Florida Department of Transportation

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January 29, 2015

Khoa Nguyen
Director, Office of Technical Services
Federal Highway Administration
545 John Knox Road, Suite 200
Tallahassee, Florida 32303

Re: State Specifications and Estimates Office
Section **695**
Proposed Specification: **6950000 Traffic Monitoring Site Equipment and Materials.**

Dear Mr. Nguyen:

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

The changes are proposed by Michelle Young of the Transportation Statistics Office to consolidate, update and move special provisions 741, 743, 744, 745, 746, 747 and 748 into the Standards Specifications as part of the Consolidation of Products and Specifications effort undertaken within FDOT central office.

Please review and transmit your comments, if any, within two weeks. Comments should be sent via email to SP965DS or daniel.scheer@dot.state.fl.us.

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

Sincerely,

signature on file

Daniel Scheer, P.E.
State Specifications Engineer

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

695 TRAFFIC MONITORING SITE EQUIPMENT AND MATERIALS.

(REV ~~12-12~~*15-14*~~1~~*1-28-15*) *(FA 2-10-15) (7-15)*

The following new Section is added after Section 687:

SECTION 695
TRAFFIC MONITORING SITE EQUIPMENT AND MATERIALS

695-1 Description.

Furnish or furnish and install a complete, operable traffic monitoring site (TMS) as shown in the Plans and Design Standards. The Department uses TMS to monitor the volume, speed, number of axles, weight of wheels, axles or vehicles, or vehicular axle classification types.

695-2 General.

695-2.1 Traffic Monitoring Site Component Approval: *Use only components that meet the requirements of this Section and are listed on the Department's Approved Products List (APL).*

Any electronics unit or software submitted for approval must be compatible with or convert the data into a format compatible with the Department's polling and processing software. Any substitute software modules submitted must be tested and approved.

695-2.2 Marking of Approved Equipment:

695-2.2.1 Manufacturer's Identification: *All TMS equipment must be permanently marked with the manufacturer's name or trademark, part or model number and date of manufacture or serial number.*

695-2.2.2 Submittal Data Requirements: *Submit forms in accordance with 603-5.*

695-2.3 Poles for Cabinets, Non-Intrusive Sensors and Solar Panels:

695-2.3.1 Requirements*: Meet the requirements of Section 646 for 20 foot aluminum poles.*

695-2.3.2 Installation: *Install cabinets in accordance with Section 676. Ground the pole in accordance with Section 620.*

695-2.4 Manufacturer's Warranty Provisions~~.~~:

695-2.4.1 General: *Secure all warranties provided by the equipment manufacturer for the specific equipment included in the Contract. Ensure that all warranties are fully transferable from the Contractor to the Department. Transfer warranties upon final acceptance in accordance with 5-11. Document all warranties and warranty transfers and provide a copy to the Engineer. The Engineer will submit warranty forms received from the Contractor to the Transportation Statistics Office (TranStat) TMS Manager.*

695-2.4.2 Terms and Conditions: *Ensure that the terms and conditions of warranties are documented by the manufacturer when submitting a request to the Department for certification and for equipment submittal for construction projects. Include terms for a specified service performance with provisions for repair parts and labor, or for replacement.*

Ensure the terms and conditions define the equipment installation date as the date for such warranty to be in effect. The installation date for construction projects is the day the site is accepted by the TranStat TMS Manager. For warehouse purchases, the installation date is the date of visual inspection approval, not to exceed ten days after delivery date.

When warranty is available, ensure that a written warranty accompanies the manufacturer's billing invoice. Ensure warranties require the manufacturer to furnish replacements within 10 calendar days of notification for any part or equipment found to be defective during the manufacturer's warranty period at no cost to the Department.

Leave a copy of the warranty in the cabinet once it is installed. Provide an original copy to the Engineer. The Engineer will submit warranty forms received from the Contractor to the TranStat TMS Manager. Comply with the terms of the warranty. The Department may suspend the certification for non-compliance.

695-3 Vehicle Sensor (Non-Weight) Applications.

695-3.1 General: *Install TMS vehicle sensors of the type and at the location shown in the Plans. Use vehicle sensors listed on the Department's APL and compatible with the electronics unit to which they will be connected.*

695-3.2 Axle Sensor (In-Roadway):

Physical Characteristics, Axle Sensor Sensors	
Sensor Element Dimensions	*6 ft. to 10 ft. in length (as specified in Plans), 3/16 in. to 3/8 in. in diameter (varies by manufacturer)*
Sensor Element Material	*Pressure sensing piezoelectric*
Pavement Operating Temperature	*0°F to +150°F*
Output Signal	*Minimum +200mV for passenger/pickup truck axle @ 70°F with less than 10% negative signal*

695-3.2.1 Installation: *Install sensors in accordance with the requirements of this Section and Design Standards, Index No. 17900. Ensure axle sensors are installed in the roadway and secured using an adhesive bonding material listed on the APL.*

Install axle sensors in the right-hand wheel-path midway between the leading and trailing loops as detailed in Design Standards, Index 17900. Install axles sensors in the left-hand wheel-path when no paved shoulder exists and sensor lead exit windows are installed at the right-hand edge of the roadway surface or in a lane which is to the left of and adjacent to an open lane of traffic.

Install the axle sensor such that the cable end is closest to the pull box to which the sensor lead cable will be routed. Install the end of the sensor mid-way into the edge line stripe or lane line stripe. Ensure that the axle sensor being installed has lead-in cables of sufficient length to reach the cabinet without splicing. Do not splice axle sensor lead-in cables.

Route the sensor lead to the pull box then to the TMS cabinet. Mark the sensor lead at the pull box and at termination in the cabinet. Provide lane numbering information as specified in Design Standards, Index No. 17900.

Allow newly applied asphalt to cure for a minimum of 30 days prior to the installation of in-road sensors. Use a chalk line or string and paint to layout the position of the sensor and lead-in cable slots.

Ensure saw cuts do not deviate more than 0.5 inches from the chalk line. Use a single blade or ganged blade saw wide enough to cut the axle sensor slot at full width in a single pass. Cutting two slots and chipping out roadway material between them is not allowed.

Cut the slot the length of the sensor plus an additional 3 to 4 inches. Ensure the depth and width of the slot is installed as recommended by the sensor manufacturer, typically 0.75 inches wide by 1.5 to 2 inches deep.

Use clips or jigs provided by the manufacturer to suspend the sensor at a uniform depth in the slot. Mix and apply the bonding agent ensuring the slot is completely full with no voids beneath the sensor.

695-3.2.42 Test Requirements: *Perform the manufacturer's recommended on-site pre-installation test to determine the sensor's condition using an Inductive Capacitance Resistance meter. Install only those sensors that pass the pre-installation test.*

Record all test results by lane on the warranty form provided by the manufacturer and leave a copy in the cabinet.

Repeat the test at the termination point in the cabinet after installation. Use an oscilloscope to view and record typical waveforms and signal intensity measurements for the axles of passenger cars and large trucks. Remove and replace any sensor that fails the test at no additional charge to the Department.

