FDOT TSM&O
Transportation Systems Management & Operations

District Five

Guidelines for Traffic Signal Plan Preparation

Version 11

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1.0 INTRODUCTION

This document is to be used as a guide for the design and/or upgrade of traffic signals as well as any traffic signal system on state roads. It is intended to augment and clarify information found in the **Florida Department of Transportation (FDOT) Standard Plans, Standard Specifications for Road and Bridge Construction, Design Manual (FDM), Manual on Uniform Traffic Control Devices (MUTCD) and the Traffic Engineering Manual (TEM).** These guidelines address the actual design requirements for traffic signals, as well as the format for a plans package. In the event of a discrepancy in requirements between these guidelines and the aforementioned references, the requirements set forth in this document should be considered as a guide only and treated as such. This document is to be used as a guide and is not intended to replace sound engineering judgment nor is it intended to provide all of the information required to produce traffic signal and/or signing and pavement marking plans. The Engineer of Record (EOR) should be fully competent in traffic and signing and pavement marking design prior to using this information.

Additional information can also be found in ITE's **Manual of Traffic Signal Design** by Kell and Fullerton.

2.0 SIGNAL POLES – STRAIN POLES AND MAST ARMS

2.1 Design Procedure for Concrete Strain Poles

Once the design phase begins, the designer should conduct field reviews of the site to determine any potential overhead utility conflicts, points of service, and locations for signal infrastructure. The designer should then coordinate utility locates for the site. The designer should account for the Maintaining Agency's insight and preferences, and ensure these are appropriately reflected in the plans and ancillary documentation. The potential for future signal infrastructure modifications should also be evaluated. For example, an intersection may have a potential, future need for a dedicated left turn phase. In this situation, the signal span infrastructure should be designed to accommodate those future displays (if possible). Similarly, the poles for flashing beacon spans should be designed to accommodate future signalization. The support wire(s) for the signal spans should be installed in a location that can accommodate the future 3-section signal head(s). This is important to note since 1-section signal heads hang less than 2 feet below the support wire while 2-section, 5-section head, and 4-section heads hang 4 feet to 5.5 feet below the support wire. The minimum vertical clearance shall be considered so the adjustment can be made without replacing the span wire.

Once the aforementioned data has been compiled, an approved strain pole design program should be utilized to select and design the pole. Only qualified individuals that are familiar with the intricacies of the approved strain pole design program should design poles. Modification to the input file may be required to model the specific intersection conditions. The EOR will be responsible for review of the output file and determining the proper pole and foundation designs. The traffic engineer will be responsible for verifying that the critical heads and poles meet the required state OSHA distance requirements from power lines and gas mains. Signal spans should not be installed between power line phases or above the neutral line(s). To avoid conflicts, the poles should be installed in front of the power lines; the power lines could also be installed underground.

Although "good soils" are often encountered throughout the District, designers should consider using a "worst-case" soil conditions (i.e. 60 pcf) in the strain pole design program.

The results of the pole designs should be provided in a pole schedule. This schedule should use the variables shown in Figure 1. The "A" dimension should be the same for each end of the span. The messenger cable should be level across the span; however, if the roadway has elevation differences of several feet between the approaches, a sloped messenger wire may be utilized. The poles should be designed in even foot increments with any extra length added to the "C" dimension. The pole schedule should also state the type of pole to be used (i.e. Type N-VII or P-VII) and specify the dimensions for other poles such as concrete pedestals for pedestrian features.

The designer should aim for an 18.25-foot clearance above the roadway. The clearance distances are measured from the roadway to the top of the signal housing. The required clearance for new signals on span wires, mast arms or other structures is 17.5 feet. This clearance is measured from the traffic lane (or shoulder directly below the signal structure) to the lowest point on the signal structure. For any construction work that affects existing signal clearances, the FDOT minimum vertical clearance of 17 feet shall be adhered to. Vertical clearances between 15 feet and 17 feet require a Design Variation. Signal clearances less than 15 feet are prohibited. When designing a near side signal, the designer should also verify the maximum height limitation is met, as shown in the *MUTCD, figure 4D-3, page 674*.

For span wire assemblies, use either perpendicular spans, box spans or drop box spans. Diagonal span assemblies may be used for flashing beacon installations. A Design Variation is required for any other diagonal installation. Required signals on each span should be shown. For two-point span wire attachments, a catenary wire sag of 5% (+/- 0.5%) shall be used in the design.

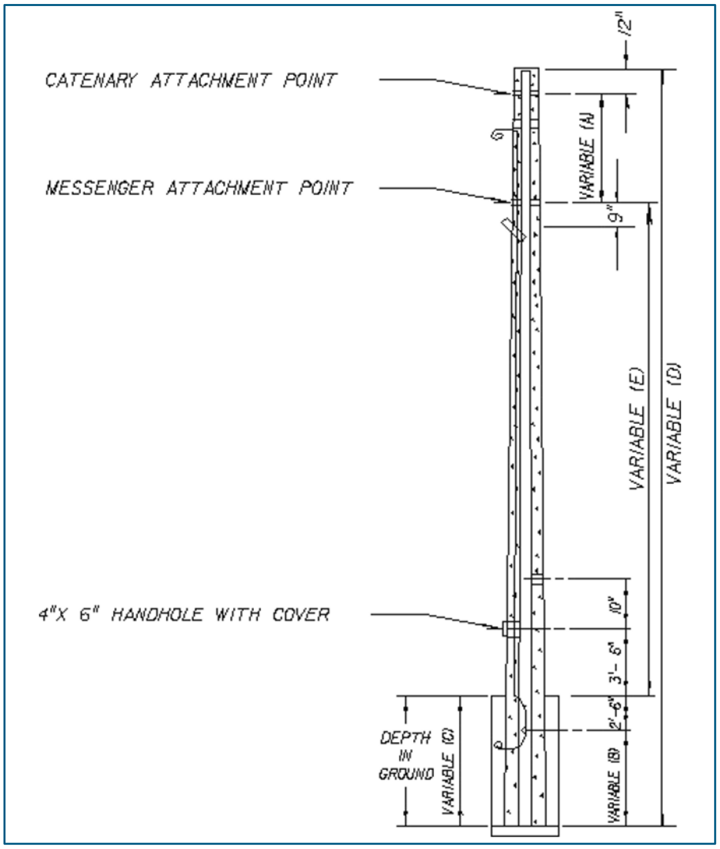


Figure 1: Concrete Strain Pole Detail

The cable diameter (3/8, 7/16 or ½ inch) should also be stated with the pole data for both the messenger and catenary cables. Note that ¼ inch cable should not be used. If the ATLAS output specifies ¼ inch cable, verify that the span was designed for 3/8 inch and specify 3/8 inch cable for use instead.

2.2 Joint Use Poles

At some locations, utility companies may request to share a pole so that they will not be required to relocate their overhead utilities. Keep in mind, it's best to avoid joint use poles if possible. The Department may also desire to share a pole to "clean up" the intersection. This "joint use" pole will need to be designed to accommodate the loading of the signal configuration and the utility lines. While coordinating with the utility owner, several design aspects will need to be discussed with some of the resolutions detailed in the plans. Some aspects that should be coordinated are:

- Exact location of the pole(s)
- Elevation of the signalization attachment points
- Required vertical separation between the signal wires and utility lines
- Rotation of pole (usually installed parallel to the roadway with symmetrical strength to each face)
- How existing utilities will be handled during construction

Notes and/or details should be added to the plans to specify who is responsible for each aspect of the pole installation. This process includes items such as:

- Adjustment of the existing utility lines and when they are to occur
- Adjustments or replacement of adjacent poles

- Removal of existing poles
- Installation of joint use poles
- Protection of existing lines during installation
- Attachment of utility lines to the joint use poles - 45° attachments will require a special bracket (must be cleared through the Utilities Office); 90° attachments may require a special pole design with more than one load face
- Need for pre-drilled holes through poles

2.3 Mast Arm Signal Design

One of the primary characteristics of a mast arm structure is the uniqueness of its design. Mast arm structures are generally made for a specific location at a specific intersection. If the pole location and/or elevation changes during the construction process, often times the structure will be an improper length or height to be used. For this reason, it is critical the design information used to develop the structure's dimensions is correct. The traffic engineer will be responsible for verifying that the critical heads meet the required clearances (see Figure 2). Since this requirement applies to each arm, poles with dual arms may have to be mounted at different heights. To verify that the poles are designed correctly, cross sections should be evaluated for each pole location.

Sight distance is an important design consideration along with signal height. Some older limited access highway bridges over arterials have bridge beams that are just over 16 feet above the roadway. Designing the span or mast arm lower and utilizing horizontally mounted signals may be necessary.

All attachments to a mast arm shall be centered on the arm. Note that the distance between the arm and the bottom of the signal head is different from the distance between the messenger cable and the bottom of the head on a span wire (see Figure 3). Coordination with the structural designer will be necessary to verify that attachment requirements can be properly accommodated.

