DESIGN OF TRAFFIC SIGNAL DETECTION TECHNOLOGIES

SEPTEMBER 2022

INFORMATIONAL GUIDE

FDOT TSM&O

Transportation Systems Management & Operations

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1 Introduction

FDOT has several vehicle and pedestrian detection devices from various vendors included on the Approved Products List (APL). While traditional loop detectors are still commonly used, other technologies and products have emerged and matured over the past 15+ years and are now in common use around the country as well as being included on the FDOT APL. While most of the newer technologies strive to emulate loops in some way, there are differences in the design parameters that need to be considered. This document is intended to serve as an educational guide for detection devices on the APL that can be used for intersection applications. This guide is less detailed than standard plans and specifications, but technical enough that it can be used by District traffic operations staff and District roadway design consultants to plan detection strategies and begin the design process on detector placement within the intersection to achieve desired results.

The purpose of the document is primarily educational in nature, intended to allow FDOT staff and consultants new to traffic signal design to become familiar with technologies used for vehicle and pedestrian detection at signalized intersections. The goal is to blend informational language with technical material on detector placement and design for APL detection technology types, including video, radar, and magnetometer as well as pedestrian detection using passive technologies such as video and thermal. This document is not intended to be a design manual or checklist for a Quality Control (QC) process.

Finally, these guidelines are intended to be generic in nature for a given detector technology type, but it should be noted that devices from different vendors can vary widely in application, functionality, and design. It is important to consult the manufacturer's design guide and/or user manual at each stage in the design process.

For more information on intersection detectors, see:

- FDOT Standard Specifications: https://www.fdot.gov/programmanagement/implemented/specbooks/default.shtm
  - Section 660 Vehicle Detection System
  - Section 663 Signal Priority and Preemption Systems
  - Section 665 Pedestrian Detection System
- Index 660-001 of the FDOT Standard Plans: https://www.fdot.gov/design/standardplans/current/default.shtm
- Traffic Detector Handbook, Third Edition: https://www.fhwa.dot.gov/publications/research/operations/its/06108/

2 Description of Detection Systems

A detection system at a signalized intersection can serve several simultaneous purposes, each of which are described below. Furthermore, each detection purpose could be implemented with one of several different technologies. Designers may choose to uniformly use one type of detection for all vehicle or pedestrian detection methods or may use multiple types based on number of lanes, utility impacts, maintaining agency expertise, or other site/resource constraints. The detection technologies described in this document can support one or more of the following traffic signal operational modes:

2.1 Basic Intersection Operation

- Vehicle Detection – vehicle presence is detected at the stop bar and, optionally, at upstream locations (e.g., advance detectors). Detection information is sent to the traffic signal controller so that it can change signals and service demand based upon settings and logic programmed in the controller.
- Pedestrian Detection – detection of pedestrian presence also informs the logic of the signal controller. Pedestrian intervals that are longer than the minimum green time for the adjacent vehicle movement are often needed to provide enough time for pedestrians to cross and clear the crosswalk.

2.2 Priority Operation

- Emergency Vehicle Preemption (EVP) – Certain emergency vehicles (e.g., fire rescue vehicles) are granted permission by some jurisdictions to preempt normal controller operation to enable swift passage through signalized intersections. To accommodate preemption, the traffic signal controller must be notified through a detection methodology that the emergency vehicle is approaching.
- Transit Signal Priority (TSP) – Some agencies deem it desirable to provide a transit vehicle, such as a bus or a light rail car, some level of advantage at an intersection over automobiles to reduce trip time and thus encourage transit use. Again, to accommodate the priority, the traffic signal must be notified the transit vehicle is approaching.
- Freight Priority – Similar to TSP, in certain situations (such as near ports or distribution centers) freight vehicles maybe be granted priority at signalized intersections to reduce their overall stops and delay. Signal operations and detection methodologies for freight priority use technologies that are like EVP and TSP.

2.3 Coordinated Operation

- Traffic Responsive Operation – Consecutive traffic signals along a roadway are often operated in a coordinated manner, with the goal being to provide a green window at each intersection to an approaching platoon of vehicles. System detector data (often at midblock locations) can help inform the logic that changes Time-of-Day (TOD) coordinated timing plans to match the prevailing traffic demands.
- Adaptive Operation – A more sophisticated strategy for the coordination of signals, Adaptive Control can adjust signals in real-time based on the volume and time variability of the traffic demand. This type of control is generally detector intensive including initial installation and quick repair turnaround needs.

2.4 Automated Traffic Signal Performance Measures (ATSPMs)

- ATSPMs provide a traffic engineer with a variety of indicators on how well a traffic signal is accommodating traffic demand. Metrics such as Arrivals on Red, Arrivals on Green, coordination quality, phase termination, and others are derived from a combination of detector volume and timing data and signal controller operational data. The metrics are quite useful in improving traffic signal performance, but collecting the data required is detector and processing intensive. These measures also require additional data storage outside of the controller memory on agency servers or vendor cloud services. A modern, Linux-based signal controller with support for high-resolution (10 Hz) data is required to collect ATSPM data. Controllers meeting Section 671 of the current FDOT Standard Specifications for Road and Bridge Construction can collect ATSPM data.

3 Functions of Detection

Vehicle detection at a signalized intersection is placed in two primary locations, at the stop bar and in advance (upstream of intersection). See Figure 1 below.

3.1 Stop Bar Detection

Detection is placed at the stop bar to let a signal know that a vehicle is present (e.g., waiting for a green indication). When a vehicle is detected at the stop bar, a "call" is placed on the corresponding phase, which places the phase in the queue for service by the controller.

3.2 Advance Detection

Advance detection is placed upstream of the stop bar. The distance upstream depends on several factors including the purposes of the detection, the roadway geometry, and the prevailing speed or posted speed limit. Upstream detection can also be used to place calls on vehicle phases. There are three types of upstream detection.

- **Queue detection** – Primarily used for protected/permissive left-turn movements and located at the end of a left turn lane, a queue detector can inform the signal controller about the number of vehicles waiting, information which the controller can use to modify the length of timing of the green interval serving the queued movement.
- **Dilemma zone** – Dilemma zone detection is a safety strategy. On high-speed signalized approaches there can be an area in which a vehicle, if presented with a yellow signal indication, may not be able to either stop comfortably for the upcoming red light or proceed through the intersection before the light changes. Detection in a dilemma zone gives a signal controller the knowledge to extend the green time slightly so as not to present a yellow indication to a vehicle within the dilemma zone.
- **System detection** – System detection supports the traffic responsive and adaptive operation described above. Advance detection is used to provide input into the logic that determines when a timing plan is changed to serve traffic, but not to directly call a phase or extend green

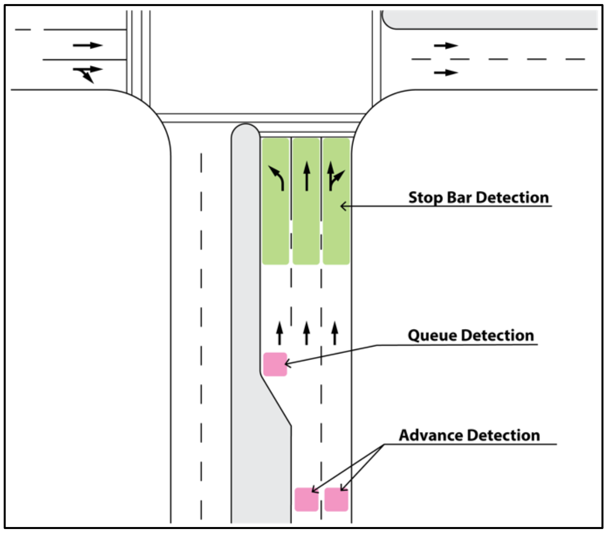

Figure 1: Approach Detection Zones

time. This detection is often at midblock locations to measure the traffic approaching the intersection.

3.3 Intersection Phasing

A discussion of phasing at an intersection is necessary along with a discussion of detection, as each detector is usually assigned to call a specific phase. A phase is a direction of movement, such as a left turn movement, or a through movement. Phases are typically identified by standard numbers, as specified according to National Electrical Manufacturers Association (NEMA) traffic signal phase conventions. Not all intersections will have all 8 phases due to geometric variabilities. See Figure 2 below.

- Each intersection detector must be assigned to a signal phase on the plans
- A detector can be programmed in the controller to call its assigned phase, extend the phase, or to simply collect traffic data for the phase movement
- Pedestrian phasing is labeled in parallel with the adjacent vehicle phase

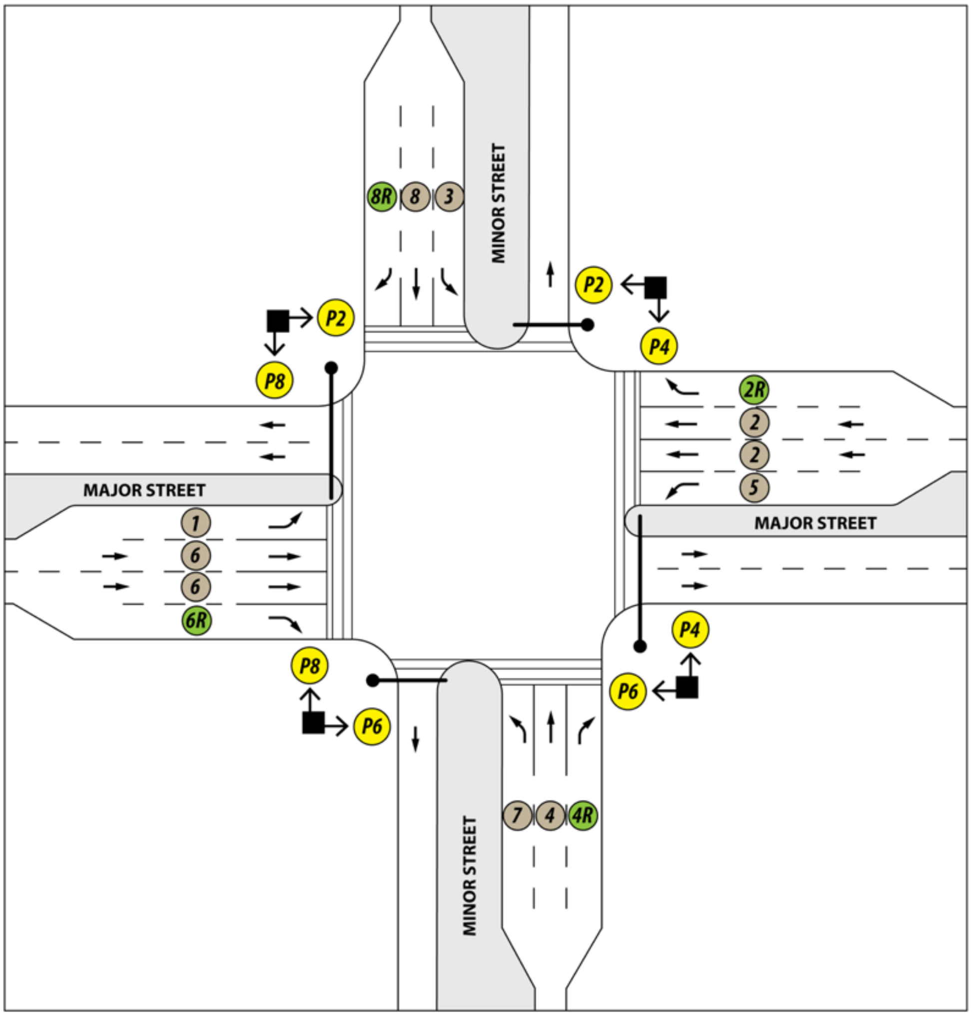

Figure 2: Typical Intersection Phasing

4 FDOT – Typical Detection Practices

Three detection technologies are commonly used in traffic signal applications in Florida:

- Inductive loop detection
- Video Vehicle Detection System (VVDS), which uses a video camera for detecting vehicle presence within a detection zone
- Microwave Vehicle Detection System (MVDS), which uses a Federal Communications Commission (FCC)-certified, low-power microwave radar signal to detect vehicle presence within a detection zone

Often, the selection of the technology is dependent on maintaining agency preference. Some agencies prefer not to use inductive loop detection on concrete pavements or on bridge structures because their in-pavement design allows for water penetration and degradation of the road surface; video and microwave detection systems provide a functional, above-ground alternative.