695-3.3 Non-Intrusive Vehicle Sensors (Off-Roadway):

695-3.3.1 General: *Install wireless (radar or microwave) vehicle sensors on a pole as shown in the Plans.*

Physical Characteristics of Non-Intrusive Sensors	
Detection Zone	*A minimum of 8 distinguishable lanes within a minimum of 200 ft. of detection zone*
Enclosure	*Weatherproof aluminum, stainless steel or polycarbonate housing*
Dimensions	*Typically up to 15 in. X 12 in. X 6 in.*
Weight	*Typically less than 10 lb.*
Operating Temperature (Ambient)	*0°F to 140°F*
Operating Frequency	*Wireless transmission in FCC approved band or unlicensed RF range*
Communications	*RS-232,RS-485 or RJ-45 ports and supports a minimum baud rate of 19,200*
Data Interface	*Compatible with the Department's field storage devices (counters) and transmits detection data via contact closure signal using a hardwired connection*

695-3.3.2 Installation Requirements: *Install the sensor on a pole perpendicular to the target lanes of traffic with room to perform horizontal and vertical aiming adjustments.*

Ensure that the wireless vehicle sensor has sufficient cable length to reach the cabinet without splicing. Fasten the cable to the pole so wind does not move it, or route the cable within the pole cavity to the cabinet termination point. Provide 18 to 24 inches of slack in the cable at the connections to the sensor and in the cabinet to ensure the cable is stress-free. Include the appropriate mounting hardware, contact closure signal that corresponds to vehicle presence and the manufacturer's recommended surge suppression as a part of the installation.

Set up the lane detection zones using the manufacturer's instructions and software and verify that the sensor's orientation is perpendicular to the roadway.

Configure the wireless vehicle sensor for vehicle volume unless otherwise specified in the Plans.

695-3.3.3 Test Requirements: *Conduct a visual test to determine that all detection zones are being counted accurately.*

Connect a ~~laptop~~personal computer (PC) to the electronics unit and observe traffic in every lane, verifying that each vehicle is displayed on-screen. A minimum of 20 vehicles should be observed for each lane of traffic with all vehicles counted; assuming a clear line of sight between the sensor and the vehicle being observed is maintained.

If any vehicles are not counted, reconfigure the wireless vehicle sensor and repeat the visual observation test until all lanes count correctly. If the sensor fails to provide accurate counts after three test attempts, it must be replaced with a new unit at no expense to the Department.

Provide a time synchronized video of testing, if requested. Provide a 48 hour verification (class, speed and volume) report for all TMS to the Engineer. The Engineer will submit video received from the Contractor to the ~~Transportation Statistics Office (~~TranStat~~)~~ TMS Manager. Leave all documents in the cabinet with a copy sent to the Engineer.

695-3.4 Method of Measurement. *The Contract unit price for each vehicle sensor will include the vehicle sensor, lead-in cables, bonding agent; and all equipment, materials, testing and labor necessary for a complete and accepted installation.*

695-3.5 Basis of Payment: *Price and payment will be full compensation for all work specified in this Section.*

Payment will be made under:

Item No.	*695- 1-*	*TMS Vehicle Axle Sensor (In-Roadway)- Non-Weight Applications- each.*
Item No.	*695- 2-*	*TMS Vehicle Non-Intrusive – Non-Weight Applications (Off-Roadway) – each.*

695-4 Vehicle Speed/Classification Unit.

695-4.1 General: *Furnish and install TMS vehicle speed/classification unit (electronics unit) in the TMS cabinet at the locations shown in the Plans.*

695-4.2 Materials:

695-4.2.1 General: *Use a vehicle speed/classification unit listed on the Department's APL compatible with the other components installed at the TMS. Ensure that the vehicle speed/classification unit and equipment cables are compatible and constructed in accordance with Design Standards.*

Ensure that the vehicle speed/classification unit is marked in accordance with 695-2.2 and the markings are visible after installation.

695-4.2.2 Vehicle Speed/Classification Unit Requirements: *Provide an electronics unit that outputs data compatible with the Department's polling computer system or furnish a software module that converts the data into a format compatible with the Department's polling computer system.*

The electronics unit operates in an unattended mode, accumulating data for later retrieval by downloading via the polling computer system. Ensure that the electronics unit is capable of downloading data through direct connection with a ~~personal computer (~~PC~~)~~, without deleting or marking the files.

Provide complete operating procedures with all software.

695-4.2.2.1 Compatibility: *Provide an electronics unit that is compatible with the embedded inductive loops, axle sensors, magnetometers and non-intrusive vehicle sensors in place at the TMS.*

Ensure that each electronics unit is capable of determining the count and classification by type and speed of all vehicles for both directions of traffic on the roadway.

Provide real-time polling software with each electronics unit, capable of operating on a PC using the Department recommended operating system and meeting the following requirements:

1. Capable of communicating with the traffic counter/classifier, and downloading data via cellular modem and producing reports of 15 minute, hourly, weekly, monthly and annual volume and classification data.

2. Capable of displaying and entering operating parameters into the vehicle class/counter, and allowing the display of real-time traffic volumes in addition to routine data collection activities.

3. Capable of processing and storing all vehicle data retrieved in routine mode, regardless of the selected parameters.

695-4.2.43 Functional Requirements: *The electronics unit must be fully functional when receiving input from two 6 foot by 6 foot embedded inductive loops, spaced 12 to 24 feet apart, leading edge to leading edge, with a single axle sensor located between the loops, in each lane of a six lane (minimum) roadway. Ensure that each electronics unit is capable of collecting data from each of the lanes of traffic in any combination of counts, classification, speed, or direction.*

Provide electrical components of solid state design, constructed so that they will not be damaged by jolts and vibrations encountered during shipping and everyday use.

Ensure that all electronics units are functionally identical and interchangeable except as follows:

1. The electronics unit may be constructed utilizing plug in modules; however, when plug in modules are used, each electronics unit must be identical except for the number and type of modules used. Ensure that modules of the same type are identical and interchangeable.

2. Should more than two electronics units be required in the same cabinet, ensure that each electronics unit has a unique, individual electronics unit number. The electronics unit number must reside in non-volatile memory, so that it is not changed when a "cold or warm boot" is performed or by a power interruption.

Provide an electronics unit having the capability of obtaining and providing the following:

1. Volume, speed, classification, and classification by speed data simultaneously.

2. Volume data by lane.

3. Speed data by lane in a minimum of 15 bins, programmable in 5 mph increments.

4. Classification by lane in vehicle type by axle class in 15 bins (minimum) in accordance with FHWA Classification Scheme "F" in Florida's Traffic Forecasting Handbook, Chapter 2, Figure 2.2 which can be accessed on the Department's

website at the following URL address:
http://www.dot.state.fl.us/planning/statistics/trafficdata/ptf.pdf.

Ensure that each electronics unit has the capability of providing real-time monitoring of volume data by lane or direction in user selected intervals of as little as 15 minutes, when required, without disrupting the above selected programs.

Provide an electronics unit capable of communicating directly with a PC or through a modem at a minimum rate of 19,200 bps.

Ensure that, at a minimum, the following parameters are programmable by direct connection to the electronics unit or via modem:

1. Six digit site number.
2. Number of lanes and directions.
3. Date and time.
4. Data operating and transmission parameters.
5. Sensor spacing.
6. Recording interval.
7. Vehicle parameter table with axle spacing ranges for each type of vehicle.
8. Number and range of speed categories, axle and length classifications, and headway.

Should an axle sensor or a loop in one or more lanes fail, the electronics unit must continue to provide the speed and volume from the remaining functioning sensors.

Ensure that the sensitivity level for each axle sensor is individually adjustable using software, by direct PC connection and remotely via telemetry.

Ensure that the loop detectors are internal and self-tuning. Ensure that the sensitivity level and any additional parameters necessary to prevent "loop crosstalk" for each embedded inductive loop can be adjusted individually using software, both by direct PC connection and remotely via telemetry.

Provide a means of introducing a time delay, or "de-bounce" value for ignoring spurious axle signals (ghost axles) in the electronics unit software.

695-4.2.~~5~~4 Power Requirements: *Provide an electronics unit that is field configurable to be powered 12 V_{DC} and does not consume more than a total of 12 watts.*

If an internal battery is required, it must be capable of being recharged and shall be furnished and included with the electronics unit at no extra cost.