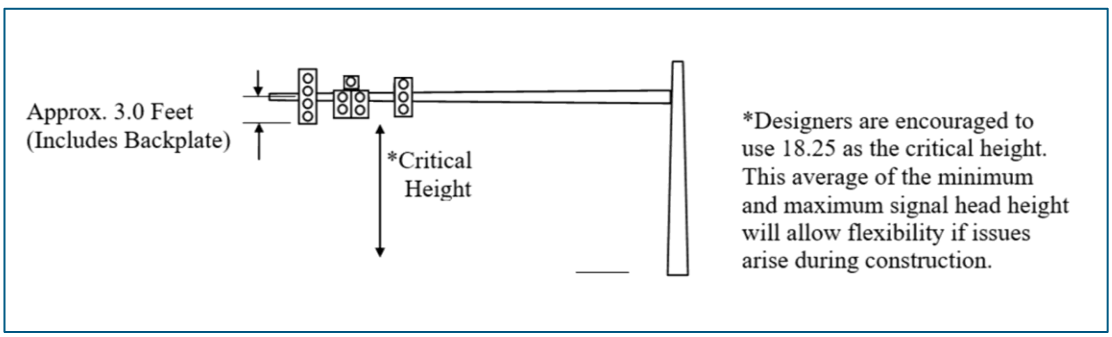


Figure 2: Mast Arm Signal Head Clearance

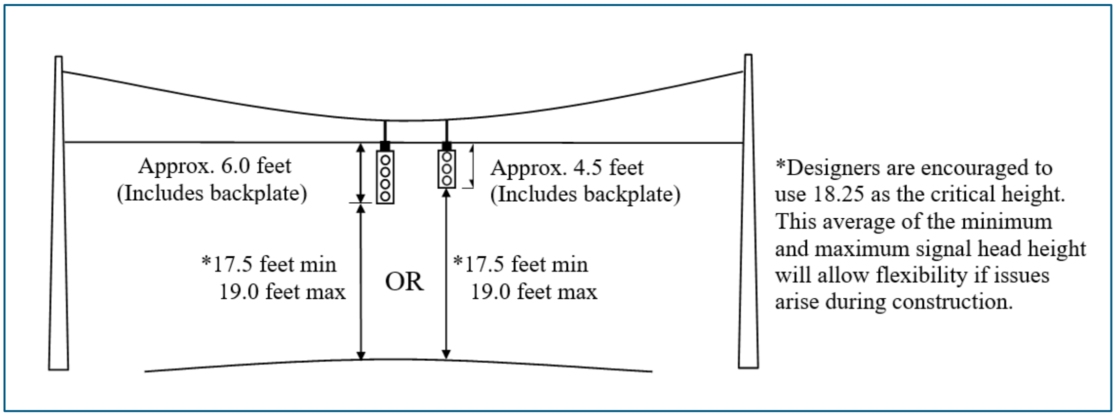


Figure 3: Span Wire Signal Head Clearance

Foundation elevation should also be considered when calculating the mounting height of the arm. For instance, in rural locations, the top of the foundation shall be 6 inches above the grade to reduce the potential of burying anchor bolts or having them submerged in water. In urban locations, if the foundation is located in or adjacent to a sidewalk, then the top of the foundation shall be flush with the sidewalk. Mast arm signal structures should be oriented approximately 90° to appopraching traffic; mast arm structures oriented diagonally to approaching traffic are prohibited.

The Department has developed standard designs for mast arm structures to decrease procurement time and improve the efficency of design modifications to existing structures. These standards are available through the FDOT web site and should be used whenever possible. The maximum acceptable length of an arm is 78 feet. If longer arms are required, a meeting with Traffic Operations and Structures design shall be required. Detailed instructions on pole and arm selections are included in the *FDOT Standard Plans* and *FDM*. When the standard designs are not applicable to a specific location (i.e., longer or taller than provided in the *FDOT Standard Plans*, *FDOT Structures Manual*, and the *FDM*), a special structural design will be required. This design may only be completed by a qualified structural engineer.

After the pole locations have been determined, the proposed arms and signal heads should be laid out. The length of the arm should not only accommodate the proposed signal heads and signs, but also potential future heads and signs. For example, the designer should consider the possibility of future left turn phases and the possibility of widening into the median for an additional left turn lane. Each of the proposed and future heads should be placed as described in Section 3. At least 2 feet of arm should extend out from the furthest (proposed or future) signal head and future sign panel.

Once the proposed and future signal head locations have been determined, the mast arm schedule should be completed. The schedule provides pole and arm design details, such as signal head and pedestrian head placements, types of signal heads, mounting configurations, etc. This information is used to determine if one of the standard arms can be used. While it is desirable to utilize the standard pole and arm configurations whenever possible, the design standards and sound engineering judgment should not be compromised for the sake of using the standard poles and arms. Designers also need to consider pedestrian head placement as they need to remain visible to approaching pedestrians throughout the crosswalk path. Ideally, they should be within 5 feet of the extended crosswalk, and not more than 10 feet away.

Galvanized finish should be provided for mast arms in District Five. If the local maintaining agency wants “painted” mast arms, then they will have to pay for the additional cost and commit to cover the maintenance cost.

2.4 Incorporating Luminaires on Strain Poles and Mast Arms

Luminaires should be incorporated on the strain poles or mast arms only if requested by the Department and/or the maintaining agency. Confirmation on who will be maintainign the proposed lighting is needed; this agreement is handled by the Traffic Design unit. For mast arms, the standard configurations allow for luminaires only under certain configurations. For strain poles, the addition of luminaires would need to be incorporated into the pole design.

If it has been determined that luminaires will be utilized on the signal poles in a project, several design elements should be addressed. These include:

- Power provisions for luminaires
  - Luminaires require power separate from that provided for the traffic signal.
  - A separate load center may be needed for luminaires.
  - Determine how lights are to be activated (if by photoelectric cell, no more than one per intersection).
  - If they are powered by the signal power service, an additional breaker for the illuminated signs shall be used, if available.
- Type of fixtures and wattage
- Mounting heights
- Mounting brackets
- Conflicts with overhead utilities
- Conflicts with signal cable spans

Consideration should also be given to how these light fixtures will affect existing lighting systems. It may be necessary to remove existing light poles located near the proposed signal poles. In those cases, modifications to the existing conductors, conduits, and pull boxes will also need to be addressed.

If the proposed light fixtures are to be added to an existing lighting system, voltage calculations and conductor sizes will need to be addressed. Consideration should also be given to the photometric light levels in the vicinity of the intersection. These calculations should only be completed by a qualified engineer.

2.5 Location of Power Services

For all new signal installations and most signal rebuilds, it will be necessary to install a new power service. The type of power service depends on the existing conditions and the type of signal structures being installed. In all cases, the designer should attempt to locate existing power transformers to supply power to the intersection. Coordination with utility owners will be required to facilitate power hookup and identify other constructability factors, such as identifying a specific side of the transformer pole that the new service conductor must be placed on.

For strain pole installations, the power service can usually be mounted to the strain pole with the power lines installed aerially from the utility pole (*FDOT Standard Plans, Index 639-001, Detail A*). However, for long spans, such an installation may impose unacceptable moment on the existing utility pole. Under these conditions, another pole may need to be installed or the power may need to be run underground (*FDOT Standard Plans, Index 639-001*).

For mast arm installations, the power service should be run underground with the power service mounted on a separate concrete pedestal. It is not acceptable to mount the power service on a metal object such as the side of the cabinet or on a mast arm pole.

If the Point of Service for an underground service is located greater than 15 feet from the Controller Assembly Cabinet, an additional electrical disconnect must be provided within 15 feet of the cabinet.

A minimum conductor size of 6 American Wire Gauge (AWG) is required from the utility provider meter to the traffic signal cabinet (*FDM Section 232.11.2*). A minimum conductor size of 14 AWG is required from the traffic signal cabinet to the traffic signal heads (*FDM Section 232.11.2*). Note that all power installations must meet the requirements of the National Electrical Code (NEC) in addition to the FDOT requirements.

3.0 SIGNAL HEAD PLACEMENT

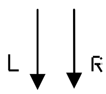
3.1 Introduction

The basic rules governing the requirements regarding overhead signal indications can be found in the **Manual on Uniform Traffic Control Devices (MUTCD)**. The minimum requirements stated in the *MUTCD* should always be adhered to.

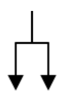
This section deals with standard overhead configurations for standard intersection designs. The designer should determine how these guidelines relate to the subject intersection. These diagrams and figures should be used as a guide and are not intended to replace sound engineering judgment.

3.2 Legend

3-Section Head (Through)



3-Section Head (Left or Right Turn) or
4-Section Head Flashing Yellow Arrow (FYA)



5-Section Head (Left or Right Depending on Location)

Note the "L" and "R" for the left and right turn displays are being used in this section only for simplicity and should not be shown on a plan sheet. Instead, signal head details should be included for each head installed. Below are some examples of signal head and pedestrian head details that are required on all signal plans, as appropriate. All signal displays shall be LED, including pedestrian signal heads.

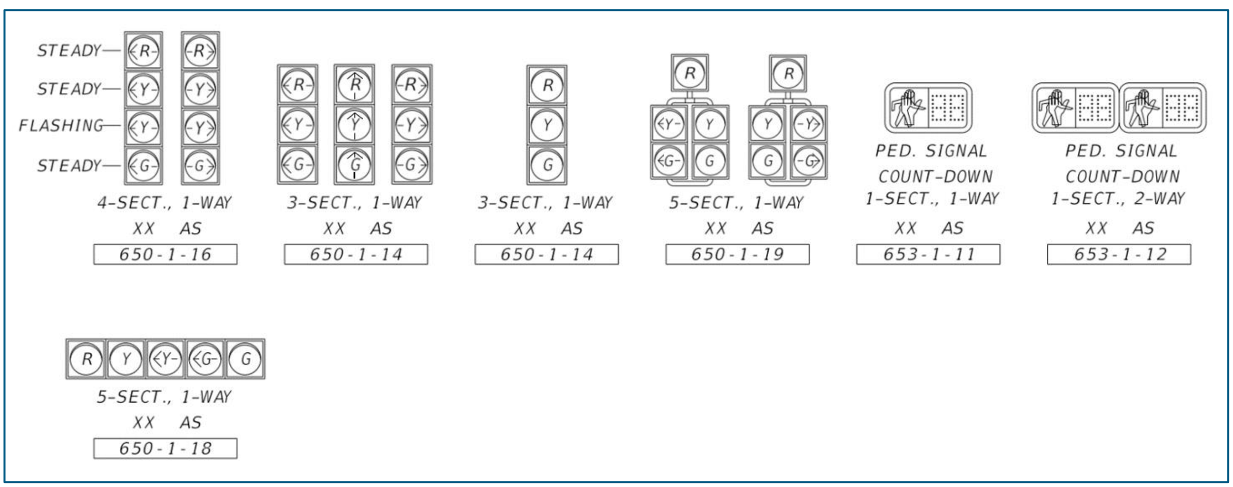
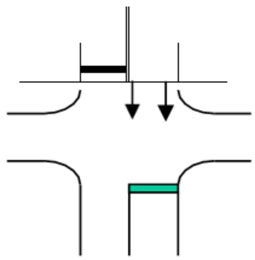


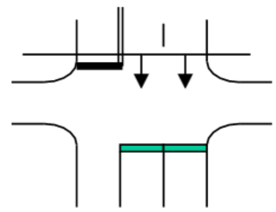
Figure 4: FDOT Standard Signal Head Details

3.3 Traffic Signal Head Placement for “Plus” Intersections

This section provides guidance for signal head placement at typical “plus” intersections under normal conditions. For many applications, the designer will utilize one or more of the diagrams shown to determine the appropriate placement for a specific intersection. These diagrams should be used as a guide and should never replace sound engineering judgment.