- Detection layouts are not defined in any FDOT statewide publications but are generally based on the engineering judgement of the district, maintaining agency, or Engineer of Record (EOR). The most common layouts seen, as illustrated in Figure 3, are:
    - Low-speed approaches where a stop is anticipated (i.e., the minor street approaches to an intersection), presence detection at the stop bar is typically used for both calling and extension purposes. Typical detection zones are shown in the FDOT Standard Plans for loop installation (Index 660-001); virtual detection zones can deviate from these designs but should mimic the functionality of an inductive loop detector and should be shown in the Plans.
    - Left-turn lanes where presence detection at the stop bar is also used for calling and extension, again with a detection zone of approximately 20 feet in length with the trailing edge near the stop bar.
    - Mainline movements at moderate speeds where a small detection zone (the equivalent of a 6-foot by 6-foot loop) approximately 50 feet upstream from the stop bar is used for calling and extension. As there is the possibility, under low vehicle demands on the approach, for a vehicle to stop at the stop bar but not to queue over the detection zone, locking detection memory is used for that controller phase.
    - Mainline movements at higher speeds with small detection zones placed about five seconds of travel time in advance of the stop bar are often used to avoid issues related to the "dilemma zone", where motorists face the often-difficult decision of whether to stop or proceed for a yellow change indication.
        - If there is development adjacent to the intersection, with a driveway entrance between the advance detectors and the stop bar, an additional presence detector, used for calling, at the stop bar can eliminate the possibility of a vehicle entering from the driveway not being detected.
        - In some higher speed cases, multiple upstream detection zones are used to allow high-speed vehicles to continue through the intersection.

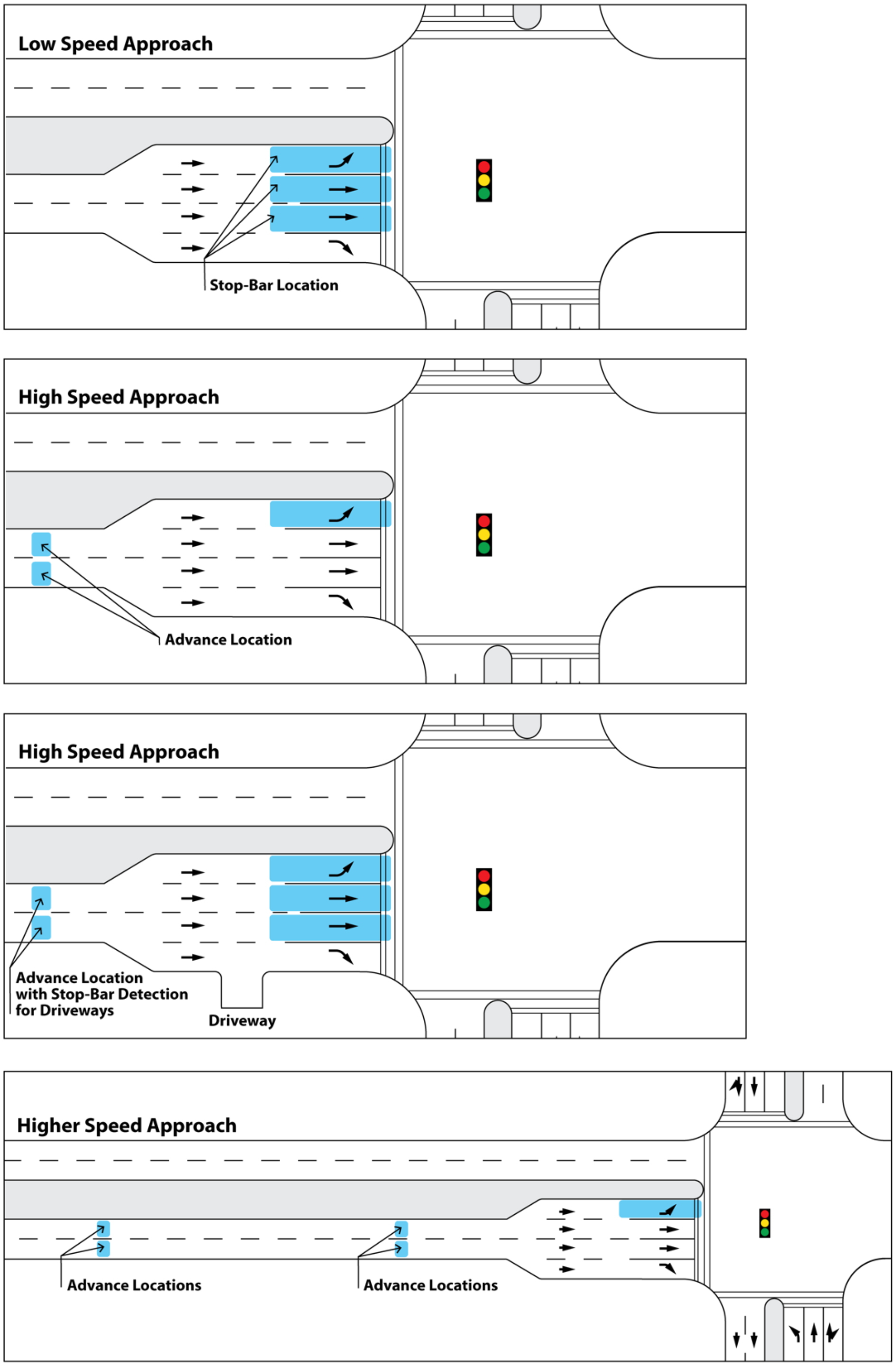

Figure 3: Common Detection Zone Configurations

5 Detection Technologies

Several manufacturers have multiple products on the APL that use the detection technologies described below. Not all devices incorporate all the features and characteristics described and some have specialized abilities designed for specific purposes. The purpose of this document is to describe the technologies in a general manner and cover the basic design principles for each technology, not for specific products. It is important for the designer to consult product specific design information from the vendor for details on specific products during design, construction, operations, and maintenance periods. Surge Protective Devices (SPDs) shall be used per Section 620 of the FDOT Standard Specifications for Road and Bridge Construction (Grounding and Lightning Protection), and per the manufacturers requirements to protect all types of detection devices.

5.1 Inductive Loop Detectors

5.1.1 General Description

An inductive loop detector is a loop of wire, embedded in the roadway pavement, connected via a lead-in cable to an electronics unit (detector card) located in the controller cabinet. When a vehicle passes over or stops on the wire loop, it reduces the loop inductance, which is detected by the electronics unit and relayed as a vehicle detection to the controller.

The complete loop detector assembly includes the loop itself, with multiple turns of wire, a lead-in connection from the loop to a nearby pull box, a shielded lead-in cable from the pull box to the controller cabinet, and an electronics unit housed in the cabinet. The loop and lead-in to the pull box are typically constructed by cutting a narrow slot in the pavement, placing the wire in the slot, and then filling the slot with a sealant to protect the wire.

Loop detectors can be configured in varying sizes and shapes based on the desired zone of detection. The loop configuration does have an impact on the sensitivity of the detector, so the design must be considered if desiring to detect small vehicles, including bicycles. See Section 660 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL).

5.1.2 Operational Considerations

5.1.2.1 Strengths

- Long-proven technology: reliable and successfully used for over fifty years
- Flexible design for multiple applications in traffic control
- Can provide accurate count, presence, occupancy, speed, and gap data based on loop configurations
- Not affected by inclement weather or darkness

5.1.2.2 Weaknesses

- Installation requires cutting into the pavement and may not be feasible on bridge decks
- Installation requires closing one or more lanes of the roadway
- Loop life is dependent on pavement conditions; potholes and severe rutting can destroy loops
- Loops are easily destroyed by resurfacing or utility pavement cuts
- Loops can provide spotty calls as wire insulation begins to fray, or splices become wet

5.1.2.3 Maintenance

- Damaged loops and lead-in cables must be recut and replaced
- Failed loops provide a constant call to the controller to maintain vehicle service at the intersection
- Loop detector cards need to be protected (via surge protection and grounding) from lightning surges, as the loop itself can act as a lighting surge attractor

5.1.3 Layout and Placement

Inductive loop detectors can generally be classified into small area detectors and large area detectors:

- Small area detectors are typically six feet by six feet (6' x 6') in size, centered in the lane, and most frequently used in traffic signal applications for upstream detection. An example is Florida's Type B detector, shown in Figure 4 below.
- Large area detectors are normally six feet (6') in width, centered in the lane, with lengths typically 20 feet, and normally used for stop-bar detection areas. A common example is Florida's Type A detector, shown below.
- A large area detector that is configured with a center slot and a figure eight wiring pattern provides improved sensitivity within the lane and reduced sensitivity to adjacent lanes, making it a frequent choice for left turn lane detection. In Florida, this is designated as a Type F detector, as shown below.
- Large area detection can also be accomplished by utilizing multiple small area loops positioned to emulate a larger detection zone. This is designated as a Type G detector, as shown below.

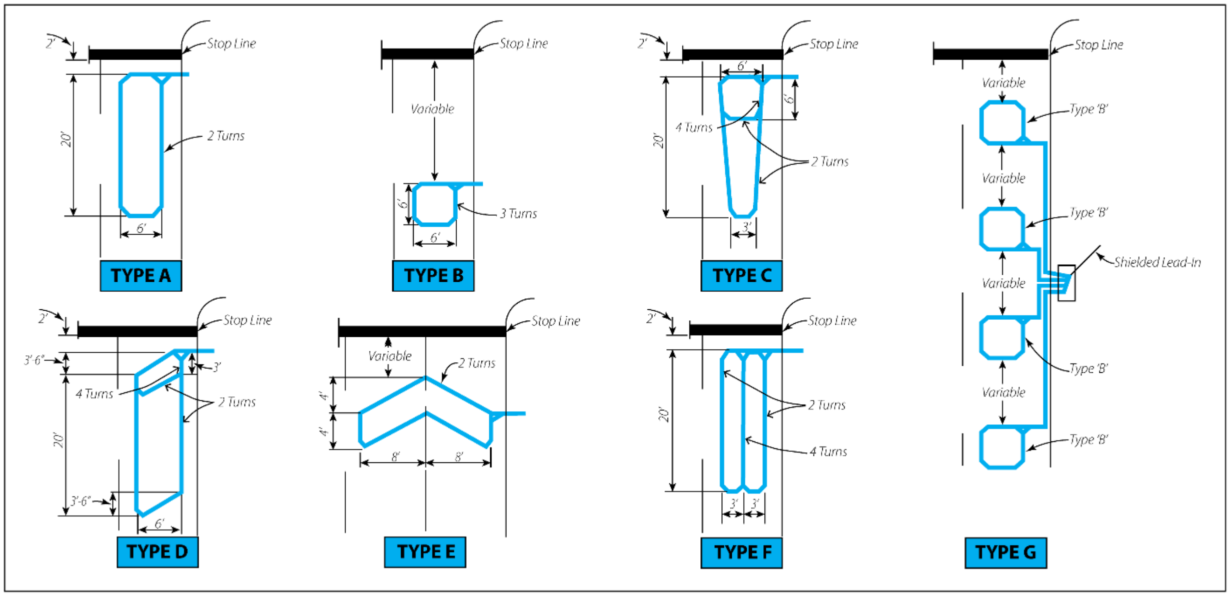

Figure 4: Florida Loop Configurations

- Other loop configurations used in Florida include:
    - Type C, a trapezoidal-shaped large area detector with a small area “hot spot” or “power-head”; this provides presence detection at the stop bar with added sensitivity at the downstream edge that can be used for motorcycles and bicycles.
    - Type D, a parallelogram-shaped large area detector with a small area “hot spot” or “power-head”. Used like the Type C detector, the angled face toward approaching traffic is designed to provide added sensitivity.
    - Type E, a chevron-shaped small area detector designed to cover two adjacent lanes.
- Design details for loop detectors include:
    - Loop designs that require a sharp bend of the loop wiring are typically chamfered with a 45-degree slot cut across the corner; this minimizes the opportunity for the loop wire insulation to be damaged during installation or the flexing of pavement due to passing vehicles or temperature changes.
    - The standard depth of the saw cut is three (3) inches; in concrete pavement, a double width and deeper saw cut is used at each expansion joint to allow movement of the wire, within the flexible sealant, without damage.
    - At the edge of the pavement, rigid conduit is placed to receive the loop wires from the saw slot and route them into the nearby pull box or cabinet.

