232 Signalization

232.1 General

Signalization provides an orderly and predictable movement of motorized and non-motorized traffic throughout the highway transportation system. They also provide guidance and warnings to ensure the safe and informed operation of the traffic stream.

The design and layout of signals should complement the basic highway design and comply with:

- ***Standard Specifications***,
- ***Standard Plans***,
- ***Traffic Engineering Manual (TEM)***,
- ***Structures Manual*** ***(Volume 3)***,
- ***Manual on Uniform Traffic Studies (MUTS)***,
- ***National Electrical Code (NEC)***, and
- ***Manual on Uniform Traffic Control Devices (MUTCD)***.

The criteria presented in the following sections supplement the ***MUTCD***.

232.1.1 Structural Supports

AASHTO's LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals and the ***FDOT Modifications to LRFDLTS-1*** provide structural design criteria.

Refer to ***FDM 261*** for information regarding structural support requirements. Refer to ***FDM 941*** for information regarding plan requirements.

232.1.2 Attachments to Barriers

Refer to ***FDM 215*** for information regarding proposed attachments to bridge traffic railings, concrete median barrier walls, concrete shoulder barrier walls or the evaluation of existing attachments.

232.1.3 Certification and Specialty Items

Traffic control signals and devices installed in Florida must be certified by the Department. The State Traffic Engineering Research Laboratory (located in Tallahassee) is responsible for certifying all traffic control equipment. If requiring new equipment types or types not typically used, contact the State Traffic Engineering Office to determine the certification status of the equipment. Noncertified equipment cannot be used.

232.1.4 LED Light Sources

The Light Emitting Diode (LED) is the standard light source for all signal indications.

232.1.5 Retroreflective Signal Backplates

Install retroreflective signal backplates on traffic signals for all approaches.

Provide rigid retroreflective backplates for all new signal structures. Flexible retroreflective backplates may be used on existing signal structures in accordance with ***TEM, Section 3.9***.

232.1.6 Signal Heads for Through Lanes

Place a three-section head over the center of each lane for approaches of two or more lanes. When a single left turn lane is provided, a five-section cluster can serve as one of the indications required for the inside through lane.

232.1.7 Vertical Clearance

See ***FDM 210.10.3*** for vertical clearance requirements.

232.2 Lane Configuration

The engineer responsible for the traffic signal design may be asked to verify the number and configuration of traffic lanes required for an intersection to function properly when signalized. For this calculation use the Design Hourly Volume (DHV) based on the Department's Standard K factor and not a peak to daily (P/D) ratio based on a 24-hour count.

The K, D, and T factors convert the two-way AADT volumes to a one-way DHV. This is appropriate for the total approach movements. The AM and PM peak turning movement counts on each approach should be addressed individually. Current turning movement counts should be taken to determine the percentage of turns for each approach. Apply the percentages to the DHV for each approach volume to determine the turning volumes that should be used for the turn lane design calculations. Compare the turning volumes to the movement counts supplied by Planning. Use the greater of the two values for the design of turn lanes. Contact the District Planning Office to determine if recent counts are available and also if any use changes are planned which would require adjustments to the turn percentages found in the current counts.

Storage lanes for left turns can affect the capacity and safety of intersections. The storage length of a left turn lane is a critical design element. The queue of left turn vehicles in a storage lane of inadequate length may extend into the through lanes. The result is loss of capacity for the through lanes. The queue of through vehicles may also extend beyond the entrance of a short-left turn storage lane, blocking access to the storage lane. Either case results in a less efficient operation of the intersection and may cause last minute lane changes, thereby increasing the possibility of conflicts.

Turn lanes should comply with ***FDM 212***. The available queue length provided should be based on a traffic study.

The factors to determine the length of a left turn storage lane are:

(1) The design year volume for the peak hour (see discussion above).

(2) An estimate for the number of cycles per hour.

NOTE: If the cycle length increases, the length of the storage for the same traffic also increases.

(3) The signal phasing and timing.

There are several techniques used to determine necessary storage length. The following are suggested guidelines for left turn lanes:

(1) Where protected left turn phasing is provided, an exclusive turn lane should be provided.

(2) Left turn lanes should be provided when turn volumes exceed 100 vehicles per hour (VPH) and may be considered for lesser volumes if space permits.

(3) For signalized intersections, the following formula may be used, assuming an average vehicle length of 25 feet.

$$Q=\frac{(2.0)(DHV)(25)}{N}$$

Where:

Q = design length for left turn storage in ft.

