

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
MULTI-SENSOR (VIDEO AND RADAR) VEHICLE DETECTION SYSTEM

SIG:EMS

1 of 11

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a. Description. This work consists of furnishing and installing, or removing, a multi-sensor detection system (MSDS). The MSDS must utilize video imaging and radar to detect and track licensed and unlicensed vehicles at distances over 500 feet. The sensor system must fuse vehicle information from the two sensors to provide highly accurate and precise detection for simultaneous stop bar presence detection, advanced detection, and special or advanced applications.

b. Materials. Ensure the MSDS uses a primary detector rack mounted processor to interface with the traffic control cabinet. Ensure the module processes information from both video imaging and radar sensors simultaneously in real-time. Ensure the MSDS consists of a hybrid video camera/radar sensor, detection processors (DP) capable of processing from one to two sensors, output extension modules, surge suppressors, a setup tool, a monitor, and a pointing device.

1. MSDS Hardware.

A. Video Imaging Camera Sensor.

(1) Ensure the camera enclosure includes a proportionally controlled Indium Tin Oxide heater design that maximizes heat transfer to the lens. Ensure the output power of the heater varies with temperature, to assure proper operation of the lens functions at low temperatures and prevent moisture condensation on the optical faceplate of the enclosure. Ensure the transparent coating does not impact the visual acuity and is optically clear.

(2) Ensure cable terminations at the data combiner for video and power does not require crimping or special tools.

(3) Ensure the camera sensor allows the user to set the focus and field of view via Wi-Fi connectivity.

(4) Ensure the camera produces a useable video image of the bodies of vehicles under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the camera can produce a useable video image must be the minimum range from nighttime to daytime, but not less than the range 1.0 lux to 10,000 lux.

(5) Ensure the camera electronics includes automatic gain control (AGC) to produce a satisfactory image at night.

(6) Ensure the imager luminance signal-to-noise ratio (S/N) is more than 50

decibel (dB) with the AGC disabled.

(7) Ensure the imager employs three dimensional dynamic noise reduction (3D-DNR) to remove unwanted image noise.

(8) Ensure the camera imager employs wide dynamic range (WDR) technology to compensate for wide dynamic outdoor lighting conditions. Ensure the dynamic range is greater than 100 dB.

(9) Ensure the camera is digital signal processor (DSP) based, uses a charge-coupled device (CCD) sensing element and output color video with resolution of not less than 550 TV lines.

(10) Ensure the camera sensor includes an electronic shutter control based upon average scene luminance and is equipped with an auto-iris lens that operates in tandem with the electronic shutter. Ensure the electronic shutter operates between the ranges of 1/4 to 1/10,000th second.

(11) Ensure the camera sensor utilizes automatic white balance.

(12) Ensure the camera sensor includes a variable focal length lens with variable focus that can be adjusted, without opening up the camera housing, to suit the site geometry by means of a portable interface device designed for that purpose and manufactured by the detection system supplier.

(13) Ensure the horizontal field of view is adjustable from 4.6 to 53.6 degrees. This camera configuration may be used for the majority of detection approaches in order to minimize the setup time and spares required by the user. Ensure the lens are a 12x zoom lens with a focal length of 3.7mm to 44.0mm. Ensure the lens also have an auto-focus feature with a manual override to facilitate ease of setup.

(14) Ensure the camera incorporates the use of preset positioning that stores zoom and focus positioning information. Ensure the camera can recall the previously stored preset upon application of power.

(15) Ensure the camera is housed in a weather-tight sealed enclosure conforming to IP-67 specifications. Ensure the housing allows the camera to be rotated to allow proper alignment between the camera and the traveled road surface.

(16) Ensure the camera enclosure is equipped with a sunshield. Ensure the sunshield includes a provision for water diversion to prevent water from flowing in the camera's field of view.

(17) Design the camera enclosure so that the pan, tilt and rotation of the camera assembly can be accomplished independently without affecting the other settings.

(18) Ensure the glass face on the front of the enclosure has an anti-reflective coating to minimize light and image reflections.