Inductive loop layout with pull boxes and conduit back to the controller cabinet is generalized in Figure 5.

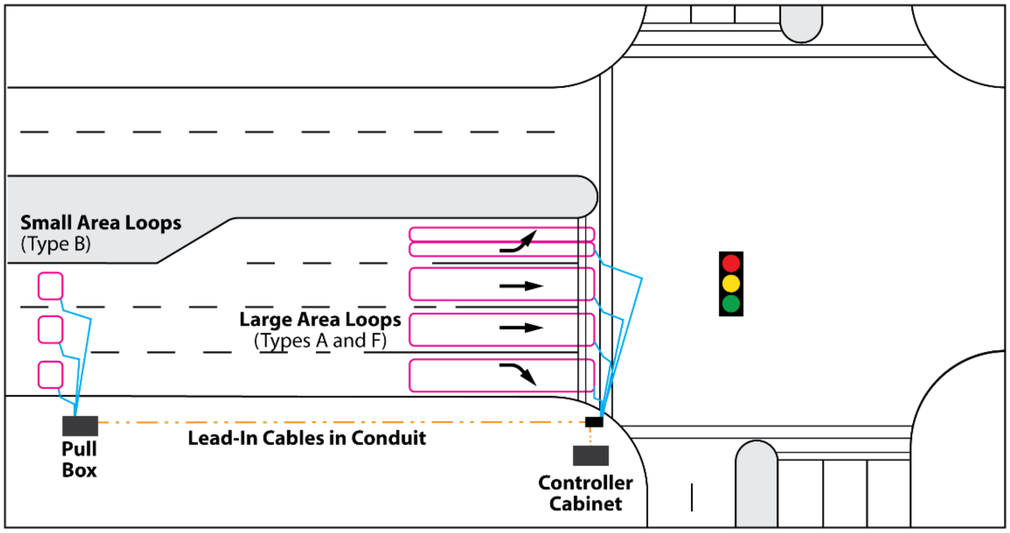

Figure 5: Typical approach loop detector installation

5.1.4 Installation Considerations

5.1.4.1 Wiring

- The wire used for the loop is a stranded copper wire as defined in IMSA 51-7 loop detection wire specifications as referenced in FDOT Standard Specifications 660-2.2.2.1.1.

- Within the loop itself, the wire is wound in a clockwise manner within the saw slot as shown in the FDOT Standard Plans. During installation, the wire is pushed to the bottom of the saw slot using a non-metallic tool (many use a wooden paint stirrer) to avoid damaging the insulation. Non-metallic hold-downs are placed at 12-inch intervals to hold the wire in place as the sealant is placed in the slots.
- Between the loop and the splice point in the adjacent pull box, the loop wire is twisted with a minimum of 10 turns per foot to minimize radio interference. If the loop detector is less than 75 feet away from the cabinet, the twisted loop wire can be extended to the cabinet without splicing to a lead-in cable.
  - The shielded lead-in cable from the roadside pull box to the cabinet is a No. 14 AWG two-conductor cable, using stranded copper wire with an aluminized shield and polyethylene insulation.
  - Quality, waterproof splicing is required between the loop wire and the shielded lead-in cable.

5.1.4.2 Calibration and Testing

- Each loop is required to be tested for conformance to FDOT requirements. Tests include:
  - Measuring the series resistance along the loop assembly (from the cabinet and including the loop and lead-in cable). A reading of more than 10 Ω (ohms) indicates a problem, most likely a poor splice or termination connector.
  - Measuring the resistance of the insulation, using an insulation tester ("megger"). If the insulation is less than 100 MΩ (megaohms), a problem exists with the insulation of either the loop wire or the lead-in cable.
- After detector turn-on, the sensitivity and frequency are adjusted to provide the optimal operation per the manufacturer's recommendations.

5.2 Video Vehicle Detection

5.2.1 General Description

Video vehicle detection is an above-ground detection option that uses cameras and video processing equipment to detect vehicles. It requires an unobstructed line-of-sight of the desired detection area. A video detection system typically uses a purpose-built closed-circuit television (CCTV) camera supplied by a vendor along with internal or external video processing capabilities. Video detection has the added value in that it can be used for traffic monitoring in the Traffic Management Center (TMC) in addition to detecting vehicles.

Video detection comes in several types and can usually be applied for stop bar detection, dilemma zone detection, queue detection, advance detection, as well as general vehicle counting. Video detection systems consist of cameras mounted near the intersection along with a processing unit and other equipment placed in the traffic signal cabinet. The cameras (aka, sensors) are generally mounted on mast arms and uprights, light poles, or dedicated poles. The processing unit can take the form of a card that slides into a cabinet detector rack, or a shelf mounted unit.

Video detection systems allow users to create detection zones of a size and shape that usually emulate loops. The detection zones are superimposed on the live video stream. See Figure 6. When an object enters the detection zone, the pixel value of the video stream is changed. Internal algorithms analyze the change to determine if the change is a result of an actual vehicle, some other object, or a result of a shadow or glare. If the algorithm determines it is a vehicle, a call is registered and parameters such as speed and occupancy can be calculated.

Because it is dependent on a video stream, video detection can be subject to issues such as false calls due to shadows, headlight glare, fog or heavy rain, wet pavement, and other reasons usually caused by environmental conditions. See Section 660 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL).

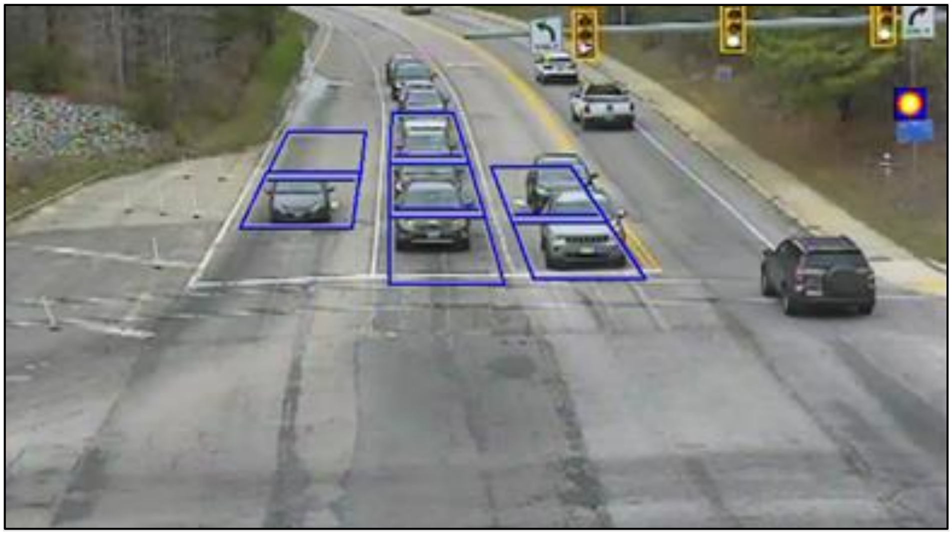

Figure 6: Typical Video Field of View with Detection Zones Drawn

5.2.2 Types of Video Detection

The FDOT Approved Products List (APL) includes several different formats of video detection:

- Traditional cameras that provide a field of view in a single direction. With this type of system, a dedicated camera is needed for each intersection approach (or perhaps more for large approaches). The cameras themselves have different shapes and sizes.
- 360 Degree camera systems that can generally see an entire intersection with a 360-degree view and cover more than one approach with a single camera.
- Hybrid systems, which combine video-based detection for stop bar detection and microwave detection for advance detection in a single unit.

5.2.3 Operational Considerations

5.2.3.1 Strengths

- Video detection is mounted above ground, so no in-pavement installation is required
- Creating detection zones within the camera field of view is easily done at the controller cabinet or remotely using vendor-provided software
- Detection zones can be easily adjusted if permitted lane usage is changed, additional lanes are added, or the lanes are shifted (due to construction activities)
- Ability to use the camera for intersection monitoring (although the camera field of view and zoom ratio must remain fixed)

5.2.3.2 Weaknesses

- Direct and unobstructed line-of-sight is needed from the camera to the detection area
- May have limited range
- All detection occurs within the area of the camera field of view, so to cover a large area or multiple approaches, multiple cameras will be needed
- Environmental conditions may temporarily interfere with detection accuracy
- Occlusion may occur when an object, such as a vehicle, blocks the camera view
- Structural analysis could be required when mounting cameras to existing mast arms

5.2.4 Maintenance

- Units must be properly aimed for accurate detection and must remain fixed. Alignment of cameras should be checked as part of preventive maintenance to ensure the field of view and detection zone alignment has not been negatively impacted by movement (e.g., loose hardware or other damage). Cameras can be checked by viewing the camera interface and checking the alignment of the zones within the lanes.
- As the cameras are usually mounted on mast arms within the intersection, lanes will likely need to be closed for maintenance access with a bucket truck.
- The camera lens should be periodically checked and cleaned for algorithms to function optimally.

5.2.5 Layout and Placement

Video vehicle detection provides a camera “view” interface of the approach being detected. Within this field of view footprint, detection zones can be placed. The detection zones should generally mimic a typical inductive loop layout. Individual loop equivalent areas can be drawn with software provided by the vendor.

5.2.5.1 Stop Bar Application

One camera per approach will usually be needed for intersection stop bar detection. Situations where multiple stop bar cameras could be needed include:

- Large number of approach lanes
- Separated/offset right or left turn lanes
- Underpass restricting mounting height
- Cameras must be placed close to detection zones due to constraints

Video vehicle detection considerations at the signalized approach include:

- Center the camera on the required detections zones.
- There are multiple mounting options, but generally, a view straight onto approaching traffic is usually best to avoid occlusion.
- Figures 7 and 8 shows an example of two locations: on the mast arm or luminaire arm aimed across the intersection at approaching traffic, and on the near side luminaire extension aimed upstream.
- The designer should pick a spot for which the footprint covers the desired detection zone without any obstructions from vegetation, signs, signal heads, mast arms, or other obstacles.

- It is acceptable if the camera field of view is larger than the detection area. The zones are drawn only where they are needed.
- For 360-degree cameras, one camera located as centrally as possible can cover all four approaches (assuming no obstacles exist).
    - Typically means on one of the luminaire extensions off the signal upright.
    - Check the manufacturer's recommendations to ensure proper placement, including distance to the center of the intersection and distance to the stop bar for each detected approach.
- Camera views should include an area at least 5-10 feet in front of the stop bar, but not the upstream horizon. Many detection cameras have zoom and focus controls to adjust the field of view.