DHV = left turn volume during design peak hour, in VPH.

N = number of cycles per hour for peak hour, use N = 30 as default.

Note: Computer programs, such as ***TRANSYT-7F*** and ***Synchro*** are used to develop signal phasing and timing. One of the outputs of these programs is the queue length. For projects where traffic signal timing is included as a part of the project, the output of these programs should be considered in determining storage length.

Where peak hour truck traffic is 10% or more, use vehicle length of one passenger car and one truck.

(4) Where left turn volumes exceed 300 vph, a double left turn should be considered.

(5) When right of way has already been purchased, and the designer has to choose between a long wide grass median or a long left turn lane, the storage length for the left turn should be as long as practical without hindering other access.

Right turn lanes are provided for many of the same reasons as left turn lanes. Right turns are, however, generally made more efficiently than left turns. Right turn storage lanes should be considered when right turn volume exceeds 300 vph and the adjacent through volume also exceeds 300 vehicles per hour per lane (vphpl). The introduction of right turn lanes can impact pedestrian crossing distances at signalized intersections; therefore, additional analysis may be required to weigh the impacts of increased pavement width and signal operations.

232.3 Left Turn Treatments

Follow the guidelines given below when determining signal treatments for left turns. For detailed information, see the ***TEM***, ***Section 3.2***.

(1) Single Turn Lane

(a) Protected/Permissive Phasing

Option #1: A five-section cluster or a separate turn signal head may be used for this location. If a separate turn signal head is used, it should be positioned over the center of the left turn lane. If a five-section cluster is used, it should be installed over the lane line between the left turn lane and through lane. The five-section cluster can serve as one of the two indications required for the through traffic.

Option #2: A flashing yellow arrow signal indication may be used. A study conducted by the National Cooperative Highway Research Program determined that drivers had fewer crashes with flashing yellow left-turn arrows than with traditional yield-on-green signal configurations. A flashing yellow arrow must use a separate four section head positioned over the center of the left turn lane.

(b) Protected Phasing

A separate signal head for the left turn lane with red, yellow and green arrow indications should be positioned over the center of the left turn lane.

(2) Dual Turn Lanes – Use only protected phasing, i.e. permissive movements will not be allowed. A single three-section head with red, yellow, and green arrow indications should be centered over each turn lane. These heads are in addition to the dual indications required for the through movement.

(3) Separated Turn and Through Lanes – Guidance for signal operation of separated left turn and through lanes is found in the ***TEM***, ***Section 3.2***.

(4) Single Lane Approach on Stem of "T" – A minimum of two three-section heads are required.

(5) Two Approach Lanes on Stem of "T"

Option #1: The approach may display two three-section heads with circular indications on all sections.

Option #2: The approach may display a five-section cluster in conjunction with a three-section head. If the lanes are exclusive left and right turn lanes, then the five-section cluster should be placed over the center of the lane line and the three-section head over the major movement lane. If one of the lanes is a shared left and right lane, then the five-section cluster should be placed over the center of this lane and the three-section head over the center of the other lane.

Option #3: The approach may display two three-section heads for the major movement and a single three-section head for the secondary movement.

(6) Three Approach lanes on Stem of "T"

Option #1: The approach may display two three-section heads for the major movement and one for the secondary movement (Exclusive left and right turn lanes).

Option #2: The approach may display a five-section cluster in conjunction with a three-section head (exclusive left and right turn lanes). The five-section cluster should be placed over the center of the lane line separating the left turn lane(s) from the right turn lane(s). The three-section head should be placed over the other lane line to provide dual indication for the major movement.

Option #3: When the middle lane is a shared left and right turn lane, then a five-section cluster should be placed over the center of this lane and a three-section head placed over each of the other two lanes. Each head must contain green and yellow arrow indications in this situation.

Modification for Non-Conventional Projects:
Add the following sentence: (7) Coordinate requirements with the local maintaining agency.

NOTE:

(1) For all cases, the approach must display "dual indications". This means that there will be at least two heads with identical indications on the major approach. For example, if a green arrow is displayed on one head of the major movement or approach then a green arrow must be displayed on the second head.

(2) The same signal display option should be used throughout an urban area to provide consistency in display to the motorist.

(3) The use of advance and/or overhead lane use signs should be used as a supplement to pavement arrows on stems of signalized "T" intersections.

232.4 Controller Assemblies

The lateral offset requirements for signal poles and controller cabinets are given in ***FDM 215***. The final location of these devices must be based on the safety of the motorist, visibility of the signal heads, ADA requirements, and access by maintenance.