(19) When mounted outdoors in the enclosure, ensure the camera operates in a temperature range from -30 degrees Fahrenheit (F) to +165 degrees F and a

humidity range from 0 percent relative humidity (RH) to 100 percent RH. Measurement of satisfactory video will be based upon DP system operation.

(20) Ensure the camera sensor acquires its power from the sensor data combiner.

(21) Ensure the video signal is fully isolated from the camera enclosure and power cabling.

(22) Provide a weather-proof protective cover to protect all terminations at the camera.

B. Radar Sensor.

(1) Ensure the radar sensor operates in the 24 Gigahertz (GHz) frequency band and operates on 1 of 7 available enumerated channels that is user selectable.

(2) Ensure the radar detection range is over 500 feet minimum, ± 5 percent.

(3) Ensure the radar sensor can track up to 20 independent objects simultaneously.

(4) Ensure object speed detection is within a range of 0 to 150 miles per hour (mph) ± 1.0 mph.

(5) Ensure the radar sensor can detect vehicles in 1 to 4 traffic lanes.

(6) House the radar sensor in a weather-tight sealed enclosure conforming to IP-67 specifications. The housing must allow the radar to be adjusted to allow proper alignment between the sensor and the traveled road surface.

(7) Ensure when mounted outdoors in the enclosure, the radar operates in a temperature range from -30 degrees F to +165 degrees F and a humidity range from 0 percent RH to 100 percent RH.

(8) Ensure the radar sensor communicates with the sensor data combiner.

(9) Ensure the radar sensor acquires its power from the sensor data combiner.

C. Multi-Sensor Assembly.

(1) House both camera and radar sensors in an overall, single enclosure assembly.

(2) Ensure the overall size of the multi-sensor enclosure does not exceed 14 inches by 15 inches by 17 inches.

(3) Ensure the overall weight of the multi-sensor unit does not exceed 11 pounds.

(4) The effective projected area (EPA) must not exceed 2.0 square feet.

(5) Ensure the maximum power consumption for the multi-sensor assembly is less than 10 watts typical, 20 watts peak.

D. Sensor Data Combiner.

(1) Employ a sensor data combiner that combines sensor information from both video and radar sensors.

(2) The sensor data combiner supplies primary power to each sensor unit.

(3) Ensure the sensor data combiner facilitates digital communications between the sensor data combiner and each of the sensor units. Ensure the power cabling is 16 American wire gauge (AWG) three-conductor cable with a minimum outside diameter of 0.325 inch and a maximum diameter of 0.490 inch. Ensure the cabling complies with the *NEC*, as well as local electrical codes.

(4) Ensure the sensor data combiner gets its primary power from an alternating current (AC) power source using industry standard 3-conductor cabling.

(5) Ensure the sensor data combiner communicates with the detection processor using a single coax cable. Ensure this cable is suitable for installation in conduit or overhead with appropriate span wire. Ensure Bayonet Neill Concelman (BNC) plug connectors are used where applicable. The coaxial cable, BNC connector, and crimping tool must be approved by the supplier of the MSDS, and the manufacturer's instructions must be followed to ensure proper connection.

(6) Ensure the sensor data combiner also employs industry standard Wi-Fi connectivity for remote sensor system setup using a mobile programming device such as a netbook or tablet computer. Ensure video camera and radar sensor can be configured independently.

(7) Ensure the sensor data signal is fully isolated from the mechanical enclosure and power cabling

(8) Ensure cable terminations at the sensor data combiner do not require crimping tools.

(9) House the sensor data combiner in a weather-tight sealed enclosure conforming to IP-67 specifications.

E. Detection Processor (DP).

(1) Ensure each sensor input accepts RS170 (National Television Standards Committee) or CCIR (Phase Alternating Line) signals from an external video source. Ensure the interface connector is BNC type and is located on the front of the processing unit. Ensure the sensor input has the capability to be terminated into 75-ohms or high impedance (Hi-Z) using dip switches or software control from the user menu. Ensure the sensor input also facilitates the data from the radar sensor.