Figures 7 and 8 show the camera field of view and detectors for a stop bar application, depicted by the colored shaded area. All detection must fit within the camera's field of view.

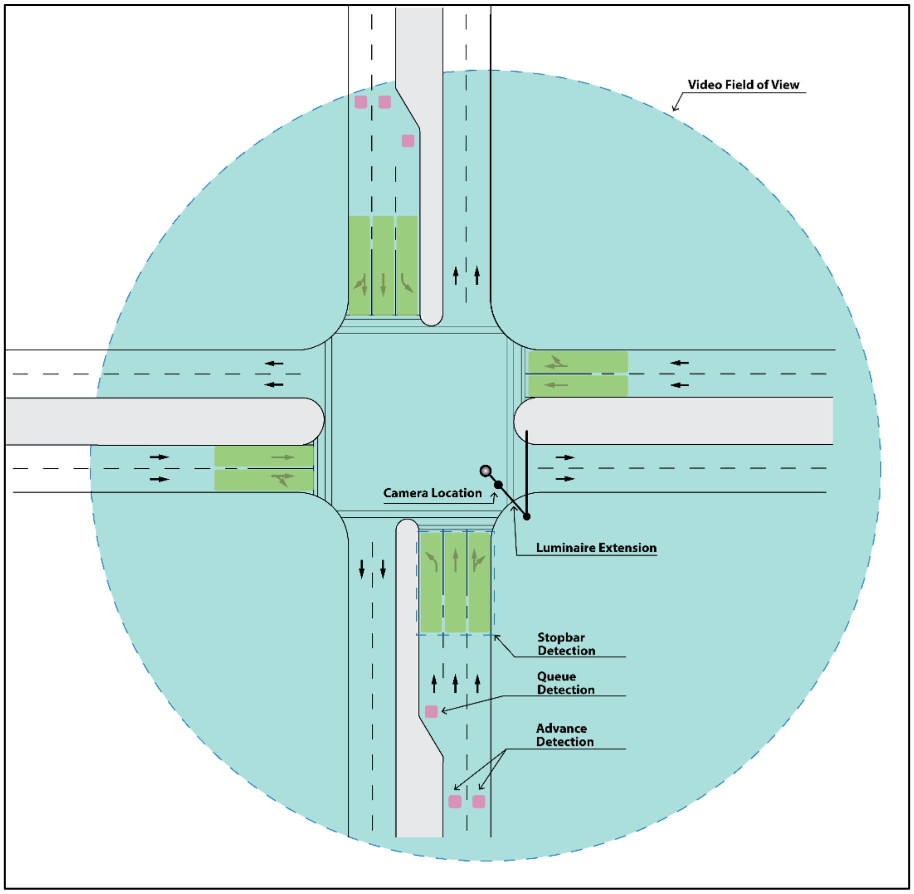

Figure 7: Stop Bar Detection Area - 360 Degree Camera Style

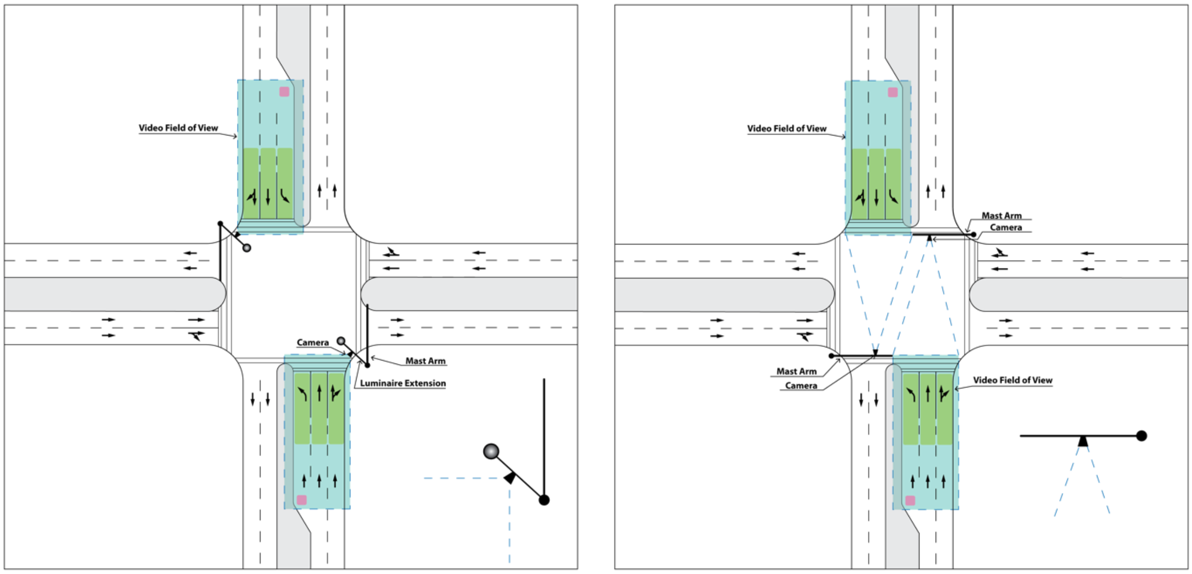

Figure 8: Stop Bar Detection Area - Traditional Camera Style (left-luminaire; right-mast arm)

5.2.5.2 Upstream Detection Application

Upstream detection can sometimes be accomplished with the same camera as stop bar detection. See Figure 9. Most video detection system manufacturers will have guidelines concerning system limitations and how far upstream they can reliably detect.

- The farther upstream a detection zone is placed, the more likely that occlusion will affect accuracy, resulting in undercounting and false calls.
- With lower resolution cameras it can be difficult to focus the image over the entire field of view, resulting in less ability to distinguish pixel value change.
- If the desired upstream detection area is beyond the capability of the proposed camera there are several choices to remedy:
    - Add an additional upstream camera
    - Use a camera with a longer field of view upstream
    - Use a "hybrid" video detection system that includes an integral microwave unit for upstream advance detection
    - Use a different detection technology or detector for advance detection

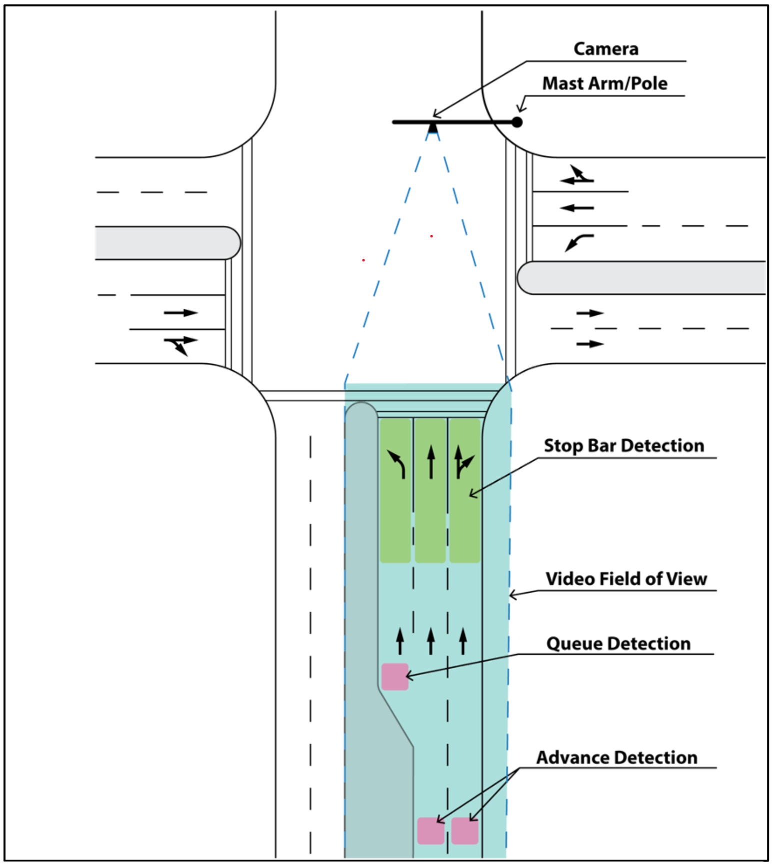

Figure 9: Advance Detection Area

5.2.6 Camera Height

- Mounting height should follow the guidelines in the manufacturer's documentation
- Typical camera mounting height for stop bar applications with a single approach camera is around 20-25 feet above the pavement, but this needs to be balanced with the angle to the roadway and the mounting location to enable the camera field of view to cover the detection area needed
- Mounting height for a 360-degree camera is usually at least 30 feet
- Distance from the stop bar to the most upstream detector will influence mounting height recommendations
- As shown in Figure 10, an extension arm can be used to gain height for better viewing
- A pole extension can also be used if additional height is required. Some vendors provide extensions and mounting brackets specifically for this application

Figure 10: Camera Extension for Additional Mounting Height

5.2.7 Installation Considerations

5.2.7.1 Mounting and Aiming

- Follow the manufacturer's mounting and installation instructions
- Camera mounts allow the device to be rotated and aimed after mounting
- Cameras should be secured to poles with mounting assemblies listed on the APL
- Cable access to the inside of the structure must be provided, either through an existing hole or a drilled hole
- Follow FDOT structural requirements for device mounting on poles with respect to location, loading, required analysis, and drilling
- When aiming, most cameras can be zoomed in and focused on the desired detection area

5.2.7.2 Wiring

- Follow the manufacturer's cabling instructions.
- Manufacturers will generally provide a specified or recommended cable type with the device. Do not substitute an equivalent cable without checking with the manufacturer.
- Generally, there is a cable length limitation due to voltage drop considerations. Check the manufacturer's guidance for maximum cable lengths.

5.3 Microwave Vehicle Detection

5.3.1 General Description

A microwave vehicle detection system (MVDS) is another above-ground detection option. It requires an unobstructed line-of-sight view of the desired detection area. A MVDS transmits, receives, and analyzes an FCC-certified, low-power microwave radar signal to detect vehicle presence and provide a detection output. It comes in several forms and can be applied for dilemma zone detection, stop line and queue detection, as well as general vehicle counting. Microwave detection systems consist of sensors mounted near the intersection along with a processing unit placed in the traffic signal cabinet. The sensors are lightweight and can be mounted on mast arm poles and uprights, light poles, or dedicated poles. The processing unit can take the form of a card that slides into a cabinet detector rack, or a shelf mounted unit. See Section 660 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL).

5.3.2 Operational Considerations

5.3.2.1 Strengths

- Microwave detection is non-intrusive
- Creating detection zones within the range of the microwave beam is easily done at the controller cabinet or remotely using vendor-provided software
- Detection zones can be easily adjusted if lane locations are changed, added, or shifted due to construction activities
- Detection performance is not impacted by changing light levels, shadows, or glare

5.3.2.2 Weaknesses

- Occlusion may occur when an object (such as a vehicle, signage, utility pole, trees, etc.) blocks the microwave beam
- Interference can occur when large flat surfaces (such as buildings, signs, barriers, etc.) are near the detector
- Some types of microwave detection have limited range

5.3.2.3 Maintenance

- Sensors must be properly aimed for accurate detection. Alignment of the device should be checked as part of a preventive maintenance program to ensure detection zone alignment has not been negatively impacted by movement (e.g., loose hardware or other damage).
- Sensors are often mounted in locations requiring bucket truck access and hence lane closures for maintenance access.

5.3.3 Layout and Placement

Microwave vehicle detection generally broadcasts a beam which disperses and expands into a "footprint" on the pavement of the approach being detected. Within this footprint, detection zones can be placed. The detection zones should generally mimic a typical inductive loop layout. Individual loop equivalent areas can be drawn with software provided by the vendor. The manufacturer's installation guide for the specific product should be consulted for configuration requirements and recommendations.

