MISSISSIPPI DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION NO. 907-651-6 **CODE (SP)**

DATE: **01/07/2013**

SUBJECT: **Magnetometer Detection System**

Section 907-651, Magnetometer Detection System, is hereby added to and made a part of the 2004 Edition of the Mississippi Standard Specifications for Road and Bridge Construction as follows:

SECTION 907-651 -- MAGNETOMETER DETECTION SYSTEM (MDS)

907-651.01--Description. This work consists of furnishing all components and materials required to enable a wireless, battery powered magnetometer detection system that detects vehicles on a roadway using battery powered magnetometers with wireless communications to transmit detection information. The system shall detect vehicles on a roadway using only changes in the earth's magnetic field and provide detection outputs to a roadside master device before the data is relayed to a freeway cabinet, a local traffic controller cabinet, a central software system, and/or data server as required by the application. The application of the MDS shall be shown in the plans or project specifications. These specifications cover both intersection presence based vehicle detection used for traffic controller input, as well as freeway system or advanced system detection data collection of volume, occupancy and speed. This specification sets forth the minimum specifications for the system.

The Magnetometer Vehicle Detection System (MDS) shall provide accurate roadway data as needed to support the traffic management application. The detection system shall consist of one or more battery-powered wireless Vehicle Sensor Nodes (VSN) installed in the pavement with reusable enclosures, one or more wireless Repeaters (RPs) mounted on poles on the side of the roadway, one or more Access Point Contact Closure (APCC) Interface cards (with Extension (EX) Card(s), if required), one or more Serial Port Protocol Digital Radios (DR) with Isolation (ISO) Modules mounted on the side of the roadway.

The MDS may also include Input/Output (I/O) Modules, if required.

The MDS shall also include CAT5E Outdoor Ethernet Cable, Epoxy Sealant for installation, and applicable operating and configuration software. Software shall provide for control and configuration of the sensors, APCC, SPP's, and RP's and operate on a conventional laptop PC. The MDS shall also include any incidental items necessary for a complete and operable unit in place and accepted.

907-651.02--Materials.

907-651.02.1--Functional Capabilities. The VSN shall detect a vehicle by measuring a change in the x, y, and z axis components of the earth's magnetic field near the VSN caused by a

stopped or passing vehicle. The VSN shall communicate the detection information to the DR or RP via embedded Direct Sequence Spread Spectrum Offset Quadrature Phase-Shift Keying (DSSS O-QPSK) wireless radio. The VSN shall transmit detection information within 150ms of a detected event. The VSN shall communicate time-stamped ON and OFF vehicle detection events. The VSN shall automatically re-transmit a detected event at least 8 times if no acknowledgement is received from the APCC/DR. The VSN shall automatically recalibrate in the event of a detector lock. If radio connection is lost due to stopped vehicles near VSN, each VSN shall be capable of re-establishing radio link with supporting APCC/DR or RP in less than two (2) seconds. Each MDS system shall consist of one or more VSN's located as identified on the plans. Communications between a VSN and DR can be direct, via a single repeater, or via two repeaters operating in tandem.

The Radio Frequency (RF) link among the DR, RP, and VSN shall conform to the following:

- The RF link shall utilize an IEEE approved wireless communications protocol.
- The center frequencies, bandwidths, and transmit power levels of the radio links shall allow operation in an unlicensed frequency band.
- Frequency channels which are user configurable shall be employed by the VSNs, DRs, and RPs to avoid interference with other devices operating in the unlicensed band. A minimum of 16 channels shall be provided for this purpose.
- The RF link budget shall be 93dB or greater.
- The DR to VSN (or RP to VSN) RF range shall be at least 150 feet for a DR/RP installed at 24 feet above the roadway and at least 100 feet at 18 feet above the roadway.
- The RP to DR or RP to another RP RF range shall be at least 750 feet when both units are installed 18 feet above the roadway with clear line-of-sight.