(2) Provide a light emitting diode (LED) indicator to indicate the presence of the sensor signal. Ensure the LED illuminates upon valid sensor synchronization and turn

off when the presence of a valid sensor signal is removed.

(3) Ensure one video output is provided. Ensure the video output is RS170 or CCIR compliant and passes through the input video signal. For multi-channel video input configurations, a momentary push-button must be provided on the front panel to cycle through each input video channel. In the absence of a valid sensor signal, the channel must be skipped and the next valid sensor signal must be switched. Ensure the real time video output has the capability to show text and graphical overlays to aid in system setup. The overlays must display real-time actuation of detection zones upon vehicle detection or presence. Ensure overlays can be turned off by the user. Provide control of the overlays and sensor switching through the serial communications port. Ensure the video output interface connector is positive locking BNC type. Friction type connectors are prohibited.

(4) Provide open collector (contact closure) outputs. Provide four open collector outputs for the single or dual channel rack-mount configuration. Additionally, the DP must allow the use of extension modules to provide up to 24 open collector contact closures per camera input. Ensure each open collector output is capable of sinking 30 milliamps (mA) at 24 volts direct current (VDC). Open collector outputs will be used for vehicle detection indicators as well as discrete outputs for alarm conditions. Ensure the DP outputs are compatible with industry standard detector racks assignments.

(5) Ensure logic inputs such as delay/extend or delay inhibit are supported through the appropriate detector rack connector pin or front panel connector in the case of the input/output (I/O) module. For DPs and extension modules, ensure four inputs are supported via detector rack interface. The I/O module must accommodate eight inputs through a 15-pin "D" connector.

(6) Provide detection status LEDs on the front panel. Ensure the LEDs illuminate when a contact closure output occurs. Ensure rack-mounted detection processors have a minimum of four LEDs. Ensure rack-mounted extension modules have two, four or eight LEDs (depending upon extension module type) to indicate detection.

(7) Ensure the front panel of the DP has detector test switches to allow the user to manually place calls on each DP output channel. Ensure the test switch can place either a constant call or a momentary call depending on the position of the switch.

(8) Provide two universal serial bus (USB) A ports on the front panel of the rack mount detection processing unit.

(i) Ensure the first USB A port is used for a mouse. Ensure the port does not require special mouse software drivers. Ensure the mouse port is used as part of system setup and configuration. Provide a mouse with each detection processor.

(ii) Ensure the second USB A port is used for a thumb drive. Ensure the port does not require special software drivers. Ensure the USB thumb drive port is used for firmware upgrades and for future count and diagnostic data collection.

(9) Provide one USB B port on the front panel of the rack mount detection processing unit. Ensure this port is used for connection to a Personal Computer for system configuration and data collection. Ensure the port does not require special

drivers.

(10) Ensure extension modules (EMs) are connected to the DP by an 8-wire twisted-pair cable with modular registered jack (RJ)-45 connectors. Accommodate DP and extension module (EM) communications by methods using differential signals to reject electrically coupled noise.

(11) Ensure EMs are available to eliminate the need of rewiring the detector rack, by enabling the user to plug an extension module into the appropriate slot in the detector rack to provide additional open collector outputs. Ensure the EM is available in both two and four channel configurations. Ensure EM configurations are programmable from the DP. Ensure a separate I/O module with 32 outputs through a 37-pin "D" connector on the front panel and 8 inputs through a 15-pin "D" connector using an external wire harness for expanded flexibility is available.

(12) Design the DP and EM to mount in a standard detector rack, using the edge connector to obtain power, provide contact closure outputs and accept logic inputs (e.g. delay/extend). Ensure no adapters are required to mount the DP or EM in a standard detector rack. Detector rack rewiring must not be required.

(13) Ensure the DP utilizes non-volatile memory technology to store on-board firmware and operational data.

(14) Ensure the DP enables the loading of modified or enhanced software through the USB port (using a USB thumb drive) and without modifying the DP hardware.