5.3.3.1 Stop Bar Application

Figure 11 below shows the microwave footprint for a stop bar application, depicted by the shaded areas. In this example, the sensor has a 140-foot radius quarter-circle detection area with the sensor being located at the circle's center point. The figure shows three optional locations for mounting the sensor. Any of these will work, but the designer should pick a spot for which the footprint covers the desired detection zone without any obstructions from vegetation, signs, or other obstacles.

5.3.3.2 Detection Area

Figure 11 also shows the detection zones within the footprint area.

- Detection zones should be at least 5 feet inside the footprint boundary to maintain detection accuracy.
- Adjust the sensor offset to provide adequate coverage in front of the stop bar.
- If the desired detection zones do not fit within the detection footprint, additional microwave units can be added upstream.
- In the vendor-provided software, individual detection zones, as well as lane lines and the stop bar, can be drawn within the footprint area.
- Be sure the sensor can be mounted such that all stop bar and queue zones will fall within the detection footprint.
- Use a scaled template to assure the sensor location will properly cover the detection area. If the intersection is skewed, care must be taken to ensure that there are no blind spots in the stop bar detection.

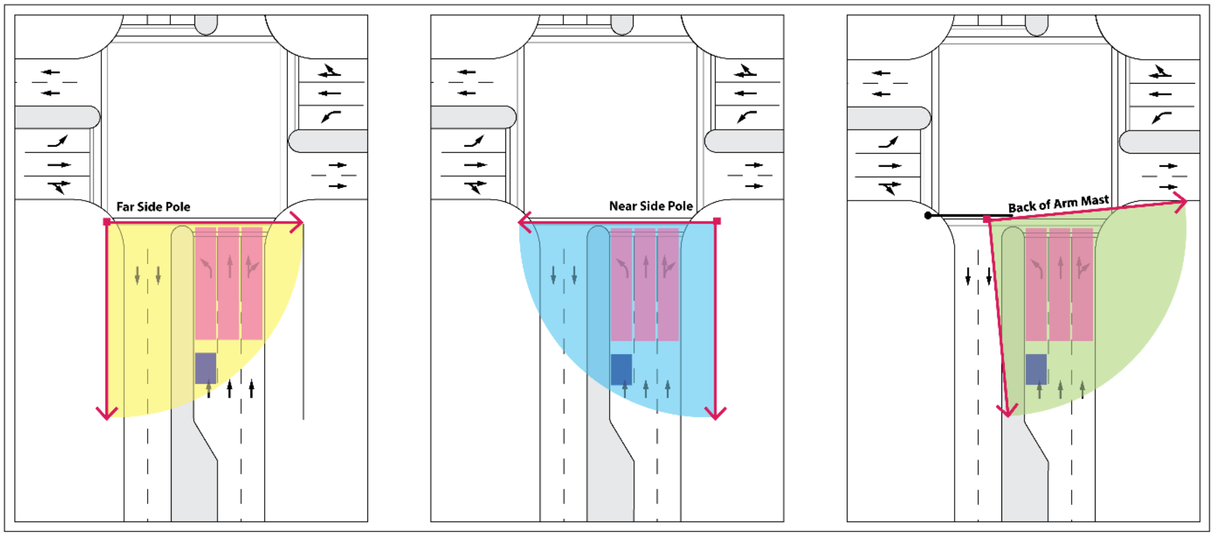

Figure 11: Typical Stop Bar Detection Areas for Microwave Detectors

The mounting height should follow the guidelines in the manufacturer's documentation. Typical sensor mounting height for stop bar applications is around 20 feet above the pavement, but this needs to be balanced with the offset of the sensor from the edge of the first lane to be detected. Check the manufacturer's recommendations for mounting heights and offsets. Some sensors require a minimum offset from the first detected lane to allow for beam dispersion. Figure 12 shows a typical cross-section of the mounting area for a stop bar application.

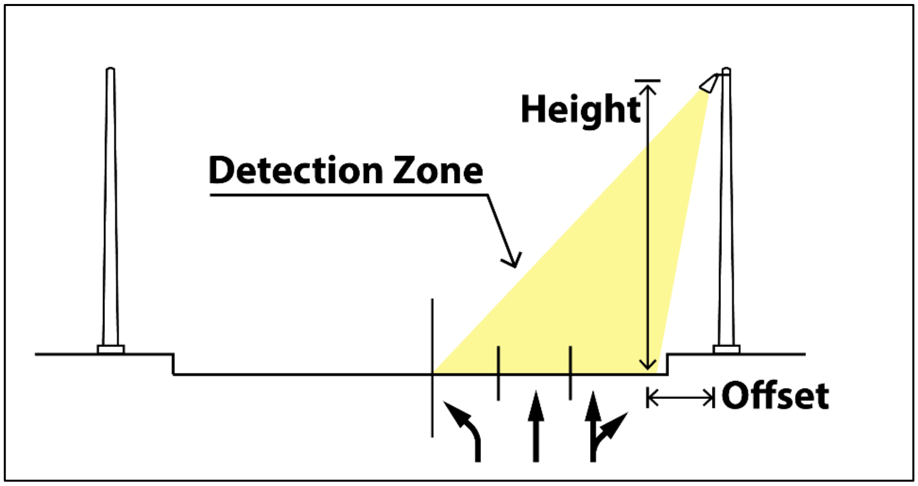

Figure 12: Cross Section of Stop Bar Detection Mounting for Microwave Detection

5.3.4 Upstream Detection Application

Upstream detection generally uses a microwave unit with a different beam shape and footprint than a stop bar detector – more of an oval or pear shape. However, the mounting and layout concepts are similar to the stop bar application. The beam footprint must cover the desired detection zone. Check the manufacturer's User Guide for a description of the footprint size and range.

- Locating a sensor higher on the pole is better to avoid occlusion and increase detection accuracy. Occlusion increases with distance at the same mounting height. This is demonstrated in Figure 13.
- Minimum and maximum mounting heights will be specified by the manufacturer.
- Mounting upstream of the intersection is also possible but pay attention to the manufacturer's maximum recommended cable run lengths back to the cabinet.
- To choose the sensor location, make sure the candidate mounting locations have a clear view of the detection area. See Figure 14.
- Typically, adequate mounting locations include signal pole uprights or the back of mast arms, as shown in the diagrams.

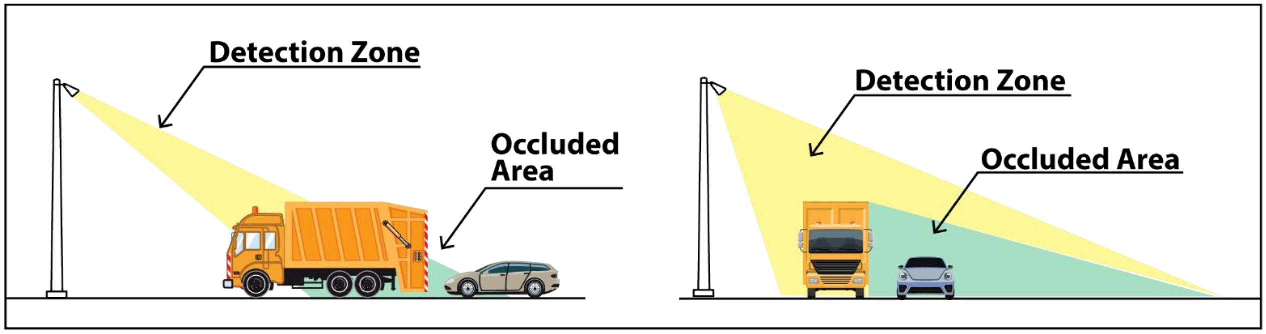

Figure 14: Vehicle Occlusion - Advance and Stop Bar Detection

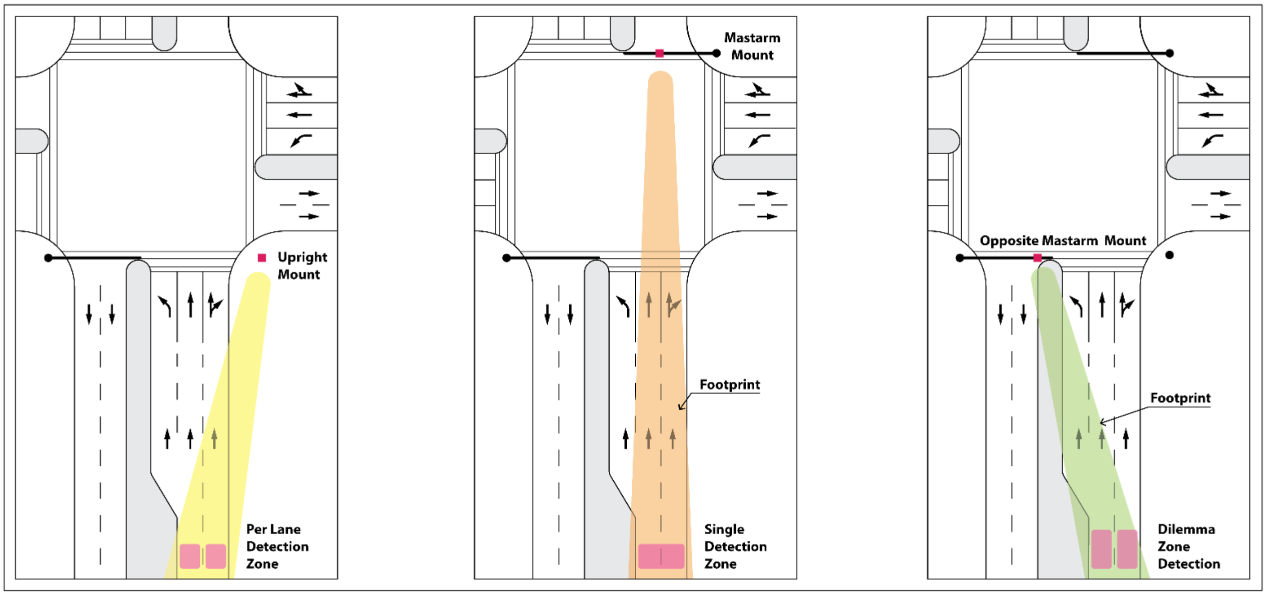

Figure 13: Advance Detection Placement

Some microwave detector units can split out upstream detection zone by lane, while others provide a single detection zone across all lanes.

5.3.5 Installation Considerations

5.3.5.1 Mounting and Aiming

- Follow the manufacturer’s mounting and installation instructions
- Mounting heights are generally a minimum of 15-17 feet above the detection area
- The devices usually are supplied with mounts or brackets from the manufacturer that allow the device to be rotated and aimed after mounting
- MVDS should be secured to poles with mounting assemblies listed on the APL
- Cable access to the inside of the structure must be provided, either through an existing hole or a drilled hole
- Follow FDOT structural requirements for device mounting on structures with respect to location, loading, required analysis, and drilling

5.3.5.2 Wiring

- Follow the manufacturer’s cabling instructions.
- Do not substitute an equivalent cable without checking with the manufacturer.
- Manufacturers will generally provide a recommended cable type with the device. It can be purchased on bulk rolls or cut to length.
- Generally, there is a cable length limitation due to voltage drop considerations. Check the manufacturer’s guidance for maximum cable lengths.

5.4 Wireless Magnetometer Vehicle Detection

5.4.1 General Description

Magnetometer vehicle detection uses an in-pavement magnetic detection device powered by a battery that wirelessly communicates vehicle detection calls back to the traffic signal cabinet. The sensors are installed in drilled core holes in the pavement and backfilled with a hard sealant, flush with the pavement. The in-pavement device varies in size and shape between manufacturers but is typically a (+/-) 3-inch x 3-inch x 3-inch cube or cylinder. A nearby vendor-provided radio receiver mounted typically on a signal pole and wired into the cabinet forwards the wireless calls into a processing unit and then into the controller. Magnetometers can be applied for dilemma zone detection, stop line, and queue detection. They are only approved on the FDOT APL for applications that require presence detection (on/off). As the wireless transmission range from the sensor to the radio is limited, a repeater device may be required for magnetometers that are a long way from the radio. The radios and repeaters are lightweight and are easily mounted on mast arms and uprights, luminary poles, or dedicated poles. The processing unit can take the form of a card that slides into a cabinet detector rack, or a shelf mounted unit connected to the cabinet Ethernet switch. See Section 660 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL).