If detection data is relayed to a central software system or central server for advanced system detection or freeway applications, per the plans and specifications, each installation of the Wireless Battery-Powered Magnetometer Vehicle Detection System shall provide the following measurements, as required by the application:

- Vehicle volume (count) per lane over a specified time interval
- Lane occupancy (percent) over a specified time interval
- Vehicle speed (mph or kph) when more than one sensor is deployed in a lane
  - Per-vehicle speed
  - Median speed over a specified time interval
  - Mean speed over a specified time interval
  - Distribution of speeds over a specified time interval
- Vehicle classification when more than one sensor is deployed in a lane
  - Per-vehicle length
  - Report distribution of vehicle lengths over a specified time interval
  - The time interval for measurements shall be selectable from 30 seconds to 24 hours

Each VSN shall transmit a unique identifying code. Each sensor in an installation shall be capable of being individually configured with its own sensitivity level. Sensitivity of the VSN

shall be adjustable as may be required to detect bicycles and/or motorcycles. The VSN shall respond within 100 seconds when the APCC/DR is powered on and transmitting.

Two types of sensor applications of sensors shall be available from the manufacturer. Type A sensors shall provide all sensor functions, including data collection functions. Sensors used for this application shall provide for advanced system detection or stop bar detection. In the advanced system detection scenario a single Type A VSN shall be configurable to approximate the detection zones of 6-foot x 6-foot. In the stop bar detection scenario multiple Type A VSNs shall be configurable to emulate 6-foot x 6-foot to longer lengths. Type B sensors shall support presence detection only. Sensors used for this application shall provide for stop bar detection. In this scenario single or multiple Type B VSNs shall be configurable to emulate 6-foot x 6-foot to longer lengths. The plans shall dictate the sensor type required.

The APCC shall have the capability to transmit detection information to central software or a centralized server through several types of communication media, as required by the application. The APCC shall be capable of simultaneously communicating detection data via the contact closure interface, Ethernet interface, and cellular data modem interface, as applicable. The APCC cards shall provide sensor information processing and support the interface between a DR and the traffic controller using contact closure signals, or, for freeway applications, mounted in a stand-alone cabinet with direct IP communications. The APCC shall have the capability to transmit detection information to 170, 2070, and NEMA TS1 and TS-2 traffic controllers to provide real time detection information via a standard contact-closure based input shelf. The VSN, RP, DR, APCC shall be capable of accepting software and firmware upgrades.

907-651.02.2--Vehicle Sensor Node (VSN) Hardware. The VSN shall consist of a magnetometer, a microprocessor, a wireless transmitter and receiver, battery, an "enclosure case", and epoxy sealant for installation. The VSN components shall be contained within a single housing. The VSN housing shall meet NEMA 6P and IEC IP68 standards. The VSN components shall be fully encapsulated within the housing to prevent moisture from degrading the components. The VSN shall be able to operate at temperatures from -37°F to +176°F. The VSN housing shall be capable of being installed in a 4-inch cored hole that is 2.50" deep. The VSN shall be designed to operate from its battery for a minimum of ten (10) years of life under normal traffic conditions.

907-651.02.3--Serial Port Protocol Digital Radio (DR) Hardware. The Serial Port Protocol Digital Radio (DR) shall support at least 48 sensors with 0.125 second latency. It shall communicate to the APCC utilizing a standard CAT5e or higher Outdoor Ethernet cable. It shall contain a weatherproof Ethernet connector on the bottom of the device, which shall be shipped with a cover firmly attached to provide protection from the elements. The connector shall not require any specialized tools for installation. The DR shall operate at temperatures from -37°F to +176 F, and DR shall be contained within a single housing that conforms to NEMA Type 4X and IEC IP67 standards.

907-651.02.4--Repeater (RP) Hardware. The RP shall extend the effective communication range of the sensor to the DR an additional 750 feet. The RP communicating directly to an APCC/DR shall support at least ten (10) sensors while an RP communicating to a DR via an

intermediate RP shall support at least (six) 6 sensors. The RP shall be battery powered. The RP shall operate in the -37°F to +176°F temperature range. All RP components shall be contained within a single housing conforming to NEMA 4X and IEC IP67 standards. The RP shall be no larger than 7" H x 7" W x 4" D and weigh no more than nine pounds (9 lbs.). The RP shall be designed to operate from its battery for a minimum of seven (7) years of life under normal traffic conditions.