(15) Ensure the DP and EM is powered by 12 or 24VDC. Ensure the DP and EM modules automatically compensate for either 12 or 24VDC operation. Ensure the DP power consumption does not exceed 7.5 watts. Ensure the EM power consumption does not exceed 3 watts.

(16) Ensure the DP operates in a temperature range from -30 degrees F to +165 degrees F and a humidity range from 0 percent RH to 95 percent RH, non-condensing as set forth in *NEMA* specifications.

(17) Provide a video surge suppresser for each sensor input. Ensure the surge suppresser is appropriately grounded to the cabinet ground rod.

F. Bus Interface Unit (BIU). Provide a BUI that meets the requirements of *Section 8 of the NEMA TS2-Specification*. Provide one 6 foot Port 1 communications cable to connect from the detector rack BIU to the controller unit.

2. General System Software Functions.

A. Program detection zones via an on board menu displayed on a video monitor and a pointing device connected to the DP. Ensure the menu facilitates placement of detection zones and setting of zone parameters or to view system parameters. Ensure a separate computer is not required for programming detection zones or to view system operation.

B. Ensure the DP stores up to three different detection zone configurations in non-

volatile memory. The DP can switch to any one of the three different detection configurations within 1 second of user request via menu selection with the pointing device. Ensure each configuration is uniquely labeled and able to be edited by the user for identification. Display the currently active configuration indicator on the monitor.

C. Ensure the DP detects vehicles in real time as they travel across each detection zone.

D. Ensure the DP accepts new detection configurations from an external computer through the USB B port when the external computer uses the correct communications protocol for downloading detection patterns. Ensure software designed for local or remote connection and providing video capture, real-time detection indication and detection zone modification capability is provided with the system.

E. Ensure the DP system can automatically switch to any one of the stored configurations based on the time of day which is programmable by the user.

F. Ensure the DP sends its detection configurations to an external computer through the USB B port when requested when the external computer uses the appropriate communications protocol for uploading detection patterns.

G. Ensure the DP defaults to a safe condition, such as a constant call on each active detection channel, in the event of unacceptable interference or loss of the sensor signal.

H. Ensure the system is capable of automatically detecting a low-visibility condition such as fog and responding by placing all effected detection zones in a constant call mode. Ensure a user-selected alarm output is active during the low-visibility condition that can be used to modify the controller operation if connected to the appropriate controller input modifier(s). Ensure the system automatically reverts to normal detection mode when the low-visibility condition no longer exists.

I. Ensure up to 24 detection zones per camera input are supported and each detection zone can be sized to suit the site and the desired vehicle detection region.

J. Ensure the DP provides up to 24 open collector output channels per sensor input using one or more extension modules.

K. Ensure a single detection zone can replace multiple inductive loops.

L. When a vehicle is detected within a detection zone, ensure a visual indication of the detection is activate on the video overlay display to confirm the detection of the vehicle for the zone.

M. Ensure detection is at least 98 percent accurate in good weather conditions, and at least 96 percent accurate under adverse weather conditions (e.g. rain, snow, or fog) which reduce visibility. Detection accuracy is dependent upon site geometry, camera placement, camera quality and detection zone location, and these accuracy levels do not include allowances for occlusion or poor video due to camera location or quality.

N. Ensure the DP provides dynamic zone reconfiguration (DZR) to enable normal operation of existing detection zones when one zone is being added or modified during

the setup process. Ensure the new zone configuration does not go into effect until the configuration is saved by the operator.

O. Ensure detection zone setup does not require site specific information such as latitude and longitude to be entered into the system.

P. Ensure the DP outputs a constant call during the background learning period of no more than 3 minutes.

Q. Ensure detection zone outputs are configurable to allow the selection of presence, pulse, extend, and delay outputs. Ensure timing parameters of pulse, extend, and delay outputs are user definable between 0.1 to 25.0 seconds.

R. Up to six video detection zones per sensor input must have the capability to count the number of vehicles detected. Store the count value internally for later retrieval through the USB B port. Ensure the zone can also calculate and store average speed and lane occupancy at bin intervals of 10 seconds, 20 seconds, 1 minute, 5 minutes, 15 minutes, 30 minutes and 60 minutes. Ensure one radar sensor zone also counts vehicles, calculates, and stores the average speed and lane occupancy across the approach.