5.4.2 Operational Considerations

5.4.2.1 Strengths

- Installation process is far less disruptive than installing inductive loops and requires a much shorter lane closure duration.
- Communication between the detectors and the roadside electronics is wireless, so there are no saw cuts for cabling in the pavement or conduit along shoulder.

- The sensitivity and effective detection zone of the magnetometer can be adjusted in the field, although there is less flexibility than microwave or video.
- Performance is not impacted by weather or environmental conditions.

5.4.2.2 Weaknesses

- Magnetometer sensor is powered by a battery, which has a limited life and is not user-replaceable.
- Sensor needs to be removed and replaced when the battery wears out.
- Sensor has limited transmission range, so a roadside repeater device is often needed, adding to the inventory of equipment that must be maintained.
- Detection zones are not moveable or adjustable to changes in lanes or operations.
- Destroyed during pavement resurfacing projects.

5.4.2.3 Maintenance

- Radios and repeater devices should be properly aimed for accurate and timely transmission.
- Depending on the product or application, an antenna may also be necessary.
- Radio repeaters should be checked as part of preventive maintenance to ensure alignment has not been disrupted due to loose hardware or damage.

5.4.3 Layout and Placement

A single magnetometer is generally intended to emulate a six-foot-by-six-foot inductive loop. Multiple magnetometers can be placed sequentially within a lane and assigned to the same cabinet channel to mimic longer loops. In some cases, the effective size of the detection zone loop can be changed slightly by adjusting the sensitivity or power output of the detector. The manufacturer's installation guide for the specific product should be consulted for layout and spacing requirements.

5.4.3.1 Detection Area

Figure 15 shows the magnetometer placement and the resulting detection zone shapes on a typical approach. Figure 16 shows a typical magnetometer layout for a stop bar for which placement dimensions should be acquired from the manufacturer. The intent of the spacing is to mimic coverage for a long loop for continuous presence detection 'Dimension A' with the last detector positioned at dimension 'X'.

- Lane Width 'B'
- Sensor location is essentially at the center of a hypothetical six-foot by six-foot loop 'C'
- FDOT recommends using three magnetometers at the stop bar in each lane to ensure capture of motorcycle detection 'Y'

- Spacing of the magnetometers should conform to the manufacturer's recommendations 'Z'

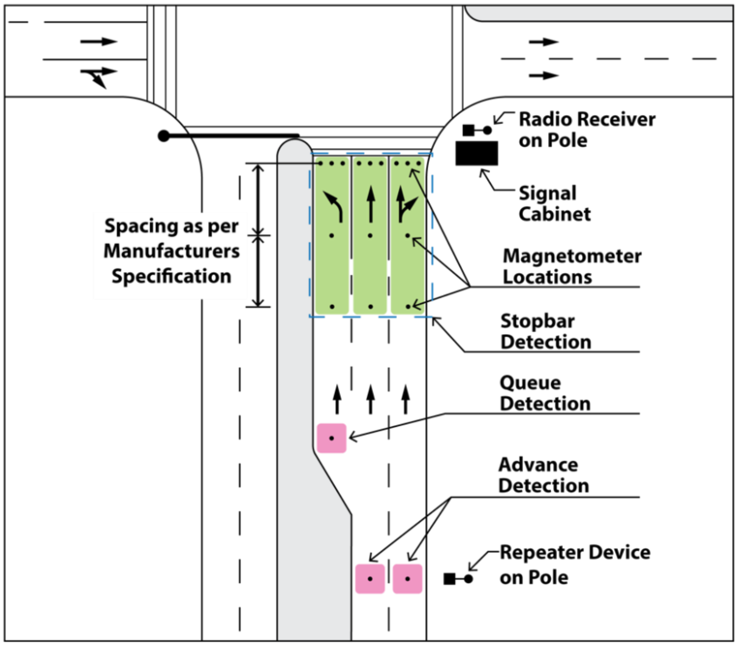

Figure 15: Approach Magnetometer Placement

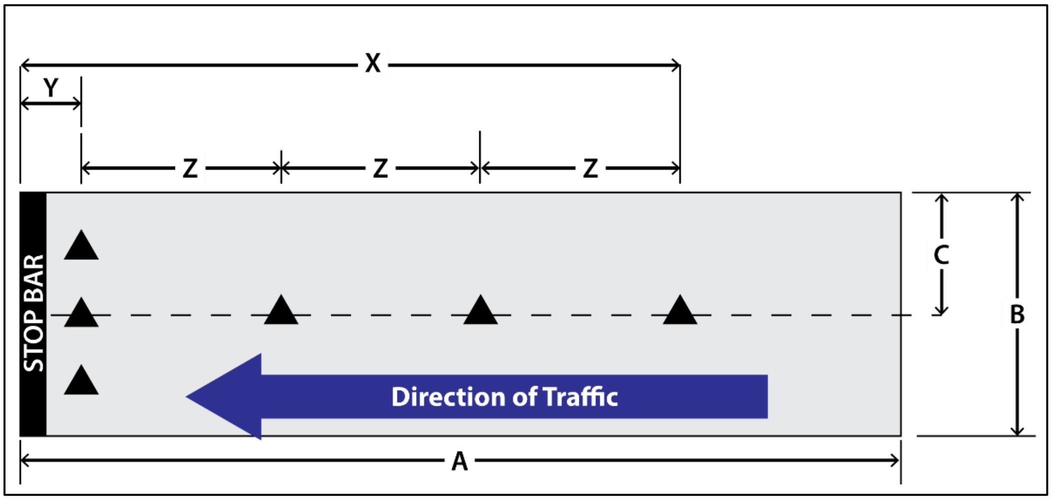

Figure 16: Typical Magnetometer Spacing for a Stop Bar Extended Loop Equivalent

5.4.3.2 Radio and Repeater Placement

As the magnetometer sensors must transmit this collected data to the traffic signal cabinet wirelessly, the signal designer must also locate and specify the communications path back to the cabinet by adding radios and possibly repeaters. The exact configuration will vary by vendor, specific product, and signal cabinet type.

- A radio receives sensor data from individual sensors and forwards it to the electronics in the signal cabinet which maps the detectors to the correct input channel in the controller.
- Radio is located near the signal cabinet and is powered from the cabinet by PoE.
- Each sensor must be in range of either a radio or a repeater, and there is a maximum range specified by the manufacturer, typically 100 – 200 feet.

- Repeaters collect data from distant sensors and forward to the radios or subsequent repeaters.
- Repeaters are remote from the signal cabinet and usually powered by a remote source. Some manufacturers offer line power, solar, and battery options.
- Repeaters are used when the distance between sensors and the radio exceed the practical limits of wireless radio, or the angle of the devices to one another results in poor signal reception. These conditions can be found at large intersections or advance detection situations.
- Radios and repeaters usually are constrained in the number of detectors they can accommodate. Large intersections with lots of detection may need more than one radio and several repeaters.

5.4.4 Installation Considerations

5.4.4.1 Mounting and Aiming of Radios and Repeaters

- Follow the manufacturer's mounting and installation instructions
- Mounting height of radios and repeaters is typically 17-25 feet above the pavement, although total distance to the magnetometers is the most important parameter
- The devices usually are supplied with mounts or brackets from the manufacturer that allow the device to be rotated and aimed after mounting
- Mounting brackets are usually secured to the pole with stainless steel bands
- Cable access to the inside of the pole must be provided, either through an existing hole or a drilled hole
- Follow FDOT structural requirements for device mounting on poles with respect to location, loading, required analysis, and drilling

5.4.4.2 Wiring

- Generally, the only wiring is between the radio and the signal cabinet. Be sure to locate the radio close enough so any cable length restrictions are not exceeded.
- Do not substitute an equivalent cable without checking with the manufacturer.

5.5 Signal Priority and Preemption Systems

5.5.1 General Description

There are multiple detection technologies available for approaching emergency, transit, or freight vehicles to activate a preemption or priority system at a signalized intersection. The three most common detection technologies are:

5.5.1.1 Optical Emitter and Receiver

- See Section 663 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL).
- Each vehicle to receive preemption or priority is equipped with a forward-facing, light-emitting device capable of displaying encoded pulses of infrared light that provides an indication of the vehicle's approach, classification, and identification number. This emitter is activated only when preemption or priority service is desired by the operator of the vehicle. See Figure 17.
- Each intersection to provide preemption or priority operation must be equipped with one or more optical receivers. These receivers are photocell sensors that can sense the infrared pulses, and each receiver is positioned so that it has an unobstructed view of the approach to have preemption or priority capabilities.

- Each optical receiver is connected via cabling to a signal cabinet processor known commonly as a "phase selector", which checks to make sure the encoded signal is from an authorized vehicle and then places the call to the controller unit.

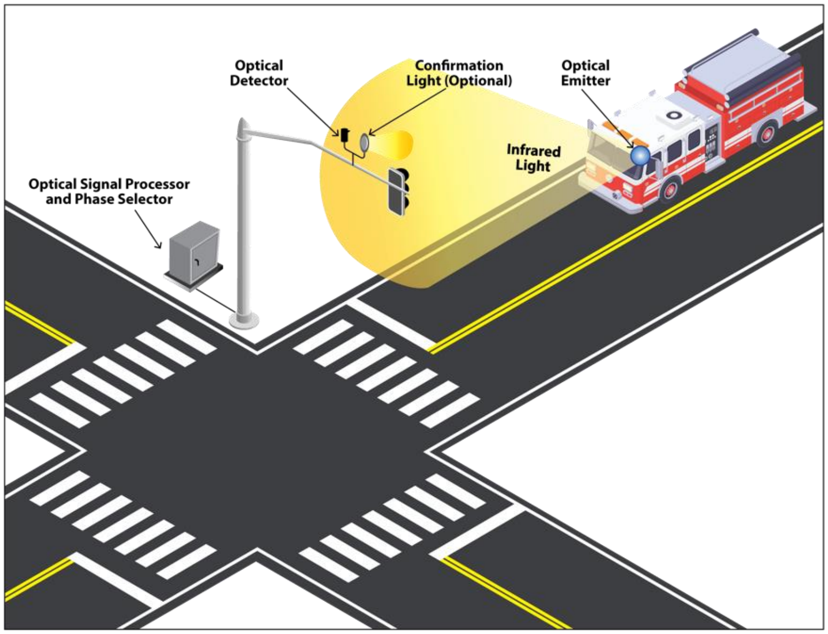

Figure 17: Optical Preemption System

5.5.1.2 Global Positioning System (GPS) and Radio

- See Section 663 of FDOT Standard Specifications. Compliant equipment is listed on the Approved Products List (APL).
- Each vehicle to receive preemption or priority is equipped with an integrated device that includes a GPS receiver and radio transmitter. When selected, the radio transmits a repeating message than includes the speed and direction of the vehicle, a vehicle identification code, and the status of the turn signal. See Figure 18.
- Intersections can be equipped with a radio receiver and phase selector device in the controller cabinet. The phase selector determines if the vehicle has entered a predefined zone of detection (through the GPS coordinates) and is approaching the intersection. In addition, the indication from the vehicle's turn signal is used to select whether a through movement or left turn is requested from the controller.

- A combined intersection system that receives both infrared and GPS/radio signals are available and is useful in areas where both types of vehicle equipment are in use.