907-651.02.5--Access Point Contact Closure (APCC) Interface Card and Extension (EX) Card Hardware. The APCC shall serve as the master device of the MDS. It shall provide all the higher level processing and interface functions of the MDS system and shall only require a single detection rack width slot. The APCC shall be capable of communicating with at least two (2) DRs. Optional Extension (EX) cards daisy-chained to the APCC shall provide additional contact closures in a signal cabinet (user configurable form 1 to 4 outputs each). All required EX cards to handle the number of sensors or controller channels as indicated in the plans or project specifications shall make up the Extension Card system.

Each APCC card shall provide detector data as contact closure signals to the traffic controller. The APCC card shall be capable of plugging directly in to standard 170/2070 input files and NEMA detector racks or shall be supplied within a standard enclosure to supply power for use in freeway applications. The APCC and EX cards front panel shall be configurable either via software or via front panel switches to provide presence/pulse mode, delay timing and extension timing. An APCC and EX card shall operate at temperatures from -37°F to +176 F, and in humidity up to 95% (non-condensing).

907-651.02.6--Isolator (ISO) Module Hardware. The MDS shall include an isolator module (ISO) to be used between each DR and APCC to extend the communication range and protect the APCC from transient surges. The isolator module shall extend the communication range between the APCC and DR from 33 feet (10 m) to 2000 feet (600 m). The isolator module shall provide electrical isolation of 1500V, surge protection of up to 1500V, and AC power cross protection.

907-651.02.7--Input/Output (I/O) Module Hardware. The MDS may include I/O modules to expand the capabilities of an APCC by providing additional communication options, memory options and a battery backed real time clock. The I/O module shall include a SD Memory Card Slot and battery backed up real time clock. The module shall include a RS232 port for serial communications. It shall also allow for detection data shall be communicated as IP data over GSM-based cellular data services via a GPRS cellular modem. The I/O module shall be physically mounted to the APCC to form a double detector slot profile.

907-651.02.8--Epoxy. The epoxy used for installation of the sensor(s) shall be a two part poly-urea based joint sealant having self-leveling characteristics. Surfaces the epoxy will be bonding to shall be free of debris, moisture, and anything else which might interfere with the bonding process. The epoxy used shall be approved by the manufacturer of the detection system.

907-651.02.9--Configuration Software. The MDS shall include the software necessary to configure the VSN, APCC, DR, EX and RP.

907-651.03--Construction Requirements.

907-651.03.1--Installation. The flush mount sensors shall be installed in the roadway using the following procedure: The roadway shall be core drilled to provide a 4-inch diameter hole, 2.50" deep. The hole shall be cleaned out per the manufactures recommendation and leveled prior to placement so that the sensors will remain flush once installed. A small layer of epoxy to cover the bottom of the hole shall be applied. The sensor shall then be placed on top of this layer of epoxy in the correct orientation. The sensor shall be fully encapsulated with the epoxy to the lip of the cored hole. The DR and RP shall be installed within range of the sensors as specified by the manufacturer.

907-651.03.2--Removal. The direction of traffic flow shall be permanently marked on top of the sensor prior to removal. The sensor and its epoxy coating shall be removed from the roadway by coring a 5-inch diameter hole to a depth of 2.50" with the sensor and epoxy being contained in the center of the core. The core shall then be extracted from the roadway using a pry bar as needed and retained for reinstallation upon completion of roadwork.

907-651.03.3--Reinstallation. Cores containing previously removed sensors shall be reinstalled by coring a 5-inch hole in the roadway to a depth of 2.50". The core shall be placed inside the hole in the correct orientation. The sensor shall be fully encapsulated with the epoxy to the lip of the cored hole. The sensors shall be configured as needed to provide vehicle detection and operate with existing system APCC, DRs, and RPs, as well as existing cabinet components.

907-651.03.4--Limited Warranty. The supplier shall provide a limited two-year warranty on the detection system from the point of the project final acceptance. During the warranty period, technical support shall be available from the supplier via telephone within 24 hours of the time a call is made by a user, and this support shall be available from factory-authorized personnel or factory-authorized installers. During the warranty period, standard updates to the software shall be available from the supplier without charge.