S. In addition to the count type zone, ensure the DP can calculate and/or acquire average speed and lane occupancy using both video and radar sensors. Ensure these values are stored in non-volatile memory for later retrieval.

T. Ensure the DP has an "advance" zone type where detection outputs to the traffic controller is compensated for angular occlusion and distance.

U. Ensure the DP supports bicycle type zones where the zone can differentiate between motorized vehicles and bicycles, producing a call for one but not the other.

V. Ensure bicycle zone types only output when a bicycle is detected. Larger motorized vehicles such as cars and trucks that traverse a bicycle zone must not provide an output.

W. Provide six additional count zones for bicycles, separate from the six data collection zones for vehicles, to accumulate bicycle counts at user specified intervals.

X. Ensure bicycle zones can have extensions assigned to individual bicycle zones for applications where the traffic controller does not have bicycle specific detection inputs.

Y. Ensure the DP provides the ability to assign a separate output channel for bicycle zones to allow traffic controllers to implement special bicycle timing for applications where the traffic controller has separate bicycle detection inputs.

Z. Ensure the DP employs color overlays on the video output.

AA. Ensure the DP can show phase status (green, yellow, or red) for up to eight phases. Ensure these indications can be color coded.

BB. Ensure the user can enable or disable the display of the phase information on the video output.

CC. Ensure the DP can change the characteristics of a detection zone based on external inputs such as signal phase. Ensure each detection zone can switch from one zone type (i.e. presence, extension, pulse, etc.) to another zone type based on the signal state. For example, a zone may be a “count” zone when the phase is green but change to a “presence” zone type when the phase is not green. Another application would be zone type of “extension” when the signal phase is green and then “delay” when red.

DD. For alpha numeric user inputs, ensure the DP utilizes a virtual keyboard on the video overlay system to ease user input. Ensure the virtual keyboard uses the standard QWERTY keyboard layout.

EE. Ensure the DP aids the user in drawing additional detection zones by automatically drawing and placing zones at appropriate locations with only a single click of the mouse. Ensure the additional zone utilizes geometric extrapolation of the parent zone when creating the child zone. Ensure the process automatically accommodates lane marking angles and zone overlaps.

FF. When the user wishes to modify the location of a zone, ensure the DP allows the user to move a single zone, multiple zones or all zones simultaneously.

GG. When the user wishes to modify the geometric shape of the zone, ensure the DP allows the user to change the shape by moving the zone corner or zone sides.

HH. Ensure on screen zone identifiers are modifiable by the user. Ensure the user can select channel output assignments, zone type, input status, zone labels or zone numbers to be the identifier.

II. For multiple camera input DPs, ensure the user can enable automatic video output switching. Ensure the dwell time for each sensor input is user programmable.

JJ. Ensure the DP supports five independent trigger points for radar outputs.

KK. For radar sensor zones, the output can be triggered by presence of a vehicle only or by presence of a vehicle above or below user-defined speed thresholds. Ensure these thresholds are in 1 mph increments, between 0 and 255 mph.

LL. For radar sensor zones, ensure the user can define the overall depth of that zone in ± 1 foot increments

MM. Provide the radar sensor system a function where detection and creation of a user-definable output is made when a minimum specified number of vehicles are detected in the region of interest.

NN. Ensure each radar zone can be programmed to output a presence detection, delay timing, or extension timing when a vehicle has been detected within the proper speed threshold, and within the programmed depth of the zone.

3. Setup Tool.

A. Provide a set up tool for the MSDS. The setup tool will provide secure access to

the Sensor Data Combiner. The secure access will be on two levels; the first is a ten digit hexadecimal Wi-Fi key embedded in the setup tool. The second is a user selectable alphanumeric password of between four and ten digits.

B. Provide a setup tool with the following Video Image Camera Sensor functions; Zoom and auto focus adjustments, low frame rate video and image snapshot storage functions.