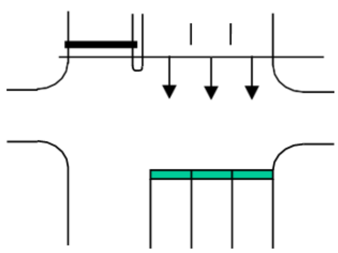
3.3.1 Approach without Turn Lanes – Not Split Phased





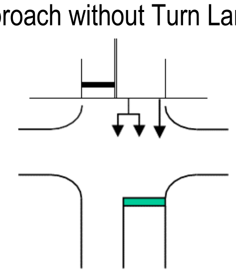
Single Through Lane
Signal heads to be aligned between the lane line and the edge line.

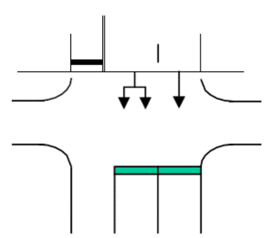
Two Through Lanes
Signal heads to be centered over each lane.



Two Through Lanes
Signal heads centered over lanes.

3.3.2 Approach without Turn Lanes – Split Phased

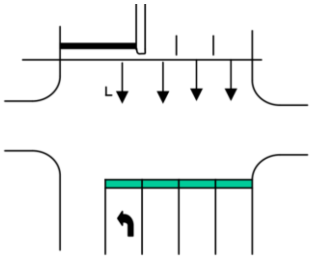




Single Through Lane
Signal heads to be aligned between the lane line and edge line.

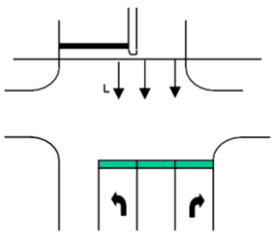
Two Through Lanes
Signal heads to be centered over each lane.

3.3.3 One Left Turn Lane – Protected Left Turn Phase

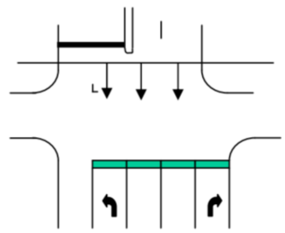


<u>Three Through Lanes</u>
Signal heads to be centered over each lane.

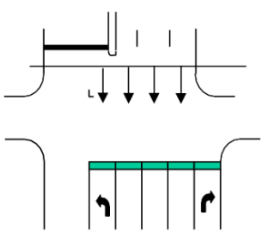
3.3.4 Two Turn Lanes (Left & Right) – Protected Left Turn Phase



<u>Single Through Lane</u>
Signal heads to be
centered over each lane.

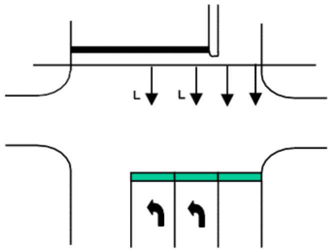


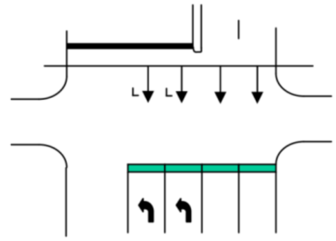
<u>Two Through Lanes</u>
Signal heads to be centered over each lane.



<u>Three Through Lanes</u>
Signal heads to be
centered over each lane.

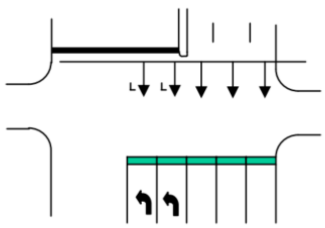
3.3.5 Dual Left Turn Lanes – Protected or Split Phased





Single Through Lane
3-section (lefts) to be centered over their respective lanes. 3-section (throughs) to be placed over the through lane. (Maintain 8 feet min. head separation.)

Two Through Lanes
All signal heads to be centered over their respective lanes.



Three Through Lanes
All signal heads to be centered over their respective lanes.

3.3.6 Dual Left Turn Lanes and Right Turn Lane – Protected Left Turn Phase or Split Phased

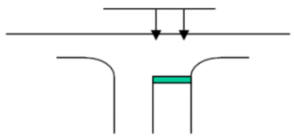
The addition of a right turn lane should reflect the sections above with no additional signal heads under normal conditions. If the right turn lane is to be signalized with an overlap, the right-most 3-section head should be replaced with a 5-section on the lane line between the right turn lane and the through lane.

Dual right turn lanes should be provided with 3-section signal heads (right turn arrows) centered over each right turn lane. If a pedestrian phase is concurrent with the through phase, replace the 3-section signal heads with 5-section signal heads. This will permit the pedestrian phase and circular indications (non-protected) to display simultaneously.

3.4 Traffic Signal Head Placement for "T" Intersections

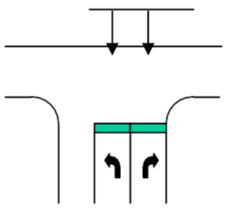
This section provides guidance for signal head placement at typical "T" intersections under normal conditions. For many applications, the designer will utilize one or more of the diagrams shown to determine the appropriate placement for a specific intersection. These diagrams should be used as a guide and should never replace sound engineering judgment.

3.4.1 Single Lane Approach



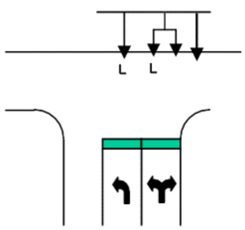
Two Approach Lanes
Signal heads to be aligned between the lane line and the edge line.

3.4.2 Two Lane Approach



Two Approach Lanes
Signal heads to be centered over each lane.

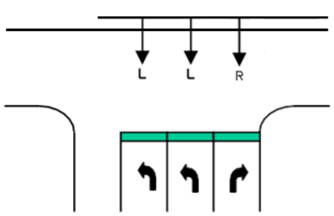
3.4.3 One Designated and One Shared Turn Lane



Two Approach Lanes
Signal heads to be centered over each lane. Provide dual arrow indications for dual turn lanes.

*Make sure that movements do not conflict with pedestrian phases.

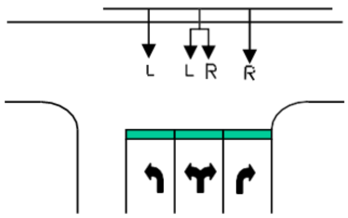
3.4.4 Dual Turn Lanes and Single Turn Lane



Three Approach Lanes
3-section (lefts) to be centered over their respective lanes. 3-section (right) to be centered over right turn lane if pedestrian phase is not present. 4-section (right) to be centered over right turn lane if pedestrian phase is present.

*Make sure that movements do not conflict with pedestrian phases.

3.4.5 Dual Right and Left Turns with Shared Center Lane



Three Approach Lanes
Signal head centered over each lane.

*Make sure that movements do not conflict with pedestrian phases.

3.5 Traffic Signal Head Placement for Skewed intersections

Traffic signal heads at skewed intersections should be placed in such a way that the drivers will clearly understand which signal is providing guidance for their approach. The signal displays should be positioned so that inappropriate approaches cannot see them. If this is not possible, special signal heads should be used. Some of the specialized equipment available to facilitate this includes attachable louvers and optically programmed heads. Cutoff tunnel visors (45°) can be used to prevent side street drivers from seeing the main street green indications at skewed intersection. The maintaining agency should be consulted to determine if they have a preference in this selection.

3.6 Traffic Signal Head Placement for Misaligned Intersections

At many intersections, the approach lanes and the receiving lanes do not line up exactly. Under these conditions, the signal head placements in Section 3.3 should still be considered, but the exact placement should be based on the specific geometry of the intersection.

The signal head placements should consider items such as:

- Visibility for approaching drivers.
- Provide guidance toward the acceptance (receiving) lanes on the opposite side of the intersection.

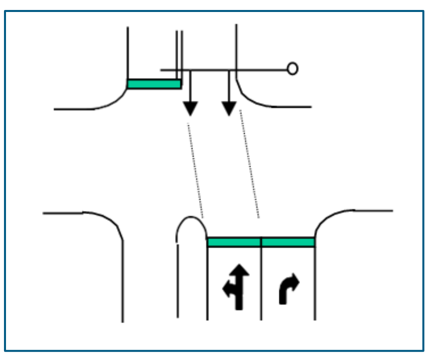


Figure 5: Signal Head Guidance (No Median)

- Verify that the proposed head placement will not guide the driver toward the approach lanes on the opposite side of the intersection. This is especially important when median treatments exist.

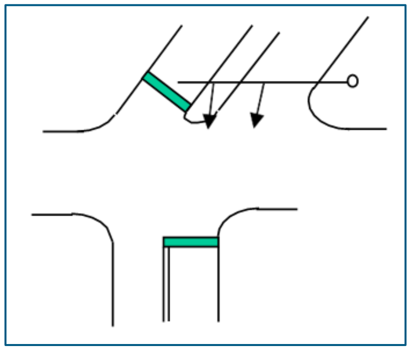


Figure 6: Signal Head Guidance (Median)

- Utilize additional signal displays where appropriate, such as nearside signal heads. Nearside heads may be needed if a curve does not allow for signal heads to be visible within the American Association of State Highway and Transportation Officials (AASHTO) stopping sight distance requirements. Advance signing should also be considered in these circumstances.
- When reconfiguring an existing signal, the designer may request a change in phasing (i.e., right turn overlaps, eliminating split phasing). The District Traffic Operation Engineer or delegate must approve any phase changes on the State Road System before they can legally be implemented. If an existing signal is split phased, the traffic engineer should always consider the possibility of removing the geometric constraints and if beneficial, removing the split phasing.
- Avoid the placement of two-way heads.

3.7 Pedestrian Signal Head Placement

The placement of pedestrian signals is an important step in the design process. Often times, a carefully laid out signal design that is coordinated with the sidewalk design can utilize signal poles for pedestrian detectors and signals. However, the designer should not assume that this is always the appropriate location for the pedestrian features.