907-651.03.5--Testing and Accuracy Requirements. The Contractor or Supplier shall provide a Wireless Magnetometer Vehicle Detection System that meets the below minimum accuracy requirements for all conditions. Accuracy measurements for the testing shall be done with an appropriate sample size of vehicles, over a specific time period.

The Contractor shall submit to the Engineer the Test plan for Accuracy testing at the location(s) that is site specific to the plans. The test plan shall take into account the roadway type (freeway, arterial), location (urban, rural), and traffic conditions in order to determine appropriate testing length and sample size. The following conditions shall be met for each sensor installed.

1) Measurement Accuracy
The following error levels shall be achievable and demonstrated during testing.

Parameter	Error Percentage
Presence	±1%
Lane Occupancy	±5%
Volume	±8%
Average Speed	±10%
Length Classification limits	±10%

2) Testing
Develop and submit plans for post-installation testing to the Project Engineer for consideration and approval. Ensure the plans test all functional requirements and the accuracy requirements. Provide the Engineer with Application Protocol Interface (API) documentation and Software Development Kit (SDK) for the MDS. The testing shall prove that all in-pavement sensors are configured appropriately. The following post installation test procedures shall be utilized after the MDS is installed in its entirety as shown on the Plans and is integrated with the existing central software. No post-installation testing shall begin until all MDS systems in the project have been configured/calibrated to gather speed, volume, classification, and occupancy, or presence, as dictated by the application and programmed to communicate on the MDOT ITS network. Including the accuracy testing requirement, at a minimum, provide the following on the test plan to be submitted and approved by the Engineer:

a. Inspect all detection system field components to ensure proper installation and cable termination.
b. Verify that field construction has been completed as specified in the plans.
c. Inspect the quality and tightness of ground and surge protector connections.
d. Check power supply voltage and outputs and ensure device connections are as specified in the Plans.
e. Verify that the installation of cables and connections between all DR's to APCC's are per manufacturer recommendations and as specified in the Plans
f. Demonstrate that each Wireless In-Pavement Vehicle Detection System is fully operational and gathering the required data types at the specified interval to the central software or controller, as required by the application.

907-651.03.6--Maintenance and Support. The supplier shall maintain a sufficient inventory of parts to provide support and maintenance of the system. These parts shall be available for delivery within 30 days of receipt of a purchase order by the supplier at the supplier's then current pricing and terms of sale.

The supplier shall maintain an ongoing program for customer support for the system. This support shall be via telephone, email or trained personnel sent to the installation upon receipt of a purchase order at the suppliers then current pricing and terms of sale for technical support services.

Installation and/or training support shall be provided by a factory authorized representative. All documentation shall be provided in the English language.

907-651.04--Method of Measurement. Magnetometer detection system will be measured as a unit quantity per each system installation. Measurement shall include controller modifications, connectors, wiring, software, epoxy sealant, other components for which there is no pay item, and other incidental items necessary to complete the work.

Magnetometer detection system component, of the type specified, will be measured as a unit quantity per each. Measurement shall include any needed modifications, hardware, connectors, wiring, cabling, mounting brackets, and other incidental items necessary to complete the work for the component.

Magnetometer detection system component removal and reinstallation will be measured as a unit quantity per each. Measurement shall include all work necessary to completely remove and reinstall an existing component, of the type specified.

907-651.05--Basis of Payment. Magnetometer detection system and magnetometer system components, measured as prescribed above, will be paid for at the contract unit price per each installed, which price shall be full compensation for furnishing all materials, for installing, connecting and testing, and for all equipment, labor, tools, and incidentals necessary to complete the work.

Magnetometer detection system component removal and reinstallation, measured as prescribed above, will be measured as a unit quantity per each, which price shall include all work necessary to completely remove and reinstall an existing component, of the type specified. It shall also include any necessary epoxy sealant, controller modifications, connectors, wiring, software programming, and any other incidental items necessary to complete the work.

Payment will be made under:

907-651-A: Magnetometer Detection System	- per each
907-651-B: Magnetometer Detection System Component, _____	- per each
907-651-C: Magnetometer Detection System Component Removal and Reinstallation, _____	- per each