C. Provide a setup tool with the following Radar Sensor functions; height, operating channel and sensor offset adjustments. Ensure the setup tool provides a visualization of the roadway with icons representing vehicles at the approach along with simulated detector outputs and instantaneous vehicle speed. The icon will be one of three sizes representing the classification of the vehicle. Ensure the detector trigger points are user adjustable along with the stop bar to MSDS distance.

D. Provide a setup tool with these other general functions; MSDS labeling, password setting and Sensor Data Combiner firmware upgrades.

c. Construction. Furnish and install, or remove a MSDS as shown on the plans or as directed by the Engineer. Ensure that the MSDS is installed as documented by installation materials provided by the manufacturer. Complete this work in accordance with sections 819 and 820 of the Standard Specifications for Construction, the applicable typical signal construction detail, and this special provision. Storage and/or disposal of the removed material are included.

Recommended camera placement height is 18 to 33 feet above the roadway, and over the traveled way on which vehicles are to be detected. For optimum detection, the camera should be centered above the traveled roadway. The camera must view approaching vehicles at a distance not to exceed 350 feet for reliable detection (height to distance ratio of 10:100). Ensure camera placement and field of view (FOV) are unobstructed and as noted in the installation documentation provided by the supplier.

When MSDS system is called for, deliver all equipment internal to the controller cabinet to the MDOT Statewide Signal shop or to the inspecting agency for setup and installation in the controller cabinet.

Do not install the MSDS equipment until all other signal equipment has been installed and inspected. Obtain the Engineer's approval prior to beginning multi-sensor installation. Correct multi-sensor installation that was completed prior to the approval of the Engineer, and which is found to be non-optimal placement of the cameras at no additional cost to the contract. The Engineer will not authorize extra payment or time extensions for work required to reorient or move the sensor(s).

The supplier must provide a limited 3-year warranty on the MSDS. Ensure during the warranty period, technical support is available from the supplier via telephone within 4 hours of the time a call is made by a user, and this support is available from factory-certified personnel or factory-certified installers. During the warranty period, ensure updates to DP software are available from the supplier without charge.

d. Measurement and Payment. The completed work, as described, will be measured and paid for at the contract unit price using the following pay items:

Pay Item**Pay Unit**

Multi-Sensor Vehicle Detection System	Each
Multi-Sensor Vehicle Detection System, Rem.....	Each
Multi-Sensor Vehicle Detection System, Salv	Each
Multi-Sensor Vehicle Detection Sensor.....	Each
Multi-Sensor Vehicle Detection Sensor, Rem	Each
Multi-Sensor Vehicle Detection Sensor, Salv.....	Each

1. **Multi-Sensor Vehicle Detection System** includes furnishing and installing the radar system, interface unit, contact closure hardware, BIU, cable, connectors, and other appurtenant material required to complete the work.

2. **Multi-Sensor Vehicle Detection System, Rem** includes removing any previous system processor, automatic control unit, monitors, amplifiers hardware, cable, connectors, and other appurtenant material. **Multi-Sensor Vehicle Detection System, Rem** also includes storage, as directed by the Engineer, or proper disposal of all removed materials.

3. **Multi-Sensor Vehicle Detection System, Salv** includes reinstalling a removed radar vehicle advanced detector system at the location(s) shown on the plans.

4. **Multi-Sensor Vehicle Detection Sensor** includes furnishing and installing a radar detection sensor, enclosure, mounting bracket, hardware, cable, connectors, and other appurtenant material required to complete the work.

5. **Multi-Sensor Vehicle Detection Sensor, Rem** includes removing all previous detection system, enclosure, mounting bracket, hardware, cable, connectors, and other appurtenant material. **Multi-Sensor Vehicle Detection Sensor, Rem** also includes storage, as directed by the Engineer, or proper disposal of all removed materials.

6. **Multi-Sensor Vehicle Detection Sensor, Salv** includes reinstalling a removed radar vehicle dilemma zone detector sensor at the location(s) shown on the plans.