Crosswalk markings should be provided for all legs of a signalized intersection unless there is a documented, project-specific justification not to do so (e.g., physical constraints, safety concern).

The proposed location of the pedestrian signals should:

- Be visible from the opposite side of the crosswalk even when large trucks are stopped at the stop bar.
- Be relatively close to the crosswalk alignment so that it is clear to the pedestrian that the signal is to be utilized with that crosswalk.
- Be in a location that is not blocked by street name signs or other obstacles (temporary or permanent). For instance, some business owners routinely place displays out near the street corner.
- Be located far enough away from the radius that off tracking trucks/trailers and buses will not hit them on a regular basis.

Always keep in mind the accessibility of pedestrians reaching the detectors. All designs should meet the standards from the Americans with Disabilities Act (ADA). Additionally, there should be at least a 4-foot by 4-foot flat, paved sidewalk area adjacent the pole/pedestal for a wheelchair to be positioned directly in front of the detector. It should not be assumed that the pedestrian could reach around the side of the pole to utilize the detector. The pavement around the detector (minimum 4-foot square) must not have a slope greater than 2%. Pedestrian button extenders are not acceptable. Since each pedestal will have an adjacent pull box, care should be taken to ensure that the pull box would not interfere with the wheelchair access.

If it is necessary to place a pedestal for pedestrian features within a "free right" island, the pole should be constructed with a frangible base whenever possible. Therefore, the designer should not place concrete poles within such islands. All pedestrian signals should be mounted using aluminum poles with transformer bases.

The intersection in Figure 7 shows 4 different pedestrian configurations. The shaded areas show concrete areas that were added to the original sidewalk to ensure adequate access to the pedestrian detectors.

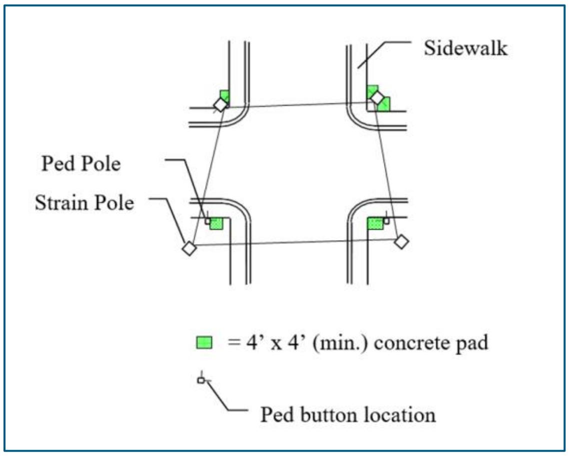


Figure 7: General ADA Pad Locations

Note that the pedestrian features mounted to the strain poles (or mast arms) are mounted to the sides of the poles. This forces the contractor to use one-way pedestrian signals even when 2 signals are mounted to the same pole. If pedestrian signals are mounted on mast arm uprights, a pedestrian detector station will need to be used to avoid the excessive reach caused by the upright base plate and anchor bolts. When pedestals are used, however, the contractor will use a two-way fixture that is mounted to the top of the pole. The designer should be careful to specify the correct pay item number to avoid conflicts during construction.

Regardless of where the pedestrian signals are located, instructions must be provided at each pedestrian detector location. This information is provided through the use of signs (see below). These signs are generally included in the cost of the pedestrian detectors by a general note. Pedestrian detectors shall be located a maximum of 10 inches from the face of the sidewalk.

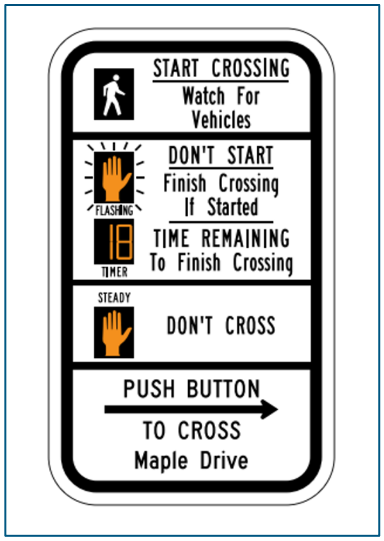


Figure 8: R10-3i Sign

3.7.1 Audible Pedestrian Features

The placement of audible pedestrian features is critical. The designer shall place the detectors a minimum of 10 feet apart. If a 10-foot spacing is not feasible, the design should meet criteria outlined in the *MUTCD, Section 4K.02*. All pedestrian signal location should be designed as if they will become audible (accessible) pedestrian signal locations.

3.8 Line of Sight (Bridge & SPUIs)

Line of sight to the signal heads is important in all signal designs. When calculating sight distance, driver eye-level should be reviewed for both passenger vehicles (3.5 feet) and large trucks (8 feet).

Special design consideration should be given to signal heads hindered by bridge decks. The engineer should explore the use of horizontal heads to improve sight distance. Another acceptable practice is to design the heads so they are 6 inches above the lowest bridge section. This may result in a vertical distance less than 17.5 feet; however, vehicles that are able to pass under the bridge should not run the risk of hitting the signal heads. A Vertical Clearance Design Variation will be required for signal heads that are designed below the 17.5-foot minimum. Refer to the *FDM* for information regarding variance submittals.

If the options listed above have been incorporated and sight distance is still a concern, other supplemental signal head options can be explored.

4.0 PAVEMENT MARKINGS AND SUPPLEMENTAL SIGNS

4.1 Pavement Marking

When making traffic signal modifications at an intersection, the engineer should review the existing pavement markings at the intersection. Even if the intersection is already signalized, modifications may be necessary to reflect current standards.

When reviewing the existing and/or proposed pavement markings, the following items should be verified:

- The inside radius for left turns should accommodate the appropriate design vehicle-type at the intersection except at minor local streets with no large trucks.
- A minimum of 8 feet separation between concurrent opposing left turn movements.
- A minimum of 4 feet separation between the travel lane and the concurrent crosswalk.
- Separation between the travel lane and the opposing stop bars (assuming no crosswalks) should accommodate a theoretical crosswalk.
- Skip stripe guidelines adhere to *FDM Sections 230.4.1*, *230.4.2*, and *230.4.6*.
- Crosswalks at signalized intersections should utilize the “special emphasis” type markings.
- Stop bars should be placed perpendicular to the lane. Staggered stop bars are allowed. In some cases, the loop may need to be move significantly ahead of the stop bar.
- If loops are being cut, any affected pavement markings (i.e., stop bars and arrows) should be completely restriped after the loop is installed.

In general, new signals will require the addition of stop bars (and likely new crosswalks in urban areas) and the modification of existing pavement markings. All pavement markings between the stop bars generally should be removed. This specifically applies to 10’-30’ skip stripe and other lane lines that extend into the intersection.

The designer should examine all existing pavement markings that are to remain and determine if they need to be restriped. Work that is to be done in the intersection also may damage existing markings that would have otherwise been acceptable. For example, when loops are cut into existing pavement, the existing pavement markings are usually significantly destroyed. For this reason, the designer should always restripe the stop bar, crosswalk, and any pavement arrows that will be cut during loop installations.

4.2 Signs

During the development of signalization plans, the designer should carefully examine the existing signs on each of the approaches. Many times, signs far from the intersection need to be removed during the signal installation. An example is a “stop ahead” (W3-1a) sign that may be placed several hundred feet away from the intersection on the side street. “Yield” and “One Way” signs that are placed within wide medians should be removed unless there is a special reason to keep them. “Keep right” (R4-7) signs with nine button delineators should be installed at the median noses. Additionally, the designer should ensure that other signs at the intersection meet current design standards. These signs include “Yield” signs and crosswalk warning signs.

4.3 Street Name Signs

Street name signs should be installed at all signalized intersections. The signs should be designed per criteria provided in the *MUTCD* and *TEM, Section 2.2*. District Five prefers that rigid mounting hardware be used for street name signs (rather than “swinging” mounting hardware).

When feasible, street block numbering should be considered for each street name sign. This numbering should be coordinated with the local agencies before implementing in the plan designs.

Advance street name signs are required when any of the below conditions exist:

- There is a documented history of side-swipe or rear-end crashes.
- There are high volume approaches.
- There is a high 65 and older population.
- Roadway with 4 lanes or greater.
- Rural high speed roadways (50 mph or greater).
- The intersection is located in a Safe Mobility or Life Coalition Priority County.

These signs are usually placed upstream to the beginning of the turn lanes to inform motorists of the upcoming intersecting side street. These signs should be designed per Section 2.37.5 of the *TEM*. An example of a NEXT SIGNAL sign is shown below:

Figure 9: "NEXT SIGNAL" Example

Where possible the word Street, Boulevard, Avenue, etc., should be abbreviated (St, Blvd, Ave) or letter height reduced to conserve sign panel width.

4.4 Sign Illumination

In some locations, street name signs are installed with internal light fixtures to illuminate the sign. If modifications are done to a signal with such signs, they should be replaced in kind. Also, if modifying or installing a signal in an area that already has internally illuminated signs at nearby intersections, the maintaining agency should be contacted to determine if that type of sign should be included at the intersection to be modified. If included, the designer should provide specifics regarding the power required to operate the signs. Internally illuminated signs use LED's that use very little power. Use 3 conductor 14 AWG signal cable to power these signs. Items to be considered include:

- Provide a separate breaker for the internally illuminated signs.
- Verify that the sign mounting location will not block the view of other signs or signals.

4.5 Changeable Messages

When adding a new signal, consideration should be given to providing a changeable (variable) message sign in advance of the intersection to warn motorists of the new signal. Such signs would only be used immediately after the signal has been turned on and is fully-operational. The intent of the signs is to reduce the potential for rear end collisions by motorists who are familiar with the pre-signalized intersection. After approximately 2 weeks, the sign should be removed.

Message Example:

(Panel 1)	(Panel 2)
NEW	**PREPARED**
SIGNAL	**TO STOP**
AHEAD	

Please note that the message on the sign shall flash, opposed to a steady message. This will help drivers identify the message on the temporary sign.