695-4.2.~~6~~5 Mechanical Requirements: *Provide a modular electronics unit which is completely enclosed in a durable housing of sheet metal or cast aluminum with a durable finish. When configured for operation the electronics unit including all cables must fit into a Type IV cabinet.*

695-4.2.~~7~~6 Environmental Requirements: *Provide an electronics unit which operates as specified when the ambient temperature and humidity inside the controller cabinet are within the following limits:*

695-4.2.~~7~~6.1 Ambient Temperature: *The operating ambient temperature range must be between minus 0 to 140ºF.*

The rate of change in ambient temperature must not exceed 63ºF per hour, during which the relative humidity must not exceed 90%.

695-4.2.~~7~~6.2 Humidity: *The relative humidity must not exceed 90% over the temperature range of 40 to 109ºF. Above 109ºF, constant absolute humidity must be*

maintained as seen in Table 695-1. The relative humidity range shown in Table 695-1 is for dynamic testing.

Table 695-1		
At 14.6 psi Barometric Pressure		
Dry Bulb ºF	Relative Humidity (%)	Wet Bulb ºF
40	75	37
50	80	46
60	83	57
70	86	66
80	87	77
90	89	88
100	89	97
109	90	108
120	70	109
130	50	109
140	38	109
150	28	109
160	21	109
165	18	109

695-4.2.7~~8~~ Cables and Connectors: *Furnish all cables and connectors for a complete and functional installation of each electronics unit in accordance with the Design Standards, Index No. 17900.*

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

Furnish one serial port cable for interconnecting each electronics unit with a PC.

695-4.3 Installation Requirements: *Install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, the Design Standards, Index No. 17900, and Contract Documents.*

695-4.4 Method of Measurement: *The Contract unit price per assembly for electronics unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.*

~~**695-4.4.4 Modify:** *The Contract unit price per assembly for electronics unit modified, as specified in the Contract Documents, includes all labor, equipment and miscellaneous materials necessary for a complete and accepted installation.*~~

695-4.5 Basis of Payment: *Prices and payments will be full compensation for all work specified in this Section.*

Payment will be made under:

Item No. 695- 3- TMS Vehicle Speed/Classification Unit - per assembly.

695-5 Wireless Magnetometer Sensor.

695-5.1 General: *Wireless, battery powered magnetometers (wireless sensors) detect vehicular traffic by measuring disturbances in the Earth's magnetic field. Detection data is*

transmitted wirelessly to a central roadside communications point (communications hub) that collects the data itself or through another device. The data may be transmitted to the communications hub directly from the sensor(s) or from an intermediary device (wireless repeater) which can amplify the signal for greater transmission distances.

695-5.2 Functional Capabilities:

695-5.2.1 Wireless Sensors: *Use wireless sensors with the following functional capabilities:*

1. Detection accuracy of the magnetometer sensors comparable to properly operating inductive loop sensors.

2. Automatic recalibration in the event of a detector lock.

3. Communicate wirelessly such that 97% of the traffic detected is transmitted to the communications hub.

4. Transmit a unique identifying code with detection data and periodically transmit status data (ex. power level, RSSI).

5. Capable of accepting software and firmware upgrades.

6. Operate at temperatures from 0 to 158°F.

The sensor housing or containment method shall conform to NEMA Type 6P and IEC IP68 standards.

The sensor power source shall have a minimum life expectancy of three years when the sensor is configured for and operating under normal traffic conditions (normal traffic conditions must be defined in writing by manufacturer and expressed as AADT).

695-5.2.2 Communications Hub: *The wireless links between each sensor and communications hub and between each wireless repeater and communications hub shall conform to the following:*

1. Meet the appropriate regulatory restrictions as is legally required.

2. Center frequencies, bandwidths, and transmit power levels of the radio links must allow operation in an unlicensed frequency band.

3. User selectable settings must be available to avoid interference with other devices operating in the unlicensed band

4. Detection data must be relayed from the communications hub to a local traffic controller via contact closure signals.

5. Support the relay of sensor detection data through several interfaces simultaneously as required by the application.

6. Be capable of accepting software and firmware upgrades.

7. Support enough sensors to support, at a minimum, six separate lanes of traffic data.

8. Be field configurable to be powered from 12 V_{DC}.

9. Properly operate at temperatures from 0 to 158°F.

Communications hub components which must be placed in a specific location for proper operation, relative to other system components such as sensors or repeaters, must conform to NEMA Type 4X and IEC IP67 standards.

695-5.2.3 Wireless Repeater: *Use wireless repeaters with the following functional capabilities:*

1. Reliably communicate at a minimum distance of 150 feet.

2. Be powered from a 12 V_{DC} source.

3. Operate at temperatures from 0 to 158°F.

Wireless repeater components which must be placed in a specific location for proper operation, relative to other system components such as sensors or repeaters, must conform to NEMA Type 4X and IEC IP67 standards.

695-5.3 Method of Measurement: *The Contract unit price for each magnetometer sensor will include the magnetometer sensor, communications hub, repeater, cables, bonding agent; and all equipment, materials, testing and labor necessary for a complete and accepted installation.*

695-5.~~6~~4 Basis of Payment: *Prices and payments will be full compensation for all work specified in this Section.*

Payment will be made under:

Item No. 695- 4- TMS Wireless Magnetometer Sensor - per ~~sensor~~each.

695-6 Solar Power Unit.

695-6.1 General: *Install TMS solar power units at the locations and as shown in the Plans and Design Standards. Solar power units are used to power TMS that collect vehicular data on a continuous basis. The solar power unit consists of the following components: solar panel(s) and mounting hardware; 12 V storage battery; and voltage regulator with wiring and associated mounting hardware.*

695-6.2 Materials: *Use solar power unit components listed on the Department's APL compatible with the other components installed at the location. Ensure that the solar power unit is marked in accordance with ~~Section~~ 695-2.2 and the markings are visible after installation.*

695-6.2.1 Solar Panel Configured for Nominal 12 V_{DC}: *Meet the following requirements:*

1. *Peak power range of 80 to 130 watts, as specified in the Contract Documents.*
2. *Voltage at maximum power greater than 16.5 V at 77°F.*
3. *Current at maximum power greater than 2.85 A at 77°F.*
4. *Photovoltaic modules constructed of mono or poly-crystalline cells.*
5. *Capable of multiple arrays and series or parallel wiring configurations.*
6. *Anodized aluminum frame.*
7. *Anodized, Galvanized or Stainless Steel Mounting hardware.*

Ensure that solar panels do not have internal voltage regulators. When multiple panels are required, use panels of the same model and manufacture.

695-6.2.2 Battery 12 V: *Meet the following requirements:*

1. *Rechargeable for photovoltaic application.*
2. *Valve regulated lead-calcium gelled electrolyte.*
3. *ABS Plastic or Polypropylene case.*
4. *Minimum current discharge rate of 100 hours at 0.9 amperes.*
5. *Approximate overall dimensions of 12 inches by 7 inches by 9 inches.*

695-6.2.3 Voltage Regulator Configured for Nominal 12 V_{DC}: *Meet the following requirements:*

1. *Minimum of 13.5- V_{DC} for battery charging.*
2. *Begin charging when battery voltage is 13.3 V or less.*
3. *Discontinue charging when battery voltage is 14.5 V.*

~~5~~4. *Quiescent current of 15 mA or less.*

~~6~~5. *Operating temperature range of 0 to 122°F.*

~~7~~6. *Approximate overall dimensions of 2 inches by 5 inches by 1 inch.*

695-6.3 Installation Requirements: *Install the solar power units in accordance with the manufacturer's recommended installation procedure, Design Standards, Index No. 17900 and the Contract Documents.*

695-6.3.1 Pole Placement: *Ensure that the pole is placed to allow for the proper placement of the solar panels.*

695-6.3.2 Solar Panel Orientation: *Mount and orient the solar panels to the south. Angle the solar panels in accordance with Design Standards, Index No. 17900.*

Install a weather head on the tenon and route the wires from the solar panels junction box to the weather head through a liquid tight flexible conduit and through the pole to the cabinet.