(1) Controller Timings:

The development of controller timings is a basic part of traffic signal design. Signal controller timing plans must be signed and sealed by a licensed Professional Engineer.

Traffic signal timings and settings are developed and designed for a specific intersection location. The settings must respond to all users at the intersection and meet objectives defined by the policies of the responsible Maintaining Agency.

Coordinate with the responsible Maintaining Agency to verify that traffic signal cabinets, controllers, assemblies, and standards are compatible with the agency's needs and are synchronized accordingly. The signal timings for the Yellow change and all red clearance intervals must be in accordance with the ***TEM***, ***Section 3.6***.

Traffic signal designs on state and local roadways must include initial timings of all controllers in the plans set. If the responsible agency decides to implement different timings than the ones in the plan set, it must insure they were prepared under the supervision of a licensed Professional Engineer.

(2) Future Intersection Expansion:

Any planned intersection improvements should be considered in the signal design. The controller type, cabinet type, and the number of load switches are examples of design features that may be affected by future intersection improvements. The signal design engineer must determine if the current design should include capabilities for future improvements.

(3) Upgrade of Existing Controller Assemblies:

Replace or expand existing controller assemblies when an upgrade is required. Minor expansions include the addition of load switches, new controller timings, or new controller unit provided the cabinet is properly wired. Major expansions include cabinet rewiring or any work requiring the removal of the cabinet back panel. Contact the District Traffic Operations Engineer before making the decision to expand or replace an existing controller assembly.

232.5 Vehicle Detection

Detection technology types commonly used with signal design include inductive loops installed in pavement and video (camera) or microwave sensors mounted on the pole or mast arm supports. Inductive loop detection is generally used with asphalt pavement, and video detection with concrete pavement or bridge structures. Coordinate with the District Transportation Systems Management and Operations (TSM&O) Engineer to determine the preferred detection technology that will serve the needs of the District and maintaining agency.

(1) Inductive Loop Detection:

The traffic signal design is to identify the placement of loops for each intersection. Vehicle detection loops are detailed in the ***Standard Plans, Index 660-001*** and are suitable for most locations. ***Index 600-001*** allows for minor modifications in size and placement of the loops when required by site conditions.

(2) Video Vehicle Detection System (VVDS):

VVDS uses a camera to detect vehicle presence. The traffic signal design is to identify the placement of cameras for each intersection.

(3) Microwave Vehicle Detection System (MVDS):

MVDS uses an FCC-certified, low-power microwave radar signal (sensors) to detect vehicle presence within a detection zone. These systems establish wired or cellular communication with the agency responsible for system operation and maintenance. This allows for remote configuration and monitoring.

232.6 Pedestrian Detection and Control Signal

The standard for detecting the presence of a pedestrian is the Pedestrian Pushbutton Detector. Pedestrian detector assemblies and pedestrian control signals are detailed in the ***Standard Plans, Index 653-001*** and ***Index 665-001***. Pedestrian detection systems are listed on the Department's Approved Product List (***APL***).

Use the countdown pedestrian signal assembly on projects that include pedestrian-controlled signal installations. Refer to the ***TEM, Chapter 3***, for additional information on pedestrian signal installation and operation.

Orient pushbutton with the face parallel to the crosswalk to be used (i.e. parallel to the crossing direction). See ***Standard Plans***, ***Index 665-001*** for additional orientation guidance.

232.6.1 Accessible Pedestrian Signal Feature

Where pedestrian facilities are provided, include provisions (e.g., conduit, conductors, signal cables) needed for future use of Accessible Pedestrian Signal (APS) devices on all new and reconstructed signalized intersections and signalized midblock crossing locations.

See ***TEM 3.7*** for installation and operation criteria of Accessible Pedestrian Signals on the State Highway System.

232.7 Signal Preemption

Determine if there is a requirement for signal preemption, e.g., close proximity to fire station or railroad crossing. Refer to the ***FDOT Procedure for Signalization Pre-Emption Design Standards (FDOT Procedure 750-030-002)*** for additional information on the conditions for which preemption is required or should be considered. Coordinate all signal preemption requirements with the local maintaining agency.

232.8 Mast Arm Supports

Utilize an underground communication cable infrastructure for those signals operating as part of an advanced traffic management system on these designated corridors.

Orient mast arm signal structures approximately 90° to approach traffic, i.e., mast arms diagonal to traffic are not allowed.

Signs on mast arms will be restricted to required regulatory and street name signs.

