

Chapter 7

Traffic and ITS Design

7.1	General	7-1
7.2	Signing and/or Pavement Marking	7-2
7.2.1	Design Criteria	7-2
7.2.2	Wind Loading Criteria - Signs	7-3
7.2.3	No-passing Zones	7-4
7.2.4	Use of Local Street Names on Guide Signs.....	7-4
7.2.5	Signing and Pavement Marking Project Coordination.....	7-5
7.2.6	Foundation Criteria	7-5
7.2.7	Signing for Bridges with Steel Decks	7-5
7.3	Lighting.....	7-6
7.3.1	Design Criteria	7-6
7.3.2	Pole Design Criteria	7-7
7.3.2.1	General	7-7
7.3.2.2	Standard Aluminum Light Poles.....	7-7
7.3.3	Foundations Criteria.....	7-8
7.3.4	Wind Loading Criteria - Lighting.....	7-8
7.3.5	Lighting Project Coordination	7-8
7.3.6	Voltage Drop Criteria	7-9
7.3.7	Maintenance of Existing Lighting During Construction.....	7-9
7.3.8	Grounding	7-10
7.4	Traffic Signals	7-11
7.4.1	Design Criteria	7-11

7.4.2	Certification and Specialty Items.....	7-12
7.4.3	Stop Line Location	7-12
7.4.4	Controller Assemblies	7-13
7.4.5	Left Turn Treatments	7-13
7.4.6	Signal Preemption.....	7-15
7.4.7	Intersection Design - Lane Configuration.....	7-16
7.4.8	Signal Loops	7-19
7.4.9	Grounding and Electrical Bonding	7-19
7.4.10	Wind Loading - Traffic Signals	7-19
7.4.11	Foundation Criteria	7-20
7.4.12	Mast Arm and Monotube Supports	7-20
	7.4.12.1 Mast Arm Supports	7-20
	7.4.12.2 Standard Monotube Signal Structures	7-22
7.4.13	Traffic Signal Project Coordination.....	7-23
7.4.14	LED Light Sources	7-24
7.4.15	Pedestrian Countdown Signal Applications	7-24
7.5	Intelligent Transportation System (ITS) Components	7-25
7.5.1	Design Criteria	7-25
7.5.2	ITS Device Approval and Compatibility.....	7-26
7.5.3	Required Information	7-27
7.5.4	Motorist Information Systems.....	7-27
	7.5.4.1 Dynamic Message Sign (DMS).....	7-27
7.5.5	Video Equipment.....	7-28
	7.5.5.1 Closed-circuit Television Cameras	7-28
7.5.6	Infrastructure	7-30
	7.5.6.1 Grounding and Transient Voltage Surge Suppression	7-30
7.6	Foundation Design	7-31

Tables

Table 7.2.1.1	Number of Luminaires for Various Sign Widths	7-3
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Chapter 7

Traffic and ITS Design

7.1 General

Traffic control devices and intelligent transportation system (ITS) deployments are necessary to help ensure highway safety by providing the orderly and predictable movement of all traffic, motorized and nonmotorized, throughout the highway transportation system, and to provide such guidance and warnings as are needed to ensure the safe and informed operation of individual elements of the traffic stream. The design and layout of signs, signals, pavement marking and lighting should complement the basic highway design.

7.2 Signing and/or Pavement Marking

The designer responsible for a signing and/or pavement marking project should be aware that the design must comply with various standards. In addition to Department Standard Specifications, the following standards should be consulted:

Manual on Uniform Traffic Control Devices (MUTCD) - The **MUTCD** was adopted by the Department as the uniform system of traffic control for use on the streets and highways of the State. This action was in compliance with **Chapter 316.0745** of the **Florida Statutes**. The **MUTCD** is therefore the basic guide for signing and marking. The requirements of the **MUTCD** must be met, as a minimum, on all roads in the State.

Standard Highway Signs, FHWA - This manual contains detailed drawings of all standard highway signs. Each sign is identified by a unique designation. Signs not included in this manual or in the **Design Standards** must be detailed in the plans.

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, AASHTO and **Structures Design Guidelines, FDOT** - These documents provide structural design criteria.

Design Standards - These standards are composed of a number of standard drawings or indexes that address specific situations that occur on a large majority of construction projects.

Manual on Uniform Traffic Studies (MUTