TEXAS DEPARTMENT OF TRANSPORTATION
SPECIAL SPECIFICATION TO-6291
VIDEO IMAGING VEHICLE DETECTION SYSTEM
(for Intersection Stop Line Detection)

1.0 GENERAL

This special specification sets forth the minimum requirements for a Video Imaging Vehicle Detection System (VIVDS) that monitors and provides vehicle stop line detection at a roadway intersection via processing of video images and provides detector outputs to a traffic controller or similar device.

1.1 A VIVDS configuration for a single intersection will consist of sufficient cameras, the field communications link, VIVDS card rack or shelf mounted processor system, and all associated equipment required to setup and operate in a field environment including a video monitor, mouse and set-up software with interface cable (if required), connectors and camera mounting hardware.

1.2 The system is composed of these principal items: the camera(s), the field communications link between the camera and the VIVDS processor unit, and the VIVDS processor unit along with a PC if required, video monitor or associated equipment required to setup the VIVDS and if required, central control software to communicate to the VIVDS processor.

1.3 The VIVDS processor unit(s) must be compatible with NEMA TS1, NEMA TS2 TYPE 1, TYPE 2 and Type 170/2070 equipment. The VIVDS processor shall either be pluggable in a NEMA TS2 detector rack, or a shelf mount unit that functions as direct replacement for the detector rack assembly (rack and bus interface unit(s).

1.4 Definitions

1.4.1 <u>VIVDS Processor Unit</u>: The electronic unit that converts the video image provided by the cameras generates vehicle detections for defined zones and collects vehicular data as specified.

1.4.2 <u>VIVDS Processor System</u>: One (1) or more VIVDS processor modular unit(s) required to handle the number of camera inputs.

1.4.3 <u>Central Control</u>: A remotely located control center, which communicates with the VIVDS. The VIVDS operator at the central control has the ability to monitor the operation and modify detector placement and configuration parameters. If required, the equipment that constitutes central control is comprised of a workstation microcomputer along with the associated peripherals.

1.4.4 <u>Field Setup Computer</u>: A portable microcomputer used to set up and monitor the operation of the VIVDS processor unit. If required to interface with the VIVDS processor unit, the field setup computer with the associated peripherals described in this special specification and a video monitor, also described in this special specification, shall be supplied as part of the VIVDS.

1.4.5   Field Communications Link: The communications connection between the camera and the VIVDS processor unit. The primary communications link media may be coaxial cable with integral power cable, twisted pair high signal integrity cable, Ethernet cable (Category 5) or fiber optic cable.

1.4.6   Remote Communications Link: The communications connection between the VIVDS processor unit and the central control and may have a network address.

1.4.7   Camera Assembly: The complete camera or optical device assembly used to collect the visual image. The camera assembly consists of a charged coupled device (CCD) or complimentary metal-oxide semiconductor CMOS camera, environmental enclosure, sun shield, temperature control mechanism, and all necessary mounting hardware.

1.4.8   Occlusion: The phenomenon when a vehicle passes through the detection zone but the view from the sensor is obstructed by another vehicle. This type of occlusion results in the vehicle not being detected by the sensor.

Or

When a vehicle in one lane passes through the detection zone of an adjacent lane. This type of occlusion can result in the same vehicle being counted in more than one lane.

1.4.9   Detection zone: The detection zone is a line or area selected through the VIVDS processor unit, when occupied by a vehicle, sends vehicle detection to the traffic controller or freeway management system.

1.4.10   Detection Accuracy: The measure of the basic operation of a detection system (shows detection when a vehicle is in the detection zone AND shows no detection when there is not a vehicle in the detection zone).

1.4.11   Live Video: Video being viewed and/or processed at 30 to 60 frames per second. Digital video being viewed and processed at 5 to 24 frames per second.

1.4.12   Lux: The unit of light intensity used to determine the minimum and maximum values of light in which a camera may operate.

1.4.13   Video Monitor: As a minimum must be a 9 inch color or black and white monitor with suitable connectors (BNC or other as needed) for video in and out or an industrial hardened PC monitor when applicable.

2.0   FUNCTIONAL CAPABILITIES

2.1   The system software must be able to detect either approaching or departing vehicles in multiple traffic lanes. Each zone and output must be user definable through interactive graphics by placing lines and/or boxes in an image on a video or VGA monitor. The user must be able to redefine previously defined detection zones.

2.2   Detection zones must be provided that are specific to the direction of vehicle travel. The direction to be detected by each detection zone must be user programmable. The vehicle detection zone should not activate if a vehicle traveling any direction other than the one specified for detection occupies the detection zone. Cross-street and wrong way traffic should not cause detection.

2.3   The VIVDS processor unit must compensate for minor camera movement (up to 2% of the field of view at 400 foot) without falsely detecting vehicles. The camera movement must be measured on the unprocessed video input to the VIVDS processor unit.

2.4   The camera must operate while directly connected to VIVDS processor unit.

2.5   Once the detector configuration has been downloaded or saved into the VIVDS processor unit, the video detection system must operate with the monitoring equipment (monitor and/or laptop) disconnected or on-line.

2.6   When the monitoring equipment is directly connected to the VIVDS processor unit, it must be possible to view vehicle detections in real time as they occur on the field setup computer's color VGA display or the video monitor.

2.7   For systems that utilize video processor module card(s) a minimum of 4 detector outputs per module is required and each module card must have a minimum of 24 detection zones.

2.8   For systems that utilize a shelf mounted processor that connects directly to the Port 1 communication cable (SDLC) the processor must be capable of providing up to 64 detector outputs in a NEMA TS2 cabinet. For a NEMA TS1 cabinet the shelf mount processor must provide 24 detector outputs through a port via input/output cables.

2.9   The VIVDS must provide real time vehicle detection (within a maximum of 700 milliseconds (ms) of vehicle arrival).

2.10   The VIVDS processor unit must be capable of simultaneously processing information from various video sources, including video players and either CCTV or CMOS video image sensors. The video sources may be, but are not required to be, synchronized or line-locked. The video must be processed at a rate of 5 to 30 frames per second by the VIVDS processor unit.

2.11   The system must be able to detect the presence of vehicles in a minimum of 12 detection zones within the combined field of view of all cameras (a minimum of 12 detection zones per camera input to the VIVDS processor unit). Shelf mount systems that utilize a fixed wide angle lens shall be capable of providing a minimum of 24 detection zone outputs for TS1 and a minimum of 64 detection zone outputs for TS2 within a 300 foot radius of a camera mounted at 30 foot.

3.0   VEHICLE DETECTION

3.1   Detection Zone Placement

The video detection system shall provide flexible detection zone placement anywhere within the combined field of view of the image sensors. Preferred presence detector configurations shall be lines or boxes placed in the lanes, or lines or boxes placed in-line with lanes of traffic. A single detector shall be able to replace one or more conventional detector loops. Detection zones shall be able to be fully overlapped. In addition, detection zones should have the capability of implementing "AND" and "OR" logical functions including presence, extension and delay timing. These logical functions may be excluded if provisions are made to bring each detector separately into the controller and the controller can provide these functions.

3.2   Detection Zone Programming

3.2.1 Placement of detection zones shall be by means of a graphical interface using the video image of the roadway. The monitor shall show images of the detection zones superimposed on the video image of traffic while the VIVDS processor is running.

3.2.2 The detection zones shall be created by using the mouse or keypad to draw detection zones on the monitor. The detection zones shall be capable of being sized, shaped and overlapped to provide optimal road coverage and detection. It shall be possible to save, upload and download the detector configurations to and from the VIVDS processor unit and to retrieve the detector configuration that is currently running in the VIVDS processor unit.

3.2.3 The mouse or keypad must be used to edit previously defined detector configurations so as to fine-tune the detection zone placement size and shape. Once a detection configuration has been created, the system shall provide a graphic display of the new configuration on its monitor. While this fine-tuning is being done, the detection shall continue to operate from the detector configuration that is currently called.

3.2.4 When a vehicle occupies a detection zone, the detection zone on the live video must indicate the presence of a vehicle, thereby verifying proper operation of the detection system. With the absence of video, the card must have an LED indicator that will indicate proper operation of the detection zones. Shelf mounted units may provide an LED or LCD display indication to satisfy this requirement.

3.2.5 Detection zones shall be specific to the direction of vehicle travel. The specific direction to be detected by each detection zone shall be user programmable. The vehicle detection zone shall not activate if a vehicle traveling any direction other than the one specified for detection occupies the detection zone. Cross-street and wrong way traffic shall not cause detection. Programming delay timings (controller or processors) will not be allowed to correct for cross-street or wrong way detection.

3.3 Design Field of View

The video detection system shall reliably detect vehicle presence in the design field of view. The design field of view shall be defined as the sensor view when the image sensor is mounted 24 foot or higher above the roadway, when the camera is adjacent (within 15 foot) to the edge of the nearest vehicle travel lane, and when the distance to the detection area is not greater than ten (10) times the mounting height of the image sensor. Within this design field of view, the VIVDS processor unit shall be capable of setting up a single detection zone for point detection (equivalent to the operation of a 6 foot by 6 foot inductive loop). A single camera, placed at the proper mounting height with the proper lens, shall be able to monitor up to and including five (5) traffic lanes simultaneously.

3.4 Detection Performance

Detection accuracy of the video detection system shall be comparable to properly operating inductive loops. Detection accuracy shall include the presence of any vehicle in the defined detection zone regardless of the lane, which the vehicle is occupying. Occlusion produced by vehicles in the same or adjacent lanes shall not be considered a failure of the VIVDS processor unit, but a limitation of the camera placement. A minimum of 95% detection accuracy shall be enforced for the entire design field of view on a lane by lane and on a time period basis. False detections shall not exceed 20 in an hour per approach. Missed or dropped calls not to exceed 10 in a 1 hour period per approach. When specified in the plans, furnish up to 24 continuous hours of recorded video of all installed intersection cameras within the 30 day test period for verification of proper camera placement, field of view, focus, detection zone placement, processor setup and operation. The video from each camera must show vehicle detections.

3.5   Equipment failure, either camera or VIVDS processor unit, shall result in constant vehicle detection on affected detection zones.

4.0   VIVDS PROCESSOR UNIT

4.1   Cabinet Mounting - The VIVDS processor unit must be mountable in a NEMA TS2 detector rack or be a shelf mounted unit not to exceed 14 inch X 12 inch X 5.5 inch (W X D X H).

4.2   VIVDS Processor Unit - Environmental Requirements: The VIVDS processor unit shall be designed to operate reliably in the adverse environment found in the typical roadside traffic cabinet. It shall meet the environmental requirements set forth by the latest National Electrical Manufacturers Association (NEMA) TS1 and TS2 standards as well as the environmental requirements for Type 170 and 2070 controllers. Operating temperature shall be from –34 (-30° F) to +74 (+165° F) degrees C at 0 percent to 95 percent relative humidity, non-condensing.

4.3   VIVDS Processor Unit - Electrical

4.3.1   The VIVDS shall have a modular electrical design.

4.3.2   VIVDS processor units that utilize the detector rack must operate at 12V or 24V DC. Shelf mounted units must operate within a range of 89V to 135V AC, 60 Hz single phase. Power to the VIVDS must be from the transient protected side of the AC power distribution system in the traffic control cabinet in which the VIVDS is installed.

4.3.3   If required in the plans, serial communications to the field setup computer shall be through an RS-232, USB or Ethernet port. This port shall be able to download the real-time detection information needed to show detector actuations. A connector on the front of the VIVDS processor unit shall be used for serial communications.

4.3.4   The VIVDS processor unit shall be equipped with RS-170 (monochrome), RS-170A (color) composite video or Ethernet inputs, so that signals from image sensors, IP based video or other synchronous or asynchronous video sources can be processed in real-time. BNC connectors or other approved connectors on the front of the VIVDS processor unit or detector input panel shall be used for all video inputs.

4.3.6   Video outputs from the processor unit shall be capable of corresponding to any one of the video inputs, as selected remotely via an external graphical user interface on a laptop computer or front panel switch on the processor/ interface module. Multiple video outputs requiring external cable connections to create a combined single video output shall not be acceptable. A BNC, RCA or VGA connector shall be used for video output and/or RJ45 Ethernet port on the front of the processor unit. Any other video formats used must have prior approval by TxDOT TRF Signal Operations Engineer.

4.3.7   Any deviation to hardware, software or accompanying elements without prior testing and approval from TxDOT, shall be grounds for automatic removal from the TxDOT Qualified Product List (QPL) for an undetermined time.

4.3.8   The VIVDS processor unit software and the supervisor software shall include diagnostic software to allow testing the VIVDS functions. This shall include the capability to set and clear individual detector outputs and display the status of video inputs to enable setup and troubleshooting in the field.

5.0   CAMERA ASSEMBLY

5.1   The cameras must be approved for use with the VIVDS processor unit by the supplier of the VIVDS. As a minimum, each camera shall provide the following capabilities:

5.1.1   Images must be produced with a Charge Coupled Device (CCD) or Digital CMOS sensing element with horizontal resolution of at least 480 lines for black and white or 470 lines for color and vertical resolution of at least 350 lines for black and white or color. Images must be output as a video signal conforming to RS170 or IP based video signal.

5.1.2   Useable video and resolvable features in the video image shall be produced when those features have luminance levels as low as 0.1 lux for black and white or as low as 1.0 lux for color for night use.

5.1.3   Useable video and resolvable features in the video image shall be produced when those features have luminance levels as high as 10,000 lux during the day.