695-6.4 Method of Measurement: *The Contract unit price each for solar power unit includes the solar power unit as specified in the Contract Documents, all equipment, materials, and labor necessary for a complete and accepted installation.*

695-6.5 Basis of Payment: *Price and payment will be full compensation for all work specified in this Section.*

Payment will be made under:
Item No. 695- 5- TMS Solar Power Unit - each.

695-7 Inductive Loop Assembly.

695-7.1 General: *Install TMS inductive loop assembly at the locations shown in the Plans meeting the requirements of this specification. Ensure that all materials furnished, assembled, or installed are new products.*

695-7.2 Materials: *Furnish and install inductive loop assembly components listed on the Department's APL that are compatible with the other components installed at the location.*

695-7.2.1 Loop Wire: *Use loop wire in accordance with Design Standards, Index No. 17900.*

695-7.2.2 Shielded Lead-In Cable: *Use shielded lead-in cable in accordance with Design Standards, Index No. 17900.*

695-7.2.3 Splicing: *No splicing loop wire less than 150 feet.*

695-7.3 Installation Requirements: *Install inductive loop assembly components and materials in accordance with the Plans and Design Standards.*

695-7.3.1 Saw Cuts: *Loop layout will be as shown in the Design Standards, Index No. 17900.*

Perform saw cuts across concrete pavement expansion joints as detailed in the Design Standards, Index No. 17900.

For pavement less than 3 inches deep, make saw cuts deep enough to allow 1 to 1-1/2 inch of sealant cover over the installed loop wire.

695-7.3.2 Loop Wire: *Ensure that all loops have four complete turns of wire, wound in a clockwise manner. Do not damage the insulation.*

Ensure that the hold down material is non-metallic; placed in the saw slot using segments 1 to 2 inches long, spaced 12 inches apart; and the distance from the top of the hold down material to the final roadway surface is not less than 1-1/2 inches.

695-7.3.3 Loop Wire Twisted Pair Lead: *Create a loop wire twisted pair lead by twisting the loop wire pair a minimum of 8 to 16 twists per foot from the edge of the loop to the termination point in the cabinet. Provide a minimum of 3 feet of twisted loop wire pair lead in the pull box located adjacent to the roadway.*

695-7.3.4 Loop Sealant: *Use loop sealant in accordance with Section 660. Prepare and apply the sealant in accordance with the manufacturer's instructions. Remove excess sealant from the roadway surface. Ensure that the loop sealant has cured completely before allowing vehicular traffic to travel over the sealant.*

695-7.3.5 Shielded Lead-In Cable: *Install the shielded lead-in cable and perform all splices in accordance with the Design Standards, Index No. 17900.*

Ensure that the shielded lead-in cable is of sufficient length to extend through the conduits to the cabinet without additional splicing.

695-7.4 Testing: *Conduct all testing with the leads disconnected from the backplane.*

695-7.4.1 Loop Resistance: *Ensure new loops have a resistance reading of 3.0 Ω~~ohms~~ or less.*

695-7.4.2 Inductance: *Ensure new loops have a minimum inductance reading of 100 MΩ*

695-7.4.3 Insulation Resistance (Megging): *Ensure new loops have a minimum reading of 200 MΩ at 500 V.*

695-7.5 Method of Measurement: *The Contract unit price per ~~assembly~~each for inductive loop assembly includes loop wire, loop sealant and shielded lead-in cable, all equipment, materials, and labor necessary for a complete and accepted installation.*

695-7.6 Basis of Payment: *Prices and payments will be full compensation for all work specified in this Section, except conduit and pull and junction boxes.*

Conduit will be paid for as specified in Section 630 and pull and junction boxes will be paid for as specified in Section 635.

Payment will be made under:

Item No. 695- 6- TMS Inductive Loop Assembly – each.

695-8 Site Cabinet.

695-8.1 General: *Install Type III, IV or V TMS cabinets in accordance with Section 676 and Design Standards, Index No. 17900.*

695-8.2 Materials:

695-8.2.1 General: *Only use TMS cabinets and components currently listed on the Department's APL. Ensure that the cabinet and components are compatible with the other components installed at the location.*

695-8.2.2 Shelf: *Ensure that the cabinet has an adjustable shelf, constructed of 0.08 inch thick aluminum, that is adjustable to within 15 inches of the top of the cabinet and to within 26 inches of the bottom of the cabinet in 2 inch increments.*

695-8.2.3 Backplane and Cabinet Cable: *Furnish and install as specified in the Design Standards, Index No. 17900.*

695-8.3 Installation Requirements: *Install the TMS cabinet in accordance with the Plans, Design Standards and manufacturer's recommended installation procedure. Ensure that all conduit entrance holes or field drilled holes are reamed and free of burrs. Use clear silicone rubber sealant to make all conduit connections to the cabinet watertight. Perform all excavation and backfill in accordance with 125-4 and 125-8.2.*

695-8.3.1 Pole Mounted Traffic Monitoring Site Cabinets (Types III and IV): *Install pole mounted traffic monitoring site cabinets in accordance with Design Standards, Index Nos. 17900 and 17841.*

695-8.3.2 Base Mounted (Type IV and V) and Pedestal Mounted (Type III) Traffic Monitoring Site Cabinets: *Install base and pedestal mounted traffic monitoring site cabinets in accordance with Design Standards, Index Nos. 17900 and 17841.*

Ensure that the end of the conduit riser is a minimum of 2 inches above the finished surface of the concrete base.

695-8.4 Method of Measurement: *The Contract unit price each for TMS cabinet includes the TMS cabinet, shelf, and backplane components as specified in the Contract Documents, all equipment, materials, and labor necessary for a complete and accepted installation.*

The cost of the base or pedestal, as shown in the Design Standards, is included in the cost of the cabinet. The cost of the pole for pole mounts will be paid in accordance with Section 646.

695-8.5 Basis of Payment: *Price and payment will be full compensation for all work specified in this Section.*

Payment will be made under:

Item No. 695- 7- TMS Cabinet - each.

695-9 Site Modem.

695-9.1 General: *Install TMS modem and antenna in the cabinet at the TMS location shown in the Plans.*

695-9.2 Materials:

695-9.2.1 General: *Use a TMS modem listed on the Department's APL compatible with the other components installed at the location.*

695-9.2.2 Modem: *Furnish and install all cables required to connect the modem to the electronics unit including the antenna.*

The device shall be field configurable to be powered from 12 V_{DC}.

695-9.2.~~3~~2.1 Network Service: *The device shall have the ability and be configured to utilize a network service that shall be at a minimum 3G EV-DO with fallback to CDMA 1xRTT.*

695-9.2.~~4~~2.2 Protocols: *The device shall have the ability to utilize, at a minimum, the following protocols:*

1. *Network: TCP/IP, UDP/IP, DNS*
2. *Routing: NAT, Host Port Routing, DHCP, PPPoE, VLAN, VRRP, Reliable Static Route*
3. *Application: SMS, Telnet/SSH, Reverse Telnet, SMTP, SNMP, SNTP*
4. *Serial: TCP/UDP PAD Mode, Modbus (ASCII, RTU, Variable), PPP*

695-9.2.~~45~~2.3 Event Reporting: *The device shall have the capability to record and report, at a minimum, the following events in plain text:*

1. *Network parameters*
2. *Data usage*
3. *Power*
4. *Device temperature*

695-9.2.~~56~~2.4 Security: *The device shall have the following security provisions:*

1. *Ability to establish VPN tunnels*

2. IPsec, SSL, and GRE VPN client
3. Port forwarding and DMZ
4. Port filtering
5. Trusted IP
6. MAC address filtering

695-9.2.~~67~~2.5 Environmental: *The device shall operate at temperatures from 0 to 158°F.*