5.0 DETECTION

5.1 Smart Signal

The purpose of Smart Signal implementation is to create a data-rich environment, deploy scalable infrastructure for future Connected and Autonomous Vehicle (CAV) applications, and develop standardization for traffic signal equipment at signalized intersections districtwide. The proposed architecture of the Smart Signal implementation will provide real-time data sets with improved granularity to enable a variety of applications to better manage and operate arterial roadways more efficiently. This additional data includes high-resolution controller detection data and intersection movement counts. The Department and maintaining agencies will ultimately utilize this data to quantify and evaluate Automated Traffic Signal Performance Measures (ATSPM). The standardization specifically provides minimum technical requirements for the system(s), but does not dictate specific equipment, products, manufacturers, or systems.

The implementation of the Smart Signal standard will be required for all signalization projects that involve cabinet work for new construction, reconstruction, widening, Resurfacing/Restoration/Rehabilitation (RRR), “Pushbutton” work, and Traffic Operations. Projects with minimal work will not require Smart Signal implementation; however, it is the EOR’s responsibility to evaluate and justify Smart Signal implementation in the project through coordination the signal maintaining agency and FDOT.

Most projects with signalized intersections will include the complete implementation of the Smart Signals requirements; however, there are a few exceptions in which specific intersections will only be required to provide the minimal defined requirements. These limited-scope projects are referred to as Smart Signal “Ready” and will be constructed such that new infrastructure is capable of accommodating equipment for a full buildout in the future. Candidates for a Smart Signal “Ready” deployment include limited-scope or private development permit projects, including the construction of a new or modification of an existing signalized intersection leg for a residential development or business entrance. The intent of Smart Signal “Ready” projects is to ensure that the magnitude of the requested signalization scope is proportional to the overall project scope and budget.

Table 1: Smart Signal Vs. Smart Signal Ready

***Smart Signal* Project (New Construction, 3R, Widening, Traffic Ops)**	**Requirement**	***Smart Signal* “Ready” Project (Private Development, minimum limited-scope) [5]**
YES	ATC Controller	YES
YES	NEMA Type 6 Cabinet Assembly w/ 64 input channels	Conditional [7]
YES	Stop Bar Detection (all lanes, all approaches)	Conditional [1]
YES	Advanced Detection (all lanes, all approaches)	*Optional* [8]
YES [6]	Queue Detection (left turn lanes)	Conditional [6]
YES	Managed Field Ethernet Switch	YES
YES	Remote Power Management Unit	YES
Conditional [4]	Uninterruptible Power Supply	Conditional [4]
YES	Fiber Optic Communications, Infrastructure [2]	*Optional*
YES [3]	Alternative Communications (wireless, cellular)	YES [3]

1 If the local agency or project preference for stop bar detection is in-pavement loops, the project <u>must</u> install loops for all lanes, all approaches impacted by the project.
2 Minimum fiber optic communications infrastructure includes dedicated conduits, fiber optic pull box or splice vault at the cabinet base, fiber optic patch panel, splice enclosure, trunkline and drop fiber optic cables.
3 If fiber optic communications are installed at an intersection, this requirement is null; alternative communications shall only be permitted if fiber optics communications are not feasible and approved by the Department.
4 If the local agency preference requires UPS, install a complete assembly with battery backup system for each signalized intersection.
5 The project is required to restore, replace, and/or upgrade all existing signalization components impacted as part of the project to the relevant Smart Signal standards.
6 Provide queue detection where applicable based on operational needs of the intersection, traffic analysis, or historical.
7 Existing NEMA Type 5 assembly shall be acceptable if existing assembly can accommodate additional equipment and detection inputs.
8 Advanced detection is not optional for corridors with posted speed limits of 40+ MPH.

All projects are anticipated to meet the Smart Signal standards, unless otherwise approved by the Department.

Refer to the District Five Smart Signal Design Guidance for further details.

5.2 Loop Placement and Application

At most signals, two types of loops are used. Presence loops (type "F") and advance loops (type "B"). The presence loops are used to detect vehicles at the stop bars. Advance loops are used to detect vehicles approaching the intersection. Each of these three types are detailed in the *FDOT Standard Plans, Index 660-001*, but are modified as described below.

For most intersections, type "F" presence loops should be 6 feet by 40 feet and placed so that they extend 5 feet in front of the stop bar. This will sometimes need to be adjusted to minimize false calls from side street driveways or to keep out of the pedestrian crosswalk. Under certain circumstances, it may be necessary to extend the loop as much as 20 feet ahead of the stop bar, especially where right turning vehicles are likely to stop ahead of the stop bar. The presence loops are usually installed on the mainline left turn lanes and on all approach lanes for the side street. Detection is not needed in a right turn lane on the mainline if that movement is programmed to utilize minimum recall or CNA (Call to Non-Actuated).

Since some of the vehicular movements can be made without receiving a dedicated phase, delay detectors are used. These movements are generally the side street right turn (which can be made on red) and the mainline left turn (when protected-permitted phasing is used). Additionally, it is sometimes desirable to delay a loop due to other movements (usually left turns) that may cross over it. For each of these loops, specify a delay detector and state that the delay shall be set to 10 seconds. Local agencies may adjust later.

After the loops are placed on the signal plan, careful consideration should be given to the route used to connect the loop to the cabinet. Since off-tracking vehicles routinely damage the pavement edges at the radii, saw-cuts should not terminate within a radius. Also, with milling and resurfacing projects occurring routinely on our major roadways, no side street loops should have saw-cuts leading out into the mainline. This may require the designer to route the saw-cut from the back of the loop to a tangent edge of the side street roadway.

Advance loops are used in conjunction with extension times to serve two purposes. First, if a vehicle is waiting on the side street, the loops detect approaching vehicles on the mainline so that the controller can extend the green long enough for the vehicle to clear the intersection (as long as the maximum green has not been reached). Second, by allowing higher speed vehicles to pass through the intersection, the number of motorists forced to make stop or go decisions is decreased. These features are intended to improve efficiency and safety at the signalized intersection.

In order for the advance loops to serve their purpose, the loop positions must be relative to the approach speed and coordinated with the extension times. Table 2 and Figure 10 provide general guidance for advance loop placement and timing development.

Table 2: Advanced Detection

Posted Speed (MPH)	Distance from Stop Bar to First Zone (D_1)	Distance from Stop Bar to Second Zone (D_2)	Extension (T_1) (seconds)
40	138'	244'	1.9 s
45	166'	298'	2.0 s
50	196'	356'	2.2 s
55	230'	419'	2.4 s
60	265'	488'	2.6 s
65	303'	561'	2.8 s

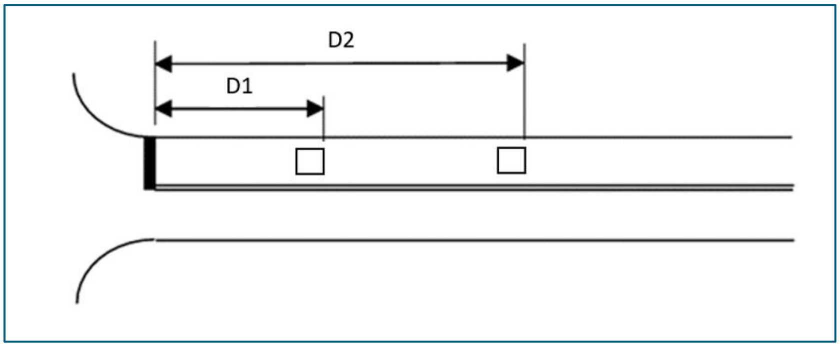


Figure 10: Advanced Detection Layout

During the design process, the engineer will use type "B" loops for advance detection. Usually, this is dependent upon the maintaining agencies desire for the subject intersection. Type "B" loops strictly follow the *FDOT Standard Plans* with one loop per lane for each set of advance loops. If a TS-1 cabinet is encountered at an existing intersection, replace the cabinet; the new cabinet shall be outfitted with enough input channels to accommodate the additional detection.

According to specifications, all twisted pair loop wires must be terminated at the controller or at a splice point within 75 feet of the loop. Each spliced loop will have a separate lead-in cable from the splice point to the controller cabinet. All loop lead-in's will be in conduit from the loop splice pull box to the cabinet. Sawcutting loop lead-in's should only be done temporarily to restore detection during construction, for example.

For urban typicals with tight right of way and/or a lot of utilities it may be necessary to saw-cut the lead-in cable back to the cabinet. Once the loop locations are determined and placed on the plan, the loops should be labeled. Each loop should be numbered to match the corresponding movement number.

It is recommended that no more than three turns of loop wire are placed in a single saw-cut window, unless otherwise stated in the *FDOT Standard Plans*. The cutting of loops in concrete pavement should be avoided. Figure 11 from the *FDOT Standard Plans* portray the typical turn values for vehicular loops at an intersection.

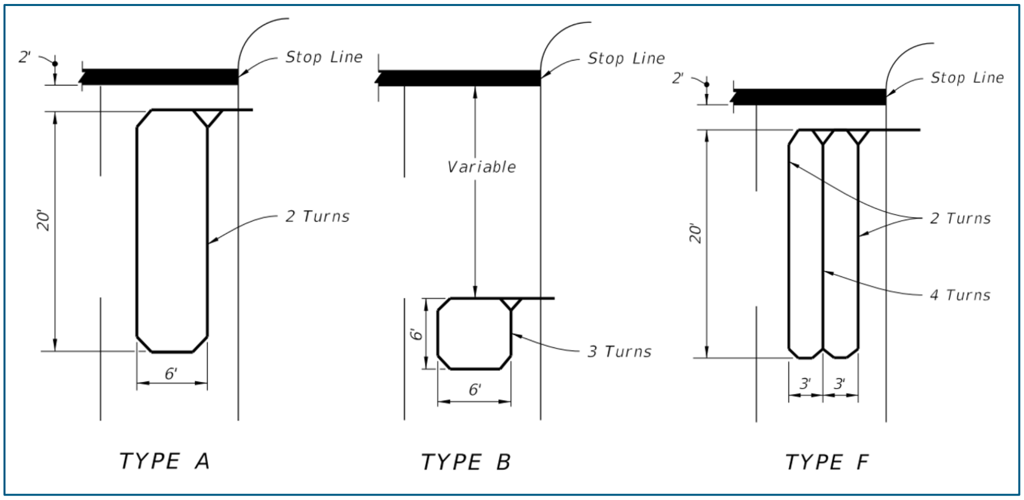


Figure 11: FDOT Standard Loop Details

5.3 Video Detection

If the designer is required to use video detection, careful consideration should be given as to where the cameras are positioned in the intersection. It is important that cameras do not detect cross-traffic through the intersection or could potentially become blocked by other stopped or turning vehicles (primarily large trucks). In general, most mast arm intersections will work with video detection. Video detection cameras work best when the traffic being detected is moving directly towards the camera. Mounting cameras on strain poles 30 feet off edge of pavement trying to cross two or three through lanes to detect vehicles in a left turn lane, does not work. Do not use any span mounted video detection equipment.