232.8.1 Mast Arm Policy

Provide mast arms in accordance with the following criteria for new signals installed on the State Highway System:

(1) Intersections within the Mast Arm Boundary Map, as defined by the State Traffic Engineering Office Implementation Guidelines (aka mast arm policy area):

Signals are to be supported by galvanized mast arms, with the signal head(s) rigidly attached to the mast arm. When it is impractical to use a mast arm or overhead rigid structure within the Mast Arm Boundary Map, a two point span wire assembly with adjustable hangers must be used and a Design Variation must be approved in accordance with ***FDM 122***. The Department will install and maintain mast arm installations only with galvanized finish. If the Local Maintaining Agency wants a painted finish, see coating requirements for ancillary structures in ***FDM 261.1***.

Modification for Non-Conventional Projects:
Delete the last three sentences of the above paragraph and see RFP for requirements.

(2) Signalized Intersections outside the Mast Arm Boundary Map:

Signals along all corridors outside the Mast Arm Boundary Map must be supported by two-point span wire assemblies with adjustable hangers. If the Local Maintaining Agency prefers a mast arm, they must provide funding for the increase in construction cost., and if the requested mast arm is to be painted, see coating requirements for ancillary structures in ***FDM 261.1***.

Modification for Non-Conventional Projects:
Delete the last sentence of the above paragraph and see RFP for requirements.

232.9 Span Wire Assemblies

Use either perpendicular spans, box spans or drop box spans for all traffic signal span wire assemblies. Signs on span wires will be restricted to required regulatory signs.

Diagonal span assemblies may be used for flashing beacon installations. A Design Variation is required for any other diagonal installation. The Design Variation must be signed by both the District Design Engineer and the District Traffic Operations Engineer.

232.10 Traffic Signal Project Coordination

Coordination with other offices and agencies is an important aspect of project design. The offices discussed in this section are normally involved in signal projects, however there may be others.

Roadway Design – Typically, the designer of a signal project receives the base sheets for design and any required cross sections from the roadway designer. Base sheets may be created from existing plans when the signal project is not part of an active roadway design project.

Utilities - The District Utilities Engineer provides the coordination between the designer and the various utilities that may be involved in the project. The Utilities Section may assist in identifying or verifying conflicts with overhead and underground utilities. The designer should coordinate with the utility company providing power on the preferred location for the electrical service.

Structures Design - The Structures Engineer of Record provides the design of the traffic signal mast arms and strain poles, including the design of the foundation. The Structures Engineer of Record should be contacted early in the design phase to allow adequate time for coordination with the Geotechnical Engineer in obtaining the necessary soils information.

Coordinate locations and attachments of traffic signals and conduits on bridge structures with the bridge structural designer. Include traffic signal and conduit locations and attachment details in the plans. Refer to the ***Structures Design Guidelines*** for details and restrictions related to bridge attachments.

Pedestrian and Bicycle Coordinator - The District Bicycle and Pedestrian Coordinator should be consulted to assure that all potential pedestrian and bicyclist concerns have been considered.

232.11 Traffic Signal System Power Design

Traffic signal systems typically operate at 120 volts alternating current (AC) from the commercial utility service provider. Refer to ***Section 233.3*** for power source design considerations. The following subsections describe the power calculations at the traffic signal intersection.

232.11.1 Power Load Requirements

The total power requirement for any traffic signal system site is the sum of the power of all components within the cabinet as well as all the components outside of the cabinet.

Assume all equipment is in continuous operation.

232.11.2 Voltage Drop

Perform voltage drop calculations for the following conductors.

(1) Conductors from the utility service provider meter to the traffic signal cabinet:

- (a) Measure the distance between the meter and the traffic signal cabinet.
- (b) Determine the conductor size for a maximum of 5% voltage drop.
- (c) Voltage drop mitigation strategies may include use of larger conductors or higher service voltage.
- (d) Minimum conductor size is 6 American Wire Gauge (AWG).

(2) Conductors from the traffic signal cabinet to the traffic signal head:

- (a) Measure the distance between the traffic signal cabinet and the farthest traffic signal head.
- (b) Determine the conductor size for a maximum of 5% voltage drop.
- (c) Voltage drop mitigation strategies may include the use of larger conductors.
- (d) Minimum conductor size is 14 AWG.

Perform traffic signal system electrical design in accordance with the ***National Electric Code (NEC)*** for traffic signal system equipment electrical designs, including voltage drop calculations, load requirements, electrical device sizing and grounding.