~~*The device shall be field configurable to be powered from 12 V_{DC}.*~~

*695-9.2.~~7~~**8**3* **Antenna:** ~~*The device shall have an antenna that m*~~*Use an antenna that meets the following requirements:*

~~**695-9.2.783.1 Electrical Requirements:**~~

1.- Frequencies: F_1=824 to 896 MHz, F_2=1850 to 1990 MHz
2.- VSWR~~:~~ of 1.5:1 or less at resonant point
3.- 50 Ω nominal ~~I~~impedance~~: of~~
4.- Gain~~:~~ of 3.0 dB
5.- Omni-directional r~~R~~adiation ~~P~~pattern~~: Omni Directional~~
6.- Vertical ~~P~~polarization~~: Vertical~~

~~**695-9.2.3.2 Mechanical Requirements:**~~

~~1~~*7. Glass-~~-~~filled ~~P~~polypropylene ~~R~~radome*
~~2~~*8. Adhesive ~~M~~mounting*
~~3~~*9. SMA ~~M~~male plug ~~C~~connectors*
~~4~~*10. 10 ~~-~~foot. (minimum) c~~C~~oaxial ~~L~~length~~: a minimum of 10 ft.~~*

695-9.3 Commercial Software Registration: *Ensure that the Department is registered as the end-user of software installed on the system communications.*

695-9.4 Installation Requirements: *Install the TMS modem in accordance with the manufacturer's recommended installation procedure, unless otherwise specified in the Contract Documents.*

695-9.5 Method of Measurement: *The Contract unit price each for TMS modem will include the antenna and all equipment, materials, and labor necessary for a complete and accepted installation.*

695-9.6 Basis of Payment: *Price and payment will be full compensation for all work specified in this Section.*

Payment will be made under:
Item No. 695- 8- TMS System Communications Modem - per each

TRAFFIC MONITORING SITE EQUIPMENT AND MATERIALS.
(REV 1-28-15)

The following new Section is added after Section 687:

SECTION 695
TRAFFIC MONITORING SITE EQUIPMENT AND MATERIALS

695-1 Description.

Furnish or furnish and install a complete, operable traffic monitoring site (TMS) as shown in the Plans and Design Standards. The Department uses TMS to monitor the volume, speed, number of axles, weight of wheels, axles or vehicles, or vehicular axle classification types.

695-2 General.

695-2.1 Traffic Monitoring Site Component Approval: Use only components that meet the requirements of this Section and are listed on the Department's Approved Products List (APL).

Any electronics unit or software submitted for approval must be compatible with or convert the data into a format compatible with the Department's polling and processing software. Any substitute software modules submitted must be tested and approved.

695-2.2 Marking of Approved Equipment:

695-2.2.1 Manufacturer's Identification: All TMS equipment must be permanently marked with the manufacturer's name or trademark, part or model number and date of manufacture or serial number.

695-2.2.2 Submittal Data Requirements: Submit forms in accordance with 603-5.

695-2.3 Poles for Cabinets, Non-Intrusive Sensors and Solar Panels:

695-2.3.1 Requirements: Meet the requirements of Section 646 for 20 foot aluminum poles.

695-2.3.2 Installation: Install cabinets in accordance with Section 676. Ground the pole in accordance with Section 620.

695-2.4 Manufacturer's Warranty Provisions:

695-2.4.1 General: Secure all warranties provided by the equipment manufacturer for the specific equipment included in the Contract. Ensure that all warranties are fully transferable from the Contractor to the Department. Transfer warranties upon final acceptance in accordance with 5-11. Document all warranties and warranty transfers and provide a copy to the Engineer. The Engineer will submit warranty forms received from the Contractor to the Transportation Statistics Office (TranStat) TMS Manager.

695-2.4.2 Terms and Conditions: Ensure that the terms and conditions of warranties are documented by the manufacturer when submitting a request to the Department for certification and for equipment submittal for construction projects. Include terms for a specified service performance with provisions for repair parts and labor, or for replacement.

Ensure the terms and conditions define the equipment installation date as the date for such warranty to be in effect. The installation date for construction projects is the day the site

is accepted by the TranStat TMS Manager. For warehouse purchases, the installation date is the date of visual inspection approval, not to exceed ten days after delivery date.

When warranty is available, ensure that a written warranty accompanies the manufacturer's billing invoice. Ensure warranties require the manufacturer to furnish replacements within 10 calendar days of notification for any part or equipment found to be defective during the manufacturer's warranty period at no cost to the Department.

Leave a copy of the warranty in the cabinet once it is installed. Provide an original copy to the Engineer. The Engineer will submit warranty forms received from the Contractor to the TranStat TMS Manager. Comply with the terms of the warranty. The Department may suspend the certification for non-compliance.

695-3 Vehicle Sensor (Non-Weight) Applications.

695-3.1 General: Install TMS vehicle sensors of the type and at the location shown in the Plans. Use vehicle sensors listed on the Department's APL and compatible with the electronics unit to which they will be connected.

695-3.2 Axle Sensor (In-Roadway):

Physical Characteristics, Axle Sensor Sensors	
Sensor Element Dimensions	6 ft. to 10 ft. in length (as specified in Plans), 3/16 in. to 3/8 in. in diameter (varies by manufacturer)
Sensor Element Material	Pressure sensing piezoelectric
Pavement Operating Temperature	0°F to +150°F
Output Signal	Minimum +200mV for passenger/pickup truck axle @ 70°F with less than 10% negative signal

695-3.2.1 Installation: Install sensors in accordance with the requirements of this Section and Design Standards, Index No. 17900. Ensure axle sensors are installed in the roadway and secured using an adhesive bonding material listed on the APL.

Install axle sensors in the right-hand wheel-path midway between the leading and trailing loops as detailed in Design Standards, Index 17900. Install axles sensors in the left-hand wheel-path when no paved shoulder exists and sensor lead exit windows are installed at the right-hand edge of the roadway surface or in a lane which is to the left of and adjacent to an open lane of traffic.

Install the axle sensor such that the cable end is closest to the pull box to which the sensor lead cable will be routed. Install the end of the sensor mid-way into the edge line stripe or lane line stripe. Ensure that the axle sensor being installed has lead-in cables of sufficient length to reach the cabinet without splicing. Do not splice axle sensor lead-in cables.

Route the sensor lead to the pull box then to the TMS cabinet. Mark the sensor lead at the pull box and at termination in the cabinet. Provide lane numbering information as specified in Design Standards, Index No. 17900.

Allow newly applied asphalt to cure for a minimum of 30 days prior to the installation of in-road sensors. Use a chalk line or string and paint to layout the position of the sensor and lead-in cable slots.

Ensure saw cuts do not deviate more than 0.5 inches from the chalk line. Use a single blade or ganged blade saw wide enough to cut the axle sensor slot at full width in a single pass. Cutting two slots and chipping out roadway material between them is not allowed.

Cut the slot the length of the sensor plus an additional 3 to 4 inches. Ensure the depth and width of the slot is installed as recommended by the sensor manufacturer, typically 0.75 inches wide by 1.5 to 2 inches deep.

Use clips or jigs provided by the manufacturer to suspend the sensor at a uniform depth in the slot. Mix and apply the bonding agent ensuring the slot is completely full with no voids beneath the sensor.

695-3.2.2 Test Requirements: Perform the manufacturer's recommended on-site pre-installation test to determine the sensor's condition using an Inductive Capacitance Resistance meter. Install only those sensors that pass the pre-installation test.

Record all test results by lane on the warranty form provided by the manufacturer and leave a copy in the cabinet.

Repeat the test at the termination point in the cabinet after installation. Use an oscilloscope to view and record typical waveforms and signal intensity measurements for the axles of passenger cars and large trucks. Remove and replace any sensor that fails the test at no additional charge to the Department.