Video detection coverage is similar for loop detection regarding mainline left turn lanes and side streets. A 6-foot by 40-foot rectangle should be shown and consideration should be given to a larger area based on engineering judgment. Advance detection should be shown as a large area that extends from the stop bar to the farthest set of advance loops to cover the “dilemma zone”. The extension time should also be reduced (i.e., 0.5 seconds). In order to achieve this coverage multiple cameras may be required and should be identified on the plans.

The designer should coordinate with the maintaining agency to ensure the detection zones are shown properly and the signal timing chart complies with the agency’s preferences. Also coordinate with maintaining agency to ensure that the detection equipment vendor is the best product fit.

Mounting hardware for the detection system shall not be attached to the poles by steel banding/straps or by drilling through the pole. Proper mounting hardware should include a mounting bracket that properly fits around the pole or mast arm. Cameras should not be positioned adjacent to energize power lines or other features that will interfere with detection.

Video detection shall also be considered with projects that provide rigid concrete pavement at signalized intersections. At times, the joints in concrete pavement create maintenance issues with standard loops. Prior to providing video detection in the design, the EOR should coordinate with the maintaining agency and Traffic Operations.

5.4 Radar Detection

If radar detection is required by the maintaining agency at a signalized intersection, mounting height and location are essential to the reliability and efficiency of traffic signal operation. Radar is typically used for stop bar detection and performs best if mounted in front of oncoming traffic (i.e. on near/far side mast arms over the roadway). If radar is to be used at an intersection with span wire and strain poles, the device should be mounted directly to the span wire or strain poles closest to the designated approach. The designer should ensure that a clear line of sight without areas of occlusion is provided for the radar devices. Typical mounting height for stop bar detection is 20 feet above pavement. For best possible coverage of the approach, the EOR and contractor should adhere to the manufacturer's recommendations for mounting heights and offsets from the edges of lanes.

For signalized intersections with mast arm structures, sensor mounting brackets should be rigidly attached to the mast arm. Ensure there is a minimum 1-foot horizonal clearance from traffic signal heads, retroreflective backplates, overhead sign panels, and other obstructions that may impact the field of view. For signalized intersections with span wire configurations, determine if mounting assemblies that rigidly attached to the catenary and/or messenger wire are available and provide the necessary field of view coverage. Where mounting directly to the span wire structure is unavailable, mount sensors to horizontal structures (e.g., luminaires, internally illuminated sign supports, cantilevered mounting brackets) attached to the upright supports or directly to the upright support structures.

The requirements for detection zones, signal timing charts, and the consideration of radar detection where rigid concrete is present shall follow what is stated in Section 5.3 for Video Detection.

6.0 CONDUIT AND JUNCTION BOXES/PULL BOXES

6.1 Introduction

This section is intended to give guidance for the installation of conduit as well as pull and junction boxes. This information is in addition to the specific information referred to in Sections 630 and 635 of the **FDOT Standard Specifications for Road and Bridge Construction**.

6.2 Conduit

Other information regarding conduit installations that should also be considered:

- The designer should note that the directional bore equipment must be positioned in an area approximately 15 feet behind the beginning of the bore. In many space restrictive intersections, this will impact the conduit routing.
- A separate conduit should be provided when using video detection.
- A spare conduit, for future improvements, should be provided across each mainline crossing at the intersection.

6.3 Pull and Junction Boxes

Pull and Junction Boxes are used to provide access for installing cables during construction and for maintenance of cables and splices during the life of the signal or the signalization equipment.

When placing pull boxes, the designer shall make sure that these minimum requirements are met:

- Do not place in areas where they will be driven over such as dirt driveways or behind unprotected radii (where off-tracking vehicles could destroy).
- Place in relatively dry areas.
- Place at least 10 feet from pavement edge without curb.
- Out of sidewalk or pedestrian ramp.

To facilitate future expansion of intersections, District Five has created a typical pull box configuration to be used at each controller cabinet. Each cabinet shall have pull boxes for high voltage signal cable, low voltage detection cable, loop cable, low voltage communication cable, and fiber optic cable.

The high voltage signal cable consists of vehicular signal head cabling and pedestrian signal head cabling. At intersections where there are four or more pedestrian phases, an additional high voltage signal cable pull box will be provided.

The low voltage detection cable consists of pedestrian detector cabling and any other low voltage cable utilized for detection at the intersection.

The loop cable consists strictly of the lead-in cabling associated with vehicular loops. Provide an additional loop pull box at intersections with more than sixteen loop lead-in cables at the cabinet. The loop pull boxes should be limited to four conduits (two-in, two-out) with a maximum of eight loop lead-in cables per conduit.

The low voltage communication cable consists of all cabling associated with the devices at the intersection. These devices include (but are not limited to) CCTV cameras, microwave vehicle detectors, video detection cameras, Bluetooth devices, and preemption equipment.

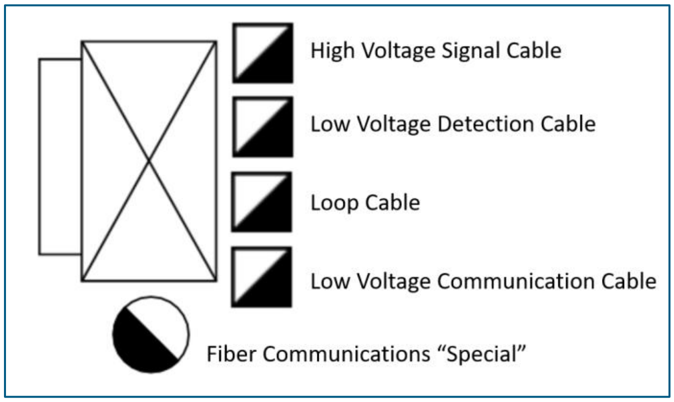


Figure 12: Pull Box Layout

The fiber communications box should be a splice vault (*FDOT Design Quantities and Estimates, Pay Item 635-2-13*) in those areas where fiber exists or will be added in the future. Consideration should be given to placing a splice vault in locations that a future signal may be warranted (generally full median openings). When utilizing the different kinds of fiber optic pull boxes, the Tabulation of Quantities line for this pay item number should separate out the splice vaults from the fiber optics pull boxes (*FDOT Design Quantities and Estimates, Pay Item 635-2-12*).

7.0 CONTROLLER SELECTION AND PHASING

7.1 Type of Controller

The maintaining agency should be contacted early in the design process to determine what their specific preferences are for the specific location. Generally, agencies have specific brands of equipment that they use for signalization and communication. The proposed controller will need to be compatible with the agency's system.

7.2 Type of Operation

Controller cabinet assemblies can be purchased with a wide range of potential capabilities. For each project location, the goal should be to provide a controller cabinet assembly that will have the potential to serve the intersection's needs throughout the expected life of the controller cabinet assembly. This will require determining the existing phasing and making educated guesses at the future phasing needs for the intersection. Consideration should also be given to preemption requirements such as train, emergency vehicle, and/or bus preemption, as well as future communication needs. It should be noted that many maintaining agencies require a SOP 10 controller assembly even for intersections not currently using all of the available phases.

7.3 Phasing to Reduce Delay

Modifications to signal phasing can have major impacts to the overall efficiency and safety of an intersection. For this reason, all phasing changes (including preemption) to a traffic signal controlling a state roadway must be preapproved in writing by the District Traffic Operations Engineer (DTOE) or delegate.

Although often requested, left turn phases should not be added to an intersection without the approval of the DTOE. In order to receive this approval, at a minimum, a Left Turn Phase Warrant will need to be provided to the DTOE (with a movement diagram and movement numbers) for approval. This warrant should not be considered an automatic approval, however, as other factors must also be taken into consideration.

In coordinated signal systems, modification to the phasing sequence can sometimes result in reductions in motorist delay. An example of this modification is changing the protected only left turn phases to a lead-lag configuration. These types of modifications should be proposed in an engineering study and approved by the DTOE prior to implementation.

Intersections where side street movements operate separately are known as split-phased intersections. This phasing configuration is common throughout Florida and District Five. In many locations this phasing configuration is used where the intersecting side streets are offset from one another such that vehicular conflicts between opposing vehicles would result if they operated concurrently. Often split phasing is used where a second left turn lane is needed to accommodate traffic demand, but widening of the intersection to add this lane is not feasible. In these situations, the through lane is reassigned to become a shared through-left turn lane. In this situation, it is necessary for the through movement and left turn movement to operate at the same time requiring the use of split phasing. Split phasing is sometimes used where one side of an intersecting roadway has much heavier traffic than the other side. Unless there are specific lane assignments, which require the split phasing, it is inefficient for the intersection to operate under this configuration due to the lost time associated with two phases instead of one. In this instance, strong consideration should be given to modifying the phasing sequence so that the side street movements operate concurrently.

7.4 Controller Selection

Just as technology and the computer and communications industry continue to evolve, traffic signal control and motorist information systems are continually being upgraded and/or replaced. It is important that the designer propose equipment that will be compatible with the local system. The designer should contact the local maintaining agency to determine the exact requirements for the equipment to be installed at the intersection under design. Specific considerations include:

- Model and type of controller
- Interface panel
- Preemption
- Communication components

Signal systems should communicate back to the central network via hardline fiber optics or cellular communications. Within a signal system, signalized intersections are typically connected via hardline fiber optics or wireless communication radios.