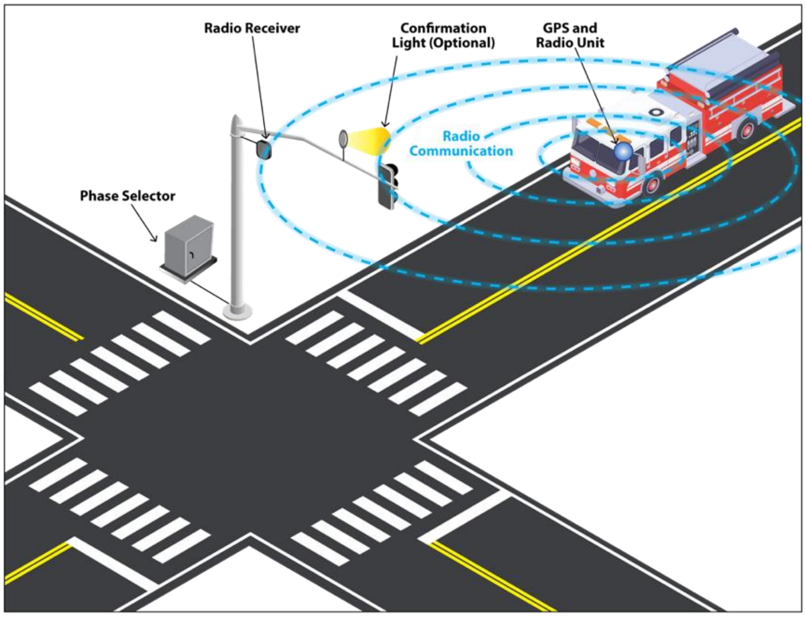

Figure 18: GPS and Radio System

5.5.1.3 Siren and Receiver

- There are no siren-based preemption systems listed on FDOT's approved product list, though there may be some existing installations in the state.
- In this system, no additional equipment is needed on the emergency vehicle; the vehicle's siren is used to initiate preemption. All siren modes (yelp, wail, high-low, etc.) can be sensed.
- Each intersection is to be equipped with one or more digital siren detectors (each comprised of a directional microphone and associated electronics) and a phase selector in the controller cabinet. The siren detector must be placed where it faces the approaching vehicle.
- Because they rely upon sirens, audible systems are not usable for transit or freight priority applications.

All preemption systems include the capability to illuminate an optional white indication facing the approaching emergency vehicle as confirmation that the preemption request has been received and the preemption sequence is underway.

Other technologies that do not require detectors to identify approaching vehicles are also available for initiating priority or preemption operations. These include central control systems that interface an emergency vehicle or transit dispatch system with an advanced traffic management system, so that the planned vehicle route can be acted upon by the traffic management system and connected vehicle applications utilizing roadside units (RSUs) and on-board units (OBUs).

5.5.2 Operational Considerations

The following are operational considerations for the two types of systems on the APL:

5.5.2.1 Optical Emitter and Receiver Systems

Strengths

- Well-established technology; over 50 years of in-the-field use
- When encoding of the optical signal is used, a very secure system
- Infrared indication is not visible to humans, making this an option for transit and freight vehicles as well as emergency vehicles

Weaknesses

- Optical detector typically installed on a span wire or mast arm to have best visibility of approaching vehicles
- Limited number of manufacturers, and encoded systems may not be compatible between manufacturers
- An approach with a curve, turn, or overhanging obstruction may block optical signal

Maintenance

- Regular cleaning of the optical receiver is required to allow the system to gauge distance from the approaching vehicle based on light intensity.
- The optical receivers must be checked for aim and the sensitivity adjusted to ensure detection of the approaching vehicle at the appropriate location on the approach; this can be critical for transit and freight priority applications with closely spaced intersections. Maintenance of vehicle optical emitters may require coordination between the vehicle fleet management group and the traffic signal operating agency.
- Database coordination is ongoing to ensure authorized vehicles have access to the system while non-authorized vehicles do not.

5.5.2.2 Global Positioning System (GPS) and Radio System

Strengths

- Proven technology; in use for over twenty years
- Allows detection of approaching vehicles around curves, turns, and beyond overhanging obstructions
- No over-the-roadway installation required

Weaknesses

- May have location issues in "urban canyons" where high buildings can block signals from GPS satellites
- Limited number of manufacturers, and systems are not compatible between manufacturers

Maintenance

- Maintenance is minimal and limited to repair/replacement of any failed components
- Database coordination is ongoing to ensure authorized vehicles have access to the system while non-authorized vehicles do not

5.5.3 Layout and Placement

5.5.3.1 Optical Emitter and Receiver Systems

- Placement of the optical receiver for an approach is based on having a clear line-of-sight view of approaching emergency, transit, or freight vehicles.

- One receiver is required for each approach to be served with preemption or priority. Some manufacturers offer a receiver assembly with two sensors that can be aimed toward different approaches.
- Typically, the receiver is placed over the roadway on a span wire or mast arm, centered over the approach.

5.5.3.2 Global Positioning System (GPS) and Radio System

- Placement of the receiver is flexible and not dependent on visibility of the approaches
- Typical location of the receiver is high on a signal pole located closest to the controller cabinet

5.5.4 Installation Considerations

5.5.4.1 Mounting and Aiming

- Optical system requires the sensor to be aimed toward the approaching vehicles that will call for preemption or priority. These can be mast arm or span wire mounted.
- GPS / radio-based system requires no specialized aiming or placement and is generally mounted to a signal pole close to the controller cabinet.

5.5.4.2 Wiring (if specialized)

- Both systems require special cabling from the receiver to the controller cabinet as specified by the manufacturer

5.5.4.3 Configuring Detection Zones

- For the optical system, the range of the detection zone can be adjusted based on the intensity of the received light from the approaching vehicle. This is performed in the field with a test vehicle at the desired distance from the intersection.
- GPS/Radio-based system utilizes a system map interface that allows the establishment of a geofence for each approach; the desired detection zone is drawn on the map.

5.5.4.4 Calibration and Testing

- Calibration and testing is performed using a test vehicle to determine that the preemption/priority request is received at the appropriate location on the approach

5.6 Automatic Vehicle Identification (AVI) Detection

5.6.1 General Description

Automatic Vehicle Identification (AVI) technology is commonly used in tolling applications but not typically used for detection in traffic signal operations. However, the FDOT APL includes several devices within the AVI category, and this section will briefly address these technologies for specialized functions in transportation. See Section 660 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL).

These functions can include:

- **Toll Collection** – recording the passage of a vehicle for electronic toll collection purposes.
- **Vehicle Classification** – using detection technology to determine vehicle types, primarily for counting purposes.
- **Travel Time Monitoring** – providing real time information on travel times along an arterial or highway.

The primary technology used for toll collection is the Radio Frequency Identification System (RFID). RFID systems have a transponder mounted in the vehicle that replies to a roadside transceiver with coded information. Early systems required that the vehicle transponder be powered, but modern toll transponders are powered by the radio waves from the roadside transceiver.

An AVI technology that is often used in arterial operations is the vehicle probe reader, typically used for travel time monitoring and origin-destination studies. Key elements include:

- Roadside sensor (Figure 19) intercepts a Bluetooth® signal (from a connection between a cell phone and vehicle audio system, or cell phone and earbuds, for example) from a passing vehicle; this is transmitted to a central system where it is time stamped.
- As a vehicle passes multiple sensors, the system determines the elapsed time between each sensor to determine travel times.
- Receiver sensitivity allows it to capture signals within an approximately 300-foot radius.

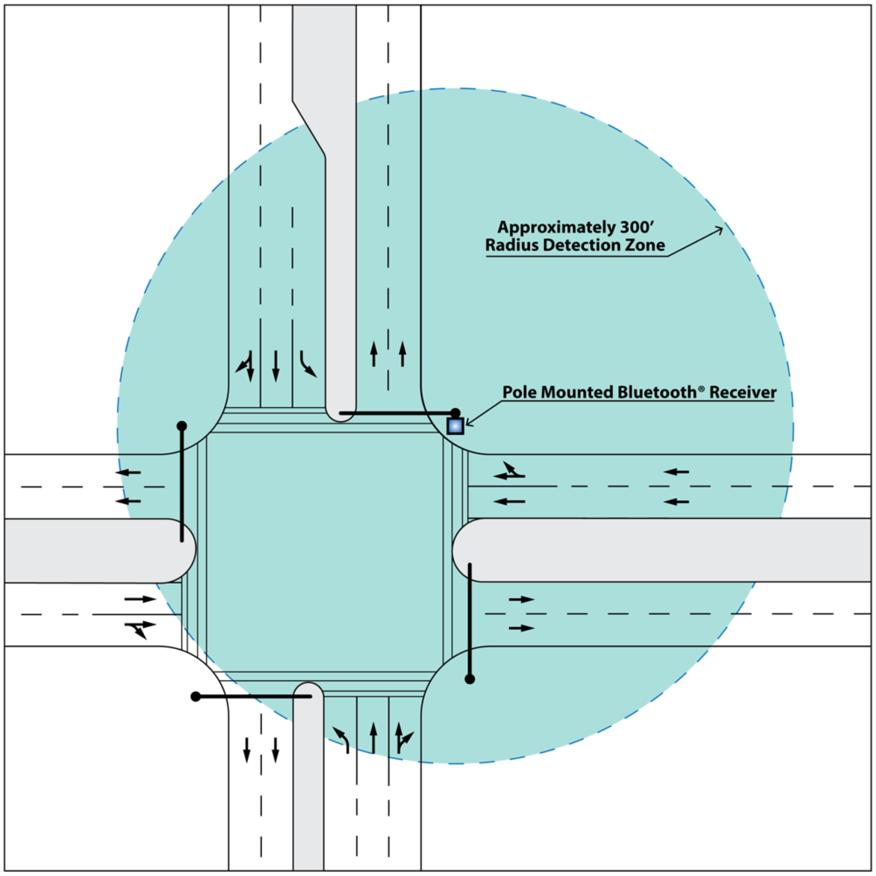

Figure 19: Vehicle Probe Reader

- Additional technologies used in AVI applications include those discussed in the section on Preemption and Priority systems.

5.6.2 Operational Considerations

In general, these are specialized technologies and not used for actuation of signalized intersections.

- RFID systems are a proven technology. These are generally part of larger systems, such as toll collection and access control, and have special design and placement strategies.
- Probe vehicle reader technology is an anonymous system, i.e., individual movements cannot be traced back to an individual, and is limited to travel time and origin-destination studies. In addition, they do not capture all vehicles, so are used primarily for vehicle speed and travel time monitoring and origin-destination study applications.

These are all specialized based on the technology and type of system. For more design information regarding placement, operations, and maintenance, the provider of the system technology should be consulted.

5.7 Pedestrian Detection System

5.7.1 General Description

A pedestrian detection system facilitates the request by the pedestrian for a signal phase change when it is activated. Florida Department of Transportation (FDOT) requires all pedestrian crossing facilities at signalized intersection to be Americans with Disabilities Act (ADA) compliant and Accessible Pedestrian Signal (APS) ready. See Section 665 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL). There are three pedestrian detection system categories approved by FDOT:

- Standard push button detection
- Accessible (audible/tactile) push button detection
- Passive pedestrian detection

5.7.1.1 Standard Push button/ Audible Push Button detection

FDOT Standard Plans Index 646-001, 665-001 and Specification Section 665 set forth the requirements for installing pedestal or post mounted push button detector assemblies. The FDOT Traffic Engineering Manual (TEM) Section 5.2 has established criteria and guidelines for pedestrian treatments at crossings. All products used for pedestrian detection systems must be listed on the FDOT APL.