695-3.3 Non-Intrusive Vehicle Sensors (Off-Roadway):

695-3.3.1 General: Install wireless (radar or microwave) vehicle sensors on a pole as shown in the Plans.

Physical Characteristics of Non-Intrusive Sensors	
Detection Zone	A minimum of 8 distinguishable lanes within a minimum of 200 ft. of detection zone
Enclosure	Weatherproof aluminum, stainless steel or polycarbonate housing
Dimensions	Typically up to 15 in. X 12 in. X 6 in.
Weight	Typically less than 10 lb.
Operating Temperature (Ambient)	0°F to 140°F
Operating Frequency	Wireless transmission in FCC approved band or unlicensed RF range
Communications	RS-232,RS-485 or RJ-45 ports and supports a minimum baud rate of 19,200
Data Interface	Compatible with the Department's field storage devices (counters) and transmits detection data via contact closure signal using a hardwired connection

695-3.3.2 Installation Requirements: Install the sensor on a pole perpendicular to the target lanes of traffic with room to perform horizontal and vertical aiming adjustments.

Ensure that the wireless vehicle sensor has sufficient cable length to reach the cabinet without splicing. Fasten the cable to the pole so wind does not move it, or route the cable within the pole cavity to the cabinet termination point. Provide 18 to 24 inches of slack in the cable at the connections to the sensor and in the cabinet to ensure the cable is stress-free.

Include the appropriate mounting hardware, contact closure signal that corresponds to vehicle presence and the manufacturer's recommended surge suppression as a part of the installation.

Set up the lane detection zones using the manufacturer's instructions and software and verify that the sensor's orientation is perpendicular to the roadway.

Configure the wireless vehicle sensor for vehicle volume unless otherwise specified in the Plans.

695-3.3.3 Test Requirements: Conduct a visual test to determine that all detection zones are being counted accurately.

Connect a personal computer (PC) to the electronics unit and observe traffic in every lane, verifying that each vehicle is displayed on-screen. A minimum of 20 vehicles should be observed for each lane of traffic with all vehicles counted; assuming a clear line of sight between the sensor and the vehicle being observed is maintained.

If any vehicles are not counted, reconfigure the wireless vehicle sensor and repeat the visual observation test until all lanes count correctly. If the sensor fails to provide accurate counts after three test attempts, it must be replaced with a new unit at no expense to the Department.

Provide a time synchronized video of testing, if requested. Provide a 48-hour verification (class, speed and volume) report for all TMS to the Engineer. The Engineer will submit video received from the Contractor to the TranStat TMS Manager. Leave all documents in the cabinet with a copy sent to the Engineer.

695-3.4 Method of Measurement. The Contract unit price for each vehicle sensor will include the vehicle sensor, lead-in cables, bonding agent; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

695-3.5 Basis of Payment: Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 1-	TMS Vehicle Axle Sensor (In-Roadway)- Non-Weight Applications- each.
Item No. 695- 2-	TMS Vehicle Non-Intrusive – Non-Weight Applications (Off-Roadway) – each.

695-4 Vehicle Speed/Classification Unit.

695-4.1 General: Furnish and install TMS vehicle speed/classification unit (electronics unit) in the TMS cabinet at the locations shown in the Plans.

695-4.2 Materials:

695-4.2.1 General: Use a vehicle speed/classification unit listed on the Department's APL compatible with the other components installed at the TMS. Ensure that the vehicle speed/classification unit and equipment cables are compatible and constructed in accordance with Design Standards.

Ensure that the vehicle speed/classification unit is marked in accordance with 695-2.2 and the markings are visible after installation.

695-4.2.2 Vehicle Speed/Classification Unit Requirements: Provide an electronics unit that outputs data compatible with the Department's polling computer system or furnish a software module that converts the data into a format compatible with the Department's polling computer system.

The electronics unit operates in an unattended mode, accumulating data for later retrieval by downloading via the polling computer system. Ensure that the electronics

unit is capable of downloading data through direct connection with a PC, without deleting or marking the files.

Provide complete operating procedures with all software.

695-4.2.2.1 Compatibility: Provide an electronics unit that is compatible with the embedded inductive loops, axle sensors, magnetometers and non-intrusive vehicle sensors in place at the TMS.

Ensure that each electronics unit is capable of determining the count and classification by type and speed of all vehicles for both directions of traffic on the roadway.

Provide real-time polling software with each electronics unit, capable of operating on a PC using the Department recommended operating system and meeting the following requirements:

1. Capable of communicating with the traffic counter/classifier, and downloading data via cellular modem and producing reports of 15 minute, hourly, weekly, monthly and annual volume and classification data.

2. Capable of displaying and entering operating parameters into the vehicle class/counter, and allowing the display of real-time traffic volumes in addition to routine data collection activities.

3. Capable of processing and storing all vehicle data retrieved in routine mode, regardless of the selected parameters.

695-4.2.3 Functional Requirements: The electronics unit must be fully functional when receiving input from two 6 foot by 6 foot embedded inductive loops, spaced 12 to 24 feet apart, leading edge to leading edge, with a single axle sensor located between the loops, in each lane of a six lane (minimum) roadway. Ensure that each electronics unit is capable of collecting data from each of the lanes of traffic in any combination of counts, classification, speed, or direction.

Provide electrical components of solid state design, constructed so that they will not be damaged by jolts and vibrations encountered during shipping and everyday use.

Ensure that all electronics units are functionally identical and interchangeable except as follows:

1. The electronics unit may be constructed utilizing plug in modules; however, when plug in modules are used, each electronics unit must be identical except for the number and type of modules used. Ensure that modules of the same type are identical and interchangeable.

2. Should more than two electronics units be required in the same cabinet, ensure that each electronics unit has a unique, individual electronics unit number. The electronics unit number must reside in non-volatile memory, so that it is not changed when a “cold or warm boot” is performed or by a power interruption.

Provide an electronics unit having the capability of obtaining and providing the following:

1. Volume, speed, classification, and classification by speed data simultaneously.

2. Volume data by lane.

3. Speed data by lane in a minimum of 15 bins, programmable in 5 mph increments.

4. Classification by lane in vehicle type by axle class in 15 bins (minimum) in accordance with FHWA Classification Scheme "F" in Florida's Traffic Forecasting Handbook, Chapter 2, Figure 2.2 which can be accessed on the Department's website at the following URL address: http://www.dot.state.fl.us/planning/statistics/trafficdata/ptf.pdf.

Ensure that each electronics unit has the capability of providing real-time monitoring of volume data by lane or direction in user selected intervals of as little as 15 minutes, when required, without disrupting the above selected programs.

Provide an electronics unit capable of communicating directly with a PC or through a modem at a minimum rate of 19,200 bps.

Ensure that, at a minimum, the following parameters are programmable by direct connection to the electronics unit or via modem:

1. Six digit site number.
2. Number of lanes and directions.
3. Date and time.
4. Data operating and transmission parameters.
5. Sensor spacing.
6. Recording interval.
7. Vehicle parameter table with axle spacing ranges for each type of vehicle.
8. Number and range of speed categories, axle and length classifications, and headway.

Should an axle sensor or a loop in one or more lanes fail, the electronics unit must continue to provide the speed and volume from the remaining functioning sensors.

Ensure that the sensitivity level for each axle sensor is individually adjustable using software, by direct PC connection and remotely via telemetry.

Ensure that the loop detectors are internal and self-tuning. Ensure that the sensitivity level and any additional parameters necessary to prevent "loop crosstalk" for each embedded inductive loop can be adjusted individually using software, both by direct PC connection and remotely via telemetry.

Provide a means of introducing a time delay, or "de-bounce" value for ignoring spurious axle signals (ghost axles) in the electronics unit software.

695-4.2.4 Power Requirements: Provide an electronics unit that is field configurable to be powered 12 V_{DC} and does not consume more than a total of 12 watts.