7.5 Controller Cabinet Location

The controller cabinet location should be carefully selected. Locations that appear to be appropriate in CADD files may be inappropriate in the field. The designer should consider items such as:

- Slope, elevation, and potential for standing water
- Driveway and sidewalks
- Off-tracking vehicle such as large trucks
- Keeping the cabinets within a corridor on one side of the roadway to ease communication cable installations
- Location of existing power transformers
- Ability of technician to see signal display during troubleshooting
- Verify that the cabinet door can be opened and is accessible from within right of way (no fences or bushes, etc.)
- Consider generator pad and location of pad

When installing a new cabinet, the base should not exceed 4 inches in height above grade. If a cabinet replacement is proposed, the old cabinet, base, and extra cabling and conduit should be completely removed from the project. The designer will need to coordinate with the maintaining agency to determine whether the removed equipment should be delivered back to the maintaining agency to be kept for spare parts.

7.6 Numbering the Vehicle Movements

To properly assign movement numbers, the following rules should generally be followed:

- Movement 2 should be a main street through movement for southbound or westbound, Movement 6 should be the opposing main street movement (northbound or eastbound).
- The remaining through movements should then be assigned with even numbers increasing clockwise around the intersection. If a leg of the intersection is missing, this movement number should be skipped.
- The main street left turn movements should be assigned numbers 1 and 5 such that sum of the through and left turn movements is always seven.
- The side street left turn movements should be assigned numbers 3 and 7 such that the sum of the though and left turn is always eleven.
- Right turn movements that are separately signalized are usually denoted with the adjacent through movement number with the addition of the letter “R” (i.e. – 2R, 4R, etc.).

7.7 Signal Operating Plan (SOP)

Standard SOPs can be found in the *FDOT Standard Plans, Index 671-001*. There are times that unique SOPs may be required. One example is the use of the Flashing Yellow Arrow. Below is a sample SOP that can be used with varying left turn phasing (by time of day). It is important to clearly convey the design intent in the plan set. Do not rely on contractor/maintain agency staff to interpret the intending signal operation.

For FYA operation, the arrow should be dashed to designate the permissive movement.

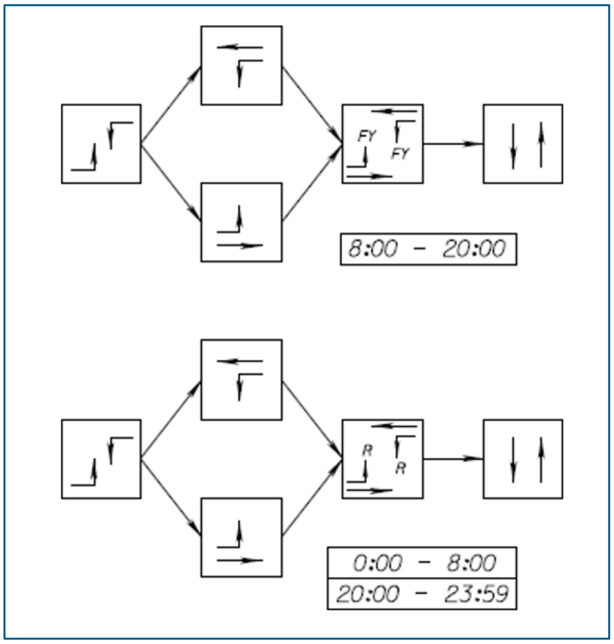


Figure 13: SOP Example

8.0 TRAFFIC SIGNAL TIMINGS

8.1 Introduction

To improve efficiency and reduce travel time, many arterial roadways within District Five have signal systems to coordinate the traffic signals within the system. In addition to providing compatible controller and communications equipment, the designer must take into consideration the implications of adding a new signal to the system. At a minimum, coordinated system timings must be developed to allow the new intersection to operate in coordination with the adjacent traffic signals in the system. Depending on the spacing and the operating characteristics of the new intersection, it may be necessary to develop a new set of system timings for the entire corridor, or it may be necessary to subdivide the existing system into separate subsystems. These considerations must be accommodated in the design of the new traffic signal. For non-FDOT projects the designer will be required to do this work. For FDOT projects, the TSM&O Arterial Engineer should be consulted during the design process to determine whether or not development of new system timings will be required. At that point, the TSM&O Arterial Engineer will also determine if pay items should be added to the plans to cover the work or if Department staff will assume responsibility for the timing modifications.

This chapter is only intended to provide simple guidance to aid signal designers. Detailed system timings should be developed and implemented by qualified individuals whenever a corridor is modified or created.

8.2 Timing

There are two basic types of timings that are entered into the traffic signal controller, local timings and system timings. Local timings should be developed or modified by the engineer and shown on the signal plans. System timings are developed after construction and are implemented and fine-tuned after traffic patterns have adjusted for the post construction condition.

Local timing must accommodate all local operations at the intersection, including:

- Minimum Green (Initial)
- Maximum Green
- Extensions
- Yellow and Red Clearances
- Pedestrian Walk (7 seconds preferred, but can be as low as 4 seconds)
- Pedestrian Clearance
- Min. and/or Max. recall (mainline is usually placed on min. recall or CNA)
- Detector Functions (Non-lock NL is used in right turn lanes, protected-permissive lefts, and can be used for shared though-rights)
- Flash mode (the display each head should utilize during flash operation)

Additional timing plans are also developed for special circumstances. Some of these include:

- Railroad Preemption (needs entrance phasing, preempt phasing, and exit phasing)
- Emergency Vehicle Preemption
- School Zones
- Interstate Off-Ramps

Below are some general guidelines for signal timing in District Five. There are merely starting points used for very basic intersections. These guidelines are not intended to meet the needs of every intersection and should not replace sound engineering judgement:

- Side street movements and left turn movements should have 5 to 6 seconds for min. green and 3 seconds for extension.
- Max. green times are to be based on volumes; however, they may be approximately 50 seconds for the main line and 15 to 20 seconds for the side streets.
- Flashing Don't Walk time should be determined using 3.5 feet/seconds crossing speed.
- Minimum recall is generally used only on the main line.
- The minimum green for the main line can be reduced to 10 seconds when video detection is used since the detection zone is larger.
- Refer to Table 2 in Section 5.2 for mainline minimum green time and extension times.

8.3 Signal Clearance Time

Refer to the *TEM, Section 3.6*.

8.3.1 Pedestrian Clearance

The pedestrian clearance time shall be determined by this formula, where the crossing distance is defined from curb to curb (per the *MUTCD*).

$$\text{Pedestrian Clearance} = \frac{\text{Crossing Distance (feet)}}{\text{3.5 feet/sec}}$$

Note that a more restrictive speed may be used per the *MUTCD* for special circumstances, at the engineer's discretion.

8.4 Coordination

Traffic signals can be coordinated through a variety of methods. These include time-based coordination (TBC), and central system control. When designing signal plans for an intersection within a signal system, it is important to know how the existing system is operating. Once the determination has been made, the designer will need to detail how the new signal will be connected to the system.

9.0 TRAFFIC SIGNAL COMMUNICATIONS

9.1 General Requirements

Traffic signals are coordinated through various communication methods. When modifications to existing systems are required, the coordination method must be addressed in the plans. There are three basic types of work that require such modifications. They are: (1) modifying the cabinet of a signal that is currently coordinated, (2) installing a new signal within or near a coordinated section, and (3) installing a new signal within a ½ mile of another signal along a corridor.

When coordination installations or modifications are required, a few basic decisions must be made to determine how the signals will communicate. If a physical connection is made between the intersections, the designer must determine the type of connection and whether the cable is to be run overhead or underground.

Overhead

For overhead cable routes, existing utility poles are generally used. The cable is attached at a certain height that is agreed upon by the utility pole owner. This height generally is a certain distance away from an existing utility already mounted to the poles or from the ground to the proposed attachment point. The designer must ensure that proper roadway clearances are met for driveways and side streets if the cable is to be mounted to the utility poles. The plans should show the poles that are to be attached to and how the cable is to be installed from controller to controller. The designer may also need to include cable guys for turns and terminations of the cable. It is important to note that aerial fiber is not self-supporting, therefore, a messenger wire should be provided in the design plans.

Prior to finalizing the cable mounting locations, a maintenance agreement between the cable owner and the pole owner is usually required. Contact the pole owner for further details and requirements. Since the maintenance agreements usually require the cable owner to pay unknown amounts at unspecified times, the Department is not able to sign such agreements. In these circumstances, contact the maintaining agency to request their assistance.

Underground

For underground installations, conduit and pull boxes are required. With these designs, the designer must ensure that the maximum pull box spacing is met, that all driveways and other obstacles are included in the design, and that the proper type of cable and pull boxes are used.

For either type of installation, the cable must be run into the controller cabinet. For existing cabinets, the designer should pay close attention to the number of spare conduits entering the cabinet. When there is no alternative method for entering the cabinet, the existing concrete base can be core drilled to add conduits or a new concrete base with more conduits can be installed. Under no circumstances shall a traffic signal cabinet be drilled into for wire entry.

Both types of installations also require slack cable at periodic points along the cable run. For overhead installations, an extra 200 feet of cable should be available at controller cabinets or wound around a 'sno-shoe', with spacing every ¼ to ½ mile. For underground installations, "special" round pull boxes (*FDOT Design Quantities and Estimates, Pay Item 635-2-13)* are to be used at the controller cabinets with 200 feet of slack. Fiber optic pull boxes (*FDOT Design Quantities and Estimates, Pay Item 635-2-12*) are used at intermediate locations with 100 feet of slack. If the "special" round pull boxes will not fit at the cabinet location, then the fiber optic boxes can be substituted in their place with 100 feet of slack. The "special" round pull boxes should also be used at full median openings where a signal is possible in the future. Either type can be spaced up to a 1/4 mile, depending on the typical section and utilities. In urban areas, for example, this maximum spacing may need to be reduced.

10.0 PREEMPTION

10.1 Introduction

Preemption is a powerful safety tool for the traffic engineer. When used properly, preemptions can allow vehicles to move quickly out of the path of other vehicles such as fire trucks and trains. However, when used incorrectly it can deteriorate the efficiency of an entire corridor.