5.7.2 Operational Considerations

5.7.2.1 Strengths

- Industry standard, readily available and used by all maintaining agencies
- Ease of installation with no mounting or aiming required
- Can be installed on a post, pedestal, or mast arm
- Piezo switch with LED/sound provides durability and sense of activation

5.7.2.2 Weaknesses

- Frequent mechanical failure
- Requires proper access to reach the push button
- Optimal to have a minimum ten (10) feet between detectors

5.7.2.3 Maintenance/Construction

- Push button and sign panel with arrow shall be oriented and the arrow shall point parallel to the intended crosswalk
- Requires two conduits to run low and high voltage cables separately from post to pull box

- Audible pedestrian detectors are installed as requested by maintaining agency where the intersection is used by special needs or high-volume crossings
- Two products are specifically approved for use with RRFB midblock crossing

5.8 Passive Pedestrian Detection System

5.8.1 General Description

Passive Pedestrian Detection (PPD) is the automated detection of pedestrians in a stationary or moving state at the curbside or in a pedestrian crossing by means other than those requiring manual input by the pedestrian (e.g., pushing a button). See Section 665 of the FDOT Standard Specifications for Road and Bridge Construction. Compliant equipment is listed on the Approved Products List (APL).

5.8.2 Operational Considerations

PPD is one of the features that should be considered when reviewing requests for Accessible Pedestrian Signal (APS) and when there is data showing low usage of pushbuttons. PPD is also helpful for locations where pedestrians have difficulty pressing the pedestrian detector.

A good candidate for PPD are locations where vehicles may have limited visibility of pedestrians or bicyclists at the sidewalk/curb. At shared-use paths that cross state roads, PPD may be added in addition to active bicyclist detection to improve road user interactions. In the absence of PPD, bicyclists would need to dismount and press the button to activate the phase, and thus there is a tendency for bicyclists not to press the pushbutton. PPD increases the activation rate or frequency and thus the safety benefits within the crosswalk.

Coordination with the local agency and pairing of this strategy with education and enforcement can further increase effective operation. Education increases awareness of the use of this technology at locations of interest.

PPD is not limited to a certain detection technology type. Currently, thermal detection products are listed on the FDOT APL. FDOT Traffic Engineering Manual (TEM) Section 5.2.7.5 establishes supplemental guidelines to improve PPD for signalized intersections, midblock crossings (RRFBs, PHBs, warning beacons) and at shared-use path crossings.

5.8.2.1 Strengths

- Passive, contactless detection
- Detects in adverse weather and low light conditions
- Can be installed on a post, pedestal, or mast arm
- Can configure detection zones by Wi-Fi access
- Cloud based data access and analysis
- May have video monitoring and occupancy

5.8.2.2 Weaknesses

- Need adequate passing space around waiting zone to reduce false calls triggered by adjacent bypass pedestrians
- Best to place at locations running free operation vs. coordination so pedestrians see a more immediate response resulting in fewer violations
- Requires the device to be mounted at a specified distance, height, and angle

- Without education, people tend to cross against signal in the absence of traditional push button

5.8.3 Installation Considerations

Most PPD support PoE or power line (where power line is used for longer cable runs from 300’ to 1000’). Thermal detectors have a maximum viewing angle of 90 degrees.

5.8.3.1 Layout and Placement

- Thermal detectors should be mounted on a pedestrian pole, mast arm, or a standalone post
- Support structure should be placed at the back of sidewalk and away from the track of turning vehicles that might damage the device
- Number of detectors is dictated by ramp and crosswalk geometry
- Detection zone should be setup to capture pedestrians and bicyclists waiting at pedestrian ramps to activate the phase and/or to capture the movement only in the direction of crosswalk, ignoring all other movements
- See Figure 20 for typical layout of detection zones

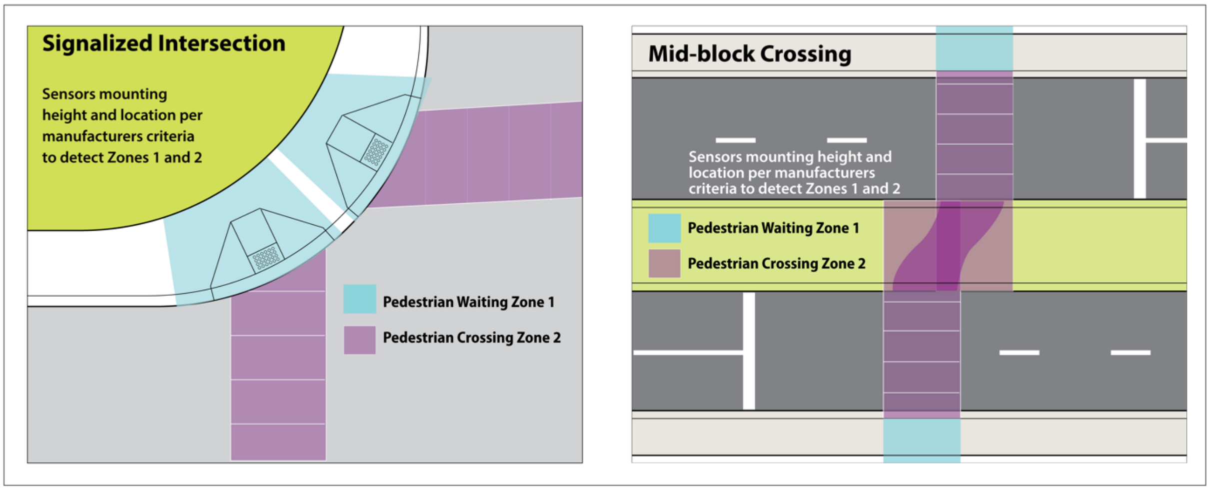

Figure 20: Typical Pedestrian Detection Zones

5.8.3.2 Mounting Height

- Thermal detectors mounted 10-20 feet high detect up to 40 feet
- Thermal detectors mounted 20-26 feet high detect up to 30-65 feet along a crosswalk.

Typical pedestrian detection zone and mounting heights are shown in Figure 21.

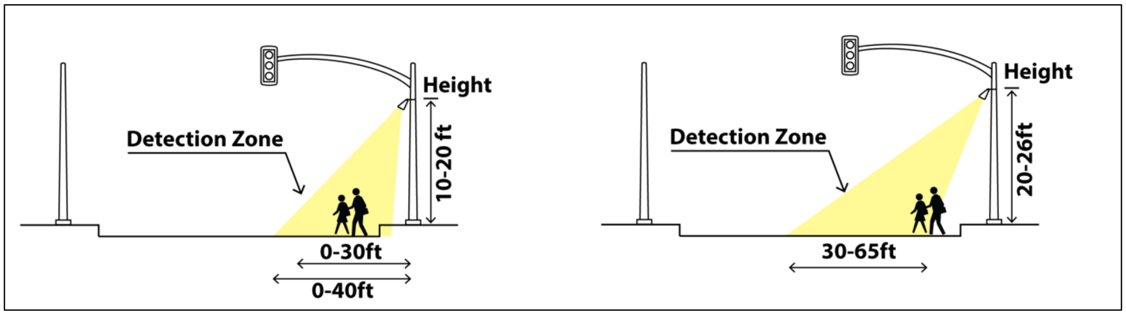

Figure 21: Typical Pedestrian Detection Placement and Reach

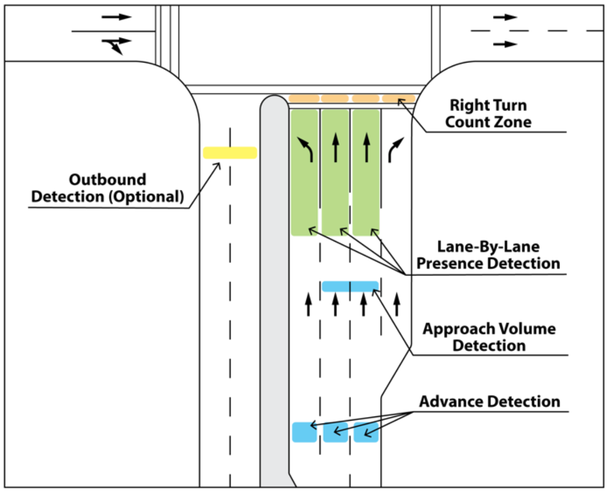

Figure 22: Typical Placement for ATSPM Detection Using Loop Zones

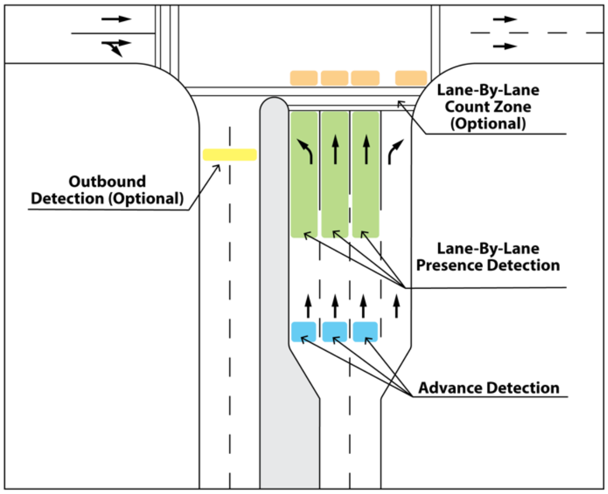

Figure 23: Typical Placement for ATSPM Detection Using Video Zones

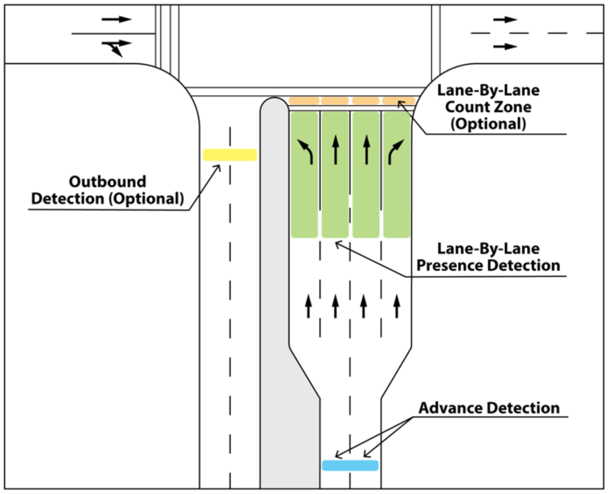

Figure 24: Typical Placement for ATSPM Detection Using Microwave Zones

6 Analysis Detection (ATSPMs)

Detection for ATSPMs largely follows the guidelines for a traffic signal's operational detection, with perhaps some adjustments made for approach speed and coverage. For instance, total upstream approach volumes may be desired to measure Arrivals on Red and/or Arrivals on Green. Additionally, for full ATSPM coverage, vehicle counts for every movement may be desired, so additional detection might be added to cover movements, such as right turn lanes that may not typically be instrumented. Finally, supplemental outbound detection may be added to confirm vehicle counts or to infer counts for movements (such as mixed through/turn lanes) that are not easily countable. Loops, video, and microwave detection can be used to collect ATSPM data. Figures 22, 23, and 24 show typical (or "starting point") locations for ATSPM detector locations for loop, video, and radar technologies. A detailed discussion on ATSPMs and the data required to support is beyond the scope of this document.

7 Summary

This educational document has described and provided high level design information for the traffic signal vehicle and pedestrian detection technologies currently included on the FDOT Approved Products List (APL). While not intended to be a design manual, it gives designers a place to begin when preparing signal plans with technologies they may not have had exposure to in the past. These guidelines are intended to be generic in nature for a specific detector type, but it should be noted that similar technologies from different vendors can vary widely in application, functionality, and design. It is important to consult the manufacturer's design guide and/or user manual at each stage in the design process.

Transportation Systems Management & Operations

For more information contact:

Edith Wong, P.E.
Traffic Engineering and Operations Office
850-410-5520
Edith.Wong@dot.state.fl.us