If an internal battery is required, it must be capable of being recharged and shall be furnished and included with the electronics unit at no extra cost.

695-4.2.5 Mechanical Requirements: Provide a modular electronics unit which is completely enclosed in a durable housing of sheet metal or cast aluminum with a durable finish. When configured for operation the electronics unit including all cables must fit into a Type IV cabinet.

695-4.2.6 Environmental Requirements: Provide an electronics unit which operates as specified when the ambient temperature and humidity inside the controller cabinet are within the following limits:

695-4.2.6.1 Ambient Temperature: The operating ambient temperature range must be between minus 0 to 140ºF.

The rate of change in ambient temperature must not exceed 63ºF per hour, during which the relative humidity must not exceed 90%.

695-4.2.6.2 Humidity: The relative humidity must not exceed 90% over the temperature range of 40 to 109ºF. Above 109ºF, constant absolute humidity must be maintained as seen in Table 695-1. The relative humidity range shown in Table 695-1 is for dynamic testing.

Table 695-1		
At 14.6 psi Barometric Pressure		
Dry Bulb ºF	Relative Humidity (%)	Wet Bulb ºF
40	75	37
50	80	46
60	83	57
70	86	66
80	87	77
90	89	88
100	89	97
109	90	108
120	70	109
130	50	109
140	38	109
150	28	109
160	21	109
165	18	109

695-4.2.7 Cables and Connectors: Furnish all cables and connectors for a complete and functional installation of each electronics unit in accordance with the Design Standards, Index No. 17900.

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

Furnish one serial port cable for interconnecting each electronics unit with a PC.

695-4.3 Installation Requirements: Install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, the Design Standards, Index No. 17900, and Contract Documents.

695-4.4 Method of Measurement: The Contract unit price per assembly for electronics unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.

695-4.5 Basis of Payment: Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 3- TMS Vehicle Speed/Classification Unit - per assembly.

695-5 Wireless Magnetometer Sensor.

695-5.1 General: Wireless, battery powered magnetometers (wireless sensors) detect vehicular traffic by measuring disturbances in the Earth's magnetic field. Detection data is transmitted wirelessly to a central roadside communications point (communications hub) that collects the data itself or through another device. The data may be transmitted to the communications hub directly from the sensor(s) or from an intermediary device (wireless repeater) which can amplify the signal for greater transmission distances.

695-5.2 Functional Capabilities:

695-5.2.1 Wireless Sensors: Use wireless sensors with the following functional capabilities:

1. Detection accuracy of the magnetometer sensors comparable to properly operating inductive loop sensors.
2. Automatic recalibration in the event of a detector lock.
3. Communicate wirelessly such that 97% of the traffic detected is transmitted to the communications hub.
4. Transmit a unique identifying code with detection data and periodically transmit status data (ex. power level, RSSI).
5. Capable of accepting software and firmware upgrades.
6. Operate at temperatures from 0 to 158°F.

The sensor housing or containment method shall conform to NEMA Type 6P and IEC IP68 standards.

The sensor power source shall have a minimum life expectancy of three years when the sensor is configured for and operating under normal traffic conditions (normal traffic conditions must be defined in writing by manufacturer and expressed as AADT).

695-5.2.2 Communications Hub: The wireless links between each sensor and communications hub and between each wireless repeater and communications hub shall conform to the following:

1. Meet the appropriate regulatory restrictions as is legally required.
2. Center frequencies, bandwidths, and transmit power levels of the radio links must allow operation in an unlicensed frequency band.
3. User selectable settings must be available to avoid interference with other devices operating in the unlicensed band
4. Detection data must be relayed from the communications hub to a local traffic controller via contact closure signals.
5. Support the relay of sensor detection data through several interfaces simultaneously as required by the application.
6. Be capable of accepting software and firmware upgrades.
7. Support enough sensors to support, at a minimum, 6 separate lanes of traffic data.
8. Be field configurable to be powered from 12 $V_{DC.}$
9. Properly operate at temperatures from 0 to 158°F.

Communications hub components which must be placed in a specific location for proper operation, relative to other system components such as sensors or repeaters, must conform to NEMA Type 4X and IEC IP67 standards.

695-5.2.3 Wireless Repeater: Use wireless repeaters with the following functional capabilities:

1. Reliably communicate at a minimum distance of 150 feet.
2. Be powered from a 12 V_{DC} source.
3. Operate at temperatures from 0 to 158°F.

Wireless repeater components which must be placed in a specific location for proper operation, relative to other system components such as sensors or repeaters, must conform to NEMA Type 4X and IEC IP67 standards.

695-5.3 Method of Measurement: The Contract unit price for each magnetometer sensor will include the magnetometer sensor, communications hub, repeater, cables, bonding agent; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

695-5.4 Basis of Payment: Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 4- TMS Wireless Magnetometer Sensor - per each.

695-6 Solar Power Unit.

695-6.1 General: Install TMS solar power units at the locations and as shown in the Plans and Design Standards. Solar power units are used to power TMS that collect vehicular data on a continuous basis. The solar power unit consists of the following components: solar panel(s) and mounting hardware; 12 V storage battery; and voltage regulator with wiring and associated mounting hardware.

695-6.2 Materials: Use solar power unit components listed on the Department's APL compatible with the other components installed at the location. Ensure that the solar power unit is marked in accordance with 695-2.2 and the markings are visible after installation.

695-6.2.1 Solar Panel Configured for Nominal 12 V_{DC}: Meet the following requirements:

1. Peak power range of 80 to 130 watts, as specified in the Contract Documents.
2. Voltage at maximum power greater than 16.5 V at 77°F.
3. Current at maximum power greater than 2.85 A at 77°F.
4. Photovoltaic modules constructed of mono or poly-crystalline cells.
5. Capable of multiple arrays and series or parallel wiring configurations.
6. Anodized aluminum frame.
7. Anodized, Galvanized or Stainless Steel Mounting hardware.

Ensure that solar panels do not have internal voltage regulators. When multiple panels are required, use panels of the same model and manufacture.

695-6.2.2 Battery 12 V: Meet the following requirements:

1. Rechargeable for photovoltaic application.
2. Valve regulated lead-calcium gelled electrolyte.
3. ABS Plastic or Polypropylene case.
4. Minimum current discharge rate of 100 hours at 0.9 amperes.
5. Approximate overall dimensions of 12 inches by 7 inches by 9 inches.

695-6.2.3 Voltage Regulator Configured for Nominal 12 V_{DC}: Meet the following requirements:

1. Minimum of 13.5 V_{DC} for battery charging.
2. Begin charging when battery voltage is 13.3 V or less.
3. Discontinue charging when battery voltage is 14.5 V.

4. Quiescent current of 15 mA or less.
5. Operating temperature range of 0 to 122°F.
6. Approximate overall dimensions of 2 inches by 5 inches by 1 inch.

695-6.3 Installation Requirements: Install the solar power units in accordance with the manufacturer's recommended installation procedure, Design Standards, Index No. 17900 and the Contract Documents.

695-6.3.1 Pole Placement: Ensure that the pole is placed to allow for the proper placement of the solar panels.

695-6.3.2 Solar Panel Orientation: Mount and orient the solar panels to the south. Angle the solar panels in accordance with Design Standards, Index No. 17900.

Install a weather head on the tenon and route the wires from the solar panels junction box to the weather head through a liquid tight flexible conduit and through the pole to the cabinet.

695-6.4 Method of Measurement: The Contract unit price each for solar power unit includes the solar power unit as specified in the Contract Documents, all equipment, materials, and labor necessary for a complete and accepted installation.

695-6.5 Basis of Payment: Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 5- TMS Solar Power Unit - each.

695-7 Inductive Loop Assembly.

695-7.1 General: Install TMS inductive loop assembly at the locations shown in the Plans meeting the requirements of this specification. Ensure that all materials furnished, assembled, or installed are new products.