10.2 Railroad Preemption

If a signal is near a railroad crossing, preemption must be considered as part of the signal design. Preemption is required when a signal is 200 feet or less from a crossing. When a signal is from 200 feet to 500 feet from a crossing a queue analysis is needed to justify not adding preemption. When preempted, the signal can be programmed to allow the vehicles to be flushed off the tracks. Afterwards, the vehicles traveling parallel to the train can continue. The engineer should evaluate the need for fiber optic blank-out signs to prohibit turning movements during the preemption phase.

The designer should also realize that railroad preemption overrides all other forms of preemption and immediately terminates the current phase, even if a pedestrian phase is active.

Guidelines for calculating railroad preemption times can be found in the *TEM, Section 3.8*.

10.3 Emergency Vehicle Preemption

Many emergency vehicles are now using infrared optical emitters to preempt the traffic signals. These flashing strobe lights provide a coded signal to the optical detector mounted over the roadway. When preempted, the signal will immediately begin the clearance portion of any phase opposing the oncoming emergency vehicle. Per the *MUTCD, Section 4D.13*, the pedestrian clearance times may be terminated early during preemption. However, in District Five the pedestrian clearance phase should be allowed to complete the full clearance interval before preempted phase is serviced. Once the clearance intervals have completed, all phases (including turn phases) for the approaching vehicle are usually programmed to display a green signal. Those phases will continue until the detector no longer receives the optical signal. At that point, the system will change to the exit phase before continuing in normal operation. The designer should clearly indicate the exit phase for each preempted approach.

Optical detectors should be replaced if a designer is impacting existing detectors at a signalized intersection. For modifications to an intersection without optical detectors, the maintaining agency should be consulted to determine if they would like the detectors added, and if so, for which approaches.

Many maintaining agencies also utilize a GPS-based preemption system. Careful coordination with the maintaining agency should be exercised to ensure the proper equipment is provided in the controller cabinet.

10.4 Preemption Phase Plan and Timings

In order for the contractor to correctly install the preemption phases, the designer should show the preemption operating plan (POP) and the preemption timings, as necessary. This is especially important for train preemptions. Preemption plans for emergency vehicles do not generally require POP's (a chart showing the exit phases in conjunction with the preempted phase is adequate). Figure 14 is an example of a POP for a theoretical intersection with a nearby train crossing.

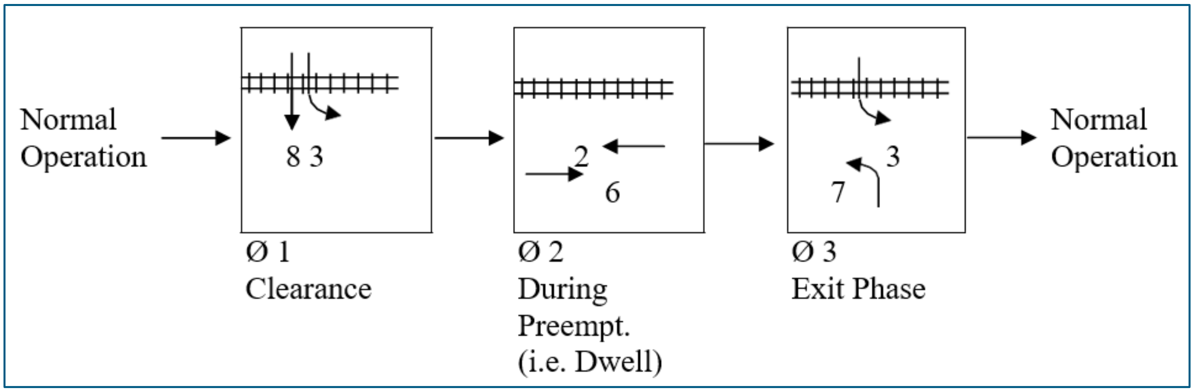


Figure 14: Train Crossing POP

Please note that preemption plans are a crucial area of design. The engineer must be very familiar with rail crossing interface requirements with traffic signals before designing preemption plans. This POP is merely an example and should not be assumed to be the proper plan for any signal. With this example, timings would be provided for phase 1 to allow time for vehicles to clear the tracks. Phase 2 would operate as long as the crossing gates are down. For other intersections, the engineer must carefully determine the proper plan and phasing.

In order for preemption devices to be interpreted and utilized by the controller, additional preemption hardware is required. When installing a new cabinet, the pay item number should incorporate the appropriate number of preemption features. For retrofitting existing cabinets, a qualified technician will need to determine what modifications will be required.

11.0 SIGNAL MAINTENANCE OF TRAFFIC DURING CONSTRUCTION

11.1 Introduction

During construction projects, the traffic signals are often impacted for extended periods of time. Although the signal hardware is often preprogrammed to avoid conflicting displays and to deal with loss of vehicle detection, the methods used result in inefficient intersection operations. To minimize these impacts, the Department requires certain unavoidable problems be addressed during the design phase and included in the signal plans.

11.2 Distruption of Signal Operation

When a traffic signal must be turned off or put into flash mode a traffic control officer should be on the scene to direct traffic. Usually, these periods can be limited to just a few hours during the changing out of poles, signal displays, or controller cabinets. Every effort should be made in the design phase to minimize or remove the necessity of turning off the traffic signal.

11.3 Loss of Vehicle Detection

During reconstruction or milling and resurfacing projects, there is often no way to avoid the destruction of existing loops in the roadway. Even projects that do not destroy the embedded loops often destroy the associated lead-in cables, which disconnects the loops from the detection system. For projects where the detection is expected to be out for more than a week, effective temporary detection should be used. On simple intersection improvements, requirements should be stated in the plans that the loops are to be replaced within a certain period of time. Temporary configurations for vehicle detection can be found in the following section.

11.3.1 Temporary Detection

All movements shall be actuated during construction efforts. Temporary detection units should be positioned to avoid “false call” detection of cross traffic or vehicles traveling in other detection zones. The equipment shall only detect the intended movement. The following note should be added to the plans:

“Before permanent vehicle detection is disrupted, provide an alternative means of detection to all lanes approaching the intersection, separating each movement which previously had detection. The type of detector and detector location shall be approved by the Engineer prior to installation. Equipment shall only detect the intended movement.”

12.0 PERMITS

12.1 Introduction

Prior to beginning any construction activities within state right of way, a permit must be acquired. This section provides simple guidance for working with the Traffic Operations Office to coordinate the signalization portion of the permit. For detailed permit information, contact the local FDOT Maintenance Office.

12.2 Signal Warrants

Before a signal is built or an additional phase is added/modified, a study must determine that the signal is needed and is in the best interest of the motoring public. This study should then be submitted for review and approval by the DTOE prior to submittal of signal plans. For detailed information on signal warrants, see the *MUTCD* and the **Florida Manual on Uniform Traffic Studies (MUTS)**.

12.3 Signal Plans

In general, once signalization plans have been developed and are ready for permit submittal, they should first be delivered to the local FDOT Maintenance Office. There, the engineer can obtain the necessary permit application forms to begin the permit review process. The Maintenance Office will assign a permit number and then forward the plans to the Traffic Operations Office.

Initial comments from Traffic Operations will be sent directly to the Engineer developing the signal plans. The plans should then be revised as necessary and returned directly to Traffic Operations with the permit number clearly identified within the submitted plans package and written responses to the previous comments. Coordination with the maintaining agency needs to be made also, and any comments that they have should also be forwarded to Traffic Operations for informational purposes. If the intersection modifications are minor (such as installing loops only), then once all of the comments made by the Traffic Operations staff have been properly addressed, the plans package will be returned to the local Maintenance Office with recommendation for signal plan approval. The Local Maintenance Office will issue the permit once all of the requirements have been satisfied, which may include driveway comments or other issues not related to Traffic Operations.

If the permit involves the installation of either strain poles or mast arms, then additional information will be requested in the initial review of the plans. This will include a Geotechnical Report (for mast arms) or a structural calculation/report (for strain poles). Traffic Operations will coordinate the review of this information with the Geotech, Structural Design, and Structures & Facilities Groups. Once all of the issues have been satisfactorily addressed, the plans package will be returned to the local Maintenance Office with recommendation for signal plan approval.

Subsurface utility exploration (SUE) reports are a requirement for any new strain pole or mast arm that is proposed. Verifying the proposed foundation locations are clear of utility conflicts during the design phase can save the permittee months of delay and additional construction costs.

The following is a basic list of the items that will be required throughout the signal permit approval process:

- Signed and Sealed Copies of the Final Plan (Seven Copies)
- Striping & Signalization CADD Files (.dxf or .dgn format)
- Signed and Sealed Structural Calculations (Strain Poles)
- Signed and Sealed Geotech Report (Mast Arms)
- Special Conditions Supplement (Mast Arms Only)
- Submittal Data (1 copy approved by the EOR)

- Quality Control Plan (Mast Arms Only)
- Drilled Shaft Installation Plan (Mast Arms Only)
- Shop Drawings Stamped by the Structural Engineer of Record and the Contractor (Non-Standard Mast Arms Only)
- Class IV Concrete Mix Design (Mast Arms Only)
- Drilled Shaft Inspection Report
- Copy of the Warranty Bond

If the installation is a mast arm, the permittee must have the shaft installation inspected and documented by a Qualified Drilled Shaft Inspector. After the drilled shaft installation/inspection is complete, the Professional Engineer (PE), in responsible charge of the drilled shaft inspector, must review the inspection documentation and provide a signed and sealed final Drilled Shaft Inspection Report.

13.0 REFERENCES

13.1 Traffic Signal Design References (Latest Versions)

FDOT Design Manual (FDM), Florida Department of Transportation

FDOT Design Quantities and Estimates, Florida Department of Transportation

FDOT Standard Plans, Florida Department of Transportation

FDOT Standard Specifications for Road and Bridge Construction, Florida Department of Transportation

FDOT Structures Manual, Florida Department of Transportation

Florida Manual on Uniform Traffic Studies (MUTS), Florida Department of Transportation

Manual of Traffic Signal Design, Kell and Fullerton

Manual on Uniform Traffic Control Devices (MUTCD), Federal Highway Administration

Traffic Engineering Manual (TEM), Florida Department of Transportation

13.2 Maintaining Agency Contact Information

The government agency (usually a city or county) that has accepted responsibility to maintain a traffic signal on a state roadway is known as the maintaining agency. A list of the maintaining agencies in District Five is available upon request.