting laptop computer to sign controller), and surge protective devices.

SUBARTICLE 995-16.8.4 is deleted and the following substituted:

995-16.8.4 Control Cabinet: A control cabinet that meets the requirements of Section 676 shall be provided. The minimum height of the cabinet must be 46 inches.

A ground control cabinet that includes the following assemblies and components: power indicator, surge suppression on both sides of all electronics, communication interface devices, connection for a laptop computer for local control and programming, a 4 foot long cable to connect laptop computers, a workspace for a laptop computer, and duplex outlets shall be provided.

All telephone, data, control, power, and confirmation connections between the sign and ground control box, and for any required wiring harnesses and connectors shall be provided.

SUBARTICLE 995-16.13 is deleted and the following substituted:

995-16.13 Warranty: The DMS system and equipment must have a manufacturer's warranty covering defects for a minimum of 5 years from the date of final acceptance.

SUBARTICLE 995-17.2.16 is deleted and the following substituted:

995-17.2.16 Warranty: The EDS systems and equipment furnished must have a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance.

SUBARTICLE 995-18.5 is deleted and the following substituted:

995-18.5 Warranty: Ensure all flashing beacons have a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance. Ensure the manufacturer will furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or maintaining agency within 30 calendar days of notification.