5.1.4   The camera shall include an electronic shutter or auto-iris control based upon average scene luminance and shall be equipped with an electronic shutter or auto-iris lens with variable focal length and variable focus that can be adjusted without opening up the camera housing to suit the site geometry. The variable focal length shall be adjustable from 6 mm to 34 mm. Fixed focal length cameras may be approved for systems that utilize a wide angle lens.

5.2   The camera and lens assembly shall be housed in an environmental enclosure that provides the following capabilities:

5.2.1   The enclosure shall be waterproof and dust-tight to the latest NEMA-4 specifications.

5.2.2   The enclosure shall allow the camera to operate satisfactorily over an ambient temperature range from -34° C (-30° F) to +60° C (+140° F) while exposed to precipitation as well as direct sunlight.

5.2.3   The enclosure shall allow the camera horizon to be rotated in the field during installation.

5.2.4   The enclosure must include a provision at the rear of the enclosure for connection of power and video signal cables fabricated at the factory. Input power to the environmental enclosure must be nominally 115V AC 60 Hz or power over Ethernet (POE) for IP based systems.

5.2.5   A thermostatically controlled heater must be provided to prevent the formation of ice and condensation, as well as to assure proper operation of the lens's iris mechanism. The heater must not interfere with the operation of the camera electronics, and it must not cause interference with the video signal.

5.2.6   The enclosure must be light colored or unfinished and must include a sun shield to minimize solar heating. The sunshield must protrude beyond the edges of the environmental enclosure and must include provision to divert water flow to the sides of the sunshield. The amount of overhang of the sun shield must be adjustable to block the view of the horizon to prevent direct sunlight from entering the lens. The requirement for overhang adjustment may be waved for cameras that mount normal to the horizon. Any plastics used in the enclosure must include ultra violet inhibitors.

5.2.7   The total weight of the image sensor in the environmental enclosure with sunshield shall be less than 11 pounds.

5.2.8   When operating in the environmental enclosure with power and video signal cables connected, the image sensor shall meet FCC class B requirements for electromagnetic interference emissions.

5.2.9   The cameras shall not be manufacturer specific or proprietary in nature.

5.3   The video output of the cameras shall be isolated from earth ground. All video connections for the cameras to the video interface panel shall also be isolated from earth ground.

5.4   Connections for both video and power shall be made to the image sensor using waterproof, quick disconnect connectors. Pigtails from the camera to a waterproof junction box (NEMA 4) or an approved waterproof connector shall be allowed for splicing. The pigtails shall not be longer than 3 foot. Use waterproof, quick disconnect connectors to the image sensor for both video and power.

5.5   A camera interface panel capable of being mounted to sidewalls of a controller cabinet shall be provided for protection of the VIVDS processor unit, camera video and power inputs/outputs. For cameras powered by utilizing 120V AC, the panel shall consist of a 10 amp breaker or blade type fuses and a power terminal strip with a minimum of eight (8) 8/32 binder head screws for the cameras. The panel shall also have, as a minimum, four (4) coax protectors (EDCO CX06 or equivalent). Additional lightning and transient protection will be allowed. All components that reside on the panel shall be TxDOT approved. For cameras utilizing POE the interface panel shall consist of surge protection meeting GR 1089 standards.

5.6   When the connection between the image sensor and the VIVDS processor unit is coaxial cable, the coaxial cable used shall be a low loss, 75 ohm, precision video cable suited for outdoor installation, such as Belden 8281 or TxDOT approved equal.

5.7   Camera mounting hardware shall allow for vertical or horizontal mounting to the camera enclosure. Pelco AS-0166-4-62 or equivalent is acceptable.

6.0   FIELD COMMUNICATIONS LINK

6.1   The field communications link shall be a one-way communications connection from the camera to the equipment cabinet. The primary communications link media may be coaxial cable or fiber optic cable accompanied by a three (3) conductor minimum 18 AWG, 24V DC or 115V AC camera power cable, a twisted pair high signal integrity Ethernet cable, or appropriate cable as approved by the engineer.

6.2   The following requirements shall govern for the various types of field communications link media described on the plans:

6.2.1   Coaxial Cable - In locations where the plans indicate coaxial cable is required as the primary communications link, this cable shall be of the RG-59 or Siamese type with a nominal impedance of 75 ohms. All cable shall have a polyethylene dielectric with copper braid shield having a minimum of 95 percent shield coverage and not greater than 0.90 dB attenuation per 100 foot at 10 MHz with a minimum 18 AWG external three (3) conductor power cable or approved equivalent as directed by the engineer.

6.2.2   Fiber Optic Cable - If specified by the plans, shall be in accordance with the special specification for fiber optic cable.