695-7.2 Materials: Furnish and install inductive loop assembly components listed on the Department's APL that are compatible with the other components installed at the location.

695-7.2.1 Loop Wire: Use loop wire in accordance with Design Standards, Index No. 17900.

695-7.2.2 Shielded Lead-In Cable: Use shielded lead-in cable in accordance with Design Standards, Index No. 17900.

695-7.2.3 Splicing: No splicing loop wire less than 150 feet.

695-7.3 Installation Requirements: Install inductive loop assembly components and materials in accordance with the Plans and Design Standards.

695-7.3.1 Saw Cuts: Loop layout will be as shown in the Design Standards, Index No. 17900.

Perform saw cuts across concrete pavement expansion joints as detailed in the Design Standards, Index No. 17900.

For pavement less than 3 inches deep, make saw cuts deep enough to allow 1 to 1-1/2 inch of sealant cover over the installed loop wire.

695-7.3.2 Loop Wire: Ensure that all loops have four complete turns of wire, wound in a clockwise manner. Do not damage the insulation.

Ensure that the hold down material is non-metallic; placed in the saw slot using segments 1 to 2 inches long, spaced 12 inches apart; and the distance from the top of the hold down material to the final roadway surface is not less than 1-1/2 inches.

695-7.3.3 Loop Wire Twisted Pair Lead: Create a loop wire twisted pair lead by twisting the loop wire pair a minimum of 8 to 16 twists per foot from the edge of the loop to the

termination point in the cabinet. Provide a minimum of 3 feet of twisted loop wire pair lead in the pull box located adjacent to the roadway.

695-7.3.4 Loop Sealant: Use loop sealant in accordance with Section 660. Prepare and apply the sealant in accordance with the manufacturer's instructions. Remove excess sealant from the roadway surface. Ensure that the loop sealant has cured completely before allowing vehicular traffic to travel over the sealant.

695-7.3.5 Shielded Lead-In Cable: Install the shielded lead-in cable and perform all splices in accordance with the Design Standards, Index No. 17900.

Ensure that the shielded lead-in cable is of sufficient length to extend through the conduits to the cabinet without additional splicing.

695-7.4 Testing: Conduct all testing with the leads disconnected from the backplane.

695-7.4.1 Loop Resistance: Ensure new loops have a resistance reading of 3.0 Ω or less.

695-7.4.2 Inductance: Ensure new loops have a minimum inductance reading of 100 MΩ

695-7.4.3 Insulation Resistance (Megging): Ensure new loops have a minimum reading of 200 MΩ at 500 V.

695-7.5 Method of Measurement: The Contract unit price per each for inductive loop assembly includes loop wire, loop sealant and shielded lead-in cable, all equipment, materials, and labor necessary for a complete and accepted installation.

695-7.6 Basis of Payment: Prices and payments will be full compensation for all work specified in this Section, except conduit and pull and junction boxes.

Conduit will be paid for as specified in Section 630 and pull and junction boxes will be paid for as specified in Section 635.

Payment will be made under:

Item No. 695- 6- TMS Inductive Loop Assembly – each.

695-8 Site Cabinet.

695-8.1 General: Install Type III, IV or V TMS cabinets in accordance with Section 676 and Design Standards, Index No. 17900.

695-8.2 Materials:

695-8.2.1 General: Only use TMS cabinets and components currently listed on the Department's APL. Ensure that the cabinet and components are compatible with the other components installed at the location.

695-8.2.2 Shelf: Ensure that the cabinet has an adjustable shelf, constructed of 0.08 inch thick aluminum, that is adjustable to within 15 inches of the top of the cabinet and to within 26 inches of the bottom of the cabinet in 2 inch increments.

695-8.2.3 Backplane and Cabinet Cable: Furnish and install as specified in the Design Standards, Index No. 17900.

695-8.3 Installation Requirements: Install the TMS cabinet in accordance with the Plans, Design Standards and manufacturer's recommended installation procedure. Ensure that all conduit entrance holes or field drilled holes are reamed and free of burrs. Use clear silicone rubber sealant to make all conduit connections to the cabinet watertight. Perform all excavation and backfill in accordance with 125-4 and 125-8.2.

695-8.3.1 Pole Mounted Traffic Monitoring Site Cabinets (Types III and IV): Install pole mounted traffic monitoring site cabinets in accordance with Design Standards, Index Nos. 17900 and 17841.

695-8.3.2 Base Mounted (Type IV and V) and Pedestal Mounted (Type III) Traffic Monitoring Site Cabinets: Install base and pedestal mounted traffic monitoring site cabinets in accordance with Design Standards, Index Nos. 17900 and 17841.

Ensure that the end of the conduit riser is a minimum of 2 inches above the finished surface of the concrete base.

695-8.4 Method of Measurement: The Contract unit price each for TMS cabinet includes the TMS cabinet, shelf, and backplane components as specified in the Contract Documents, all equipment, materials, and labor necessary for a complete and accepted installation.

The cost of the base or pedestal, as shown in the Design Standards, is included in the cost of the cabinet. The cost of the pole for pole mounts will be paid in accordance with Section 646.

695-8.5 Basis of Payment: Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 7- TMS Cabinet - each.

695-9 Site Modem.

695-9.1 General: Install TMS modem and antenna in the cabinet at the TMS location shown in the Plans.

695-9.2 Materials:

695-9.2.1 General: Use a TMS modem listed on the Department's APL compatible with the other components installed at the location.

695-9.2.2 Modem: Furnish and install all cables required to connect the modem to the electronics unit including the antenna.

The device shall be field configurable to be powered from 12 V_{DC}.

695-9.2.2.1 Network Service: The device shall have the ability and be configured to utilize a network service that shall be at a minimum 3G EV-DO with fallback to CDMA 1xRTT.

695-9.2.2.2 Protocols: The device shall have the ability to utilize, at a minimum, the following protocols:

1. Network: TCP/IP, UDP/IP, DNS
2. Routing: NAT, Host Port Routing, DHCP, PPPoE, VLAN, VRRP, Reliable Static Route
3. Application: SMS, Telnet/SSH, Reverse Telnet, SMTP, SNMP, SNTP
4. Serial: TCP/UDP PAD Mode, Modbus (ASCII, RTU, Variable), PPP

695-9.2.2.3 Event Reporting: The device shall have the capability to record and report, at a minimum, the following events in plain text:

1. Network parameters
2. Data usage
3. Power
4. Device temperature

695-9.2.2.4 Security: The device shall have the following security provisions:

1. Ability to establish VPN tunnels

2. IPsec, SSL, and GRE VPN client
3. Port forwarding and DMZ
4. Port filtering
5. Trusted IP
6. MAC address filtering

695-9.2.2.5 Environmental: The device shall operate at temperatures from 0 to 158°F.

695-9.2.3 Antenna: Use an antenna that meets the following requirements:

1. Frequencies: F_1=824 to 896 MHz, F_2=1850 to 1990 MHz
2. VSWR of 1.5:1 or less at resonant point
3. 50 Ω nominal impedance
4. Gain of 3.0 dB
5. Omni-directional radiation pattern
6. Vertical polarization
7. Glass-filled polypropylene radome
8. Adhesive mounting
9. SMA male plug connectors
10. 10 foot. (minimum) coaxial length

695-9.3 Commercial Software Registration: Ensure that the Department is registered as the end-user of software installed on the system communications.

695-9.4 Installation Requirements: Install the TMS modem in accordance with the manufacturer's recommended installation procedure, unless otherwise specified in the Contract Documents.

695-9.5 Method of Measurement: The Contract unit price each for TMS modem will include the antenna and all equipment, materials, and labor necessary for a complete and accepted installation.

695-9.6 Basis of Payment: Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 8- TMS System Communications Modem - per each