6.2.3   Twisted wire pairs – Shall be Belden 9556 or equivalent 18 AWG TWP control cable.

6.2.4   Category 5 Cable, if specified must be in compliance with EIA/TIA 568 B.2-1, Commercial Buildings Telecommunications Wiring Standard, must be 24 AWG TWP burial grade, gel filled, cable with black, outdoor jacket, as recommended by the manufacturer. If cable runs exceed 100 meters, sufficient temperature and weather hardened POE extenders/repeaters shall be provided. POE extenders/ repeaters shall be provided with suitable waterproof enclosure.

6.3   All connection cables shall be continuous from the equipment cabinet to the camera locations.

6.4   Lightning and transient surge suppression devices shall be installed on the processor side of the field communications link to protect the peripheral devices. The suppression devices shall be all solid state. In the event a fiber optics communications, then no lightning protection is required for that communication line. The devices shall present high impedance to, and shall not interfere with, the communications lines during normal operation. The suppression devices shall not allow the peak voltage on any line to exceed 300 percent of the normal operating peak voltage at any time. The response time of the devices shall not exceed five (5) nanoseconds.

7.0   **VIVDS SET-UP SYSTEM**

7.1   The minimum VIVDS set-up system, as needed for detector setup and viewing of vehicle detections, shall consist of a field setup computer and Windows-based interface software (if required) and/or a video monitor and mouse or keypad with interface software built-in to the VIVDS processor unit. Live video (5 - 30 FPS) shall be available on the field setup computer to determine proper operation of detectors. The field set-up computer as a minimum, shall have an NTSC video input port, Ethernet port for IP based systems, or equivalent.

7.2   If a field setup computer is required for system set-up, it shall be supplied by the supplier of the VIVDS.

7.3   The field setup computer shall include all necessary cabling and a Windows-based program to interface with the VIVDS processor unit. This software shall provide an easy to use graphical user interface and support all models/versions of the supplied VIVDS.

7.4   Live video with the detection overlaid is required for field verification of the system

8.0   CENTRAL CONTROL SOFTWARE

If required, the central control software shall transmit and receive all information needed for detector setup, monitor the vehicle detection, view the vehicle traffic flow at a rate of 2 FPS or greater for telephone, or 5 FPS or greater for ISDN lines and interrogate all required stored data. The remote communications link between the VIVDS processor unit and central control may be dial-up (telephone or ISDN lines) or dedicated twisted wire pair communications cable which may be accompanied with coaxial cable or fiber-optic cable. Communications with the central control shall not interfere with the on-street detection of the VIVDS processor. Quality of the video at 2 FPS rate must be such that the view with the traffic flow is clear and in focus.

9.0   INSTALLATION AND TRAINING

9.1   The supplier of the video detection system shall supervise the installation and testing of the video and computer equipment. A factory certified representative from the supplier shall be on-site during installation.

9.2   In the event that the field setup computer is furnished by the contracting agency, such installation and testing shall be done at the time that training is conducted.

9.3   If requested, up to two days of training shall be provided to personnel of TxDOT in the operation, setup and maintenance of the video detection system. Instruction and materials shall be provided for a maximum of 20 persons and shall be conducted at a location selected by TxDOT. TxDOT shall be responsible for the cost of training.

9.4   Instruction personnel are required to be certified by the equipment manufacturer. The User's Guide is not an adequate substitute for practical, classroom training and formal certification by an approved agency.

9.5   Formal levels of factory authorized training are required for installers, contractors and system operators. All training must be certified by the manufacturer.

10.0   WARRANTY, MAINTENANCE AND SUPPORT

10.1   The video detection system shall be warranted to be free of defects in material and workmanship for a period of 5 years from date of shipment from the supplier's facility. During the warranty period, the supplier shall repair with new or refurbished materials, or replace at no charge, any product containing a warranty defect provided the product is returned FOB to the supplier's factory or authorized repair site. Product repair or replaced under warranty by the supplier will be returned with transportation prepaid. This warranty does not apply to products damaged by accident, improper operation, abused, serviced by unauthorized personnel or unauthorized modification.

10.2   During the warranty period, technical support shall be available from the supplier via telephone within 4 hours of the time a call is made by a user, and this support shall be available from factory certified personnel or factory certified installers.

10.3 Ongoing software support by the supplier shall include updates of the VIVDS processor unit and supervisor software (if a field setup computer is required for set up). These updates shall be provided free of charge during the warranty period. The update of the VIVDS software shall be tested and approved by TxDOT before installation.

10.4 The supplier shall maintain a program for technical support and software updates following expiration of the warranty period. This program shall be made available to TxDOT in the form of a separate agreement for continuing support.

10.5 The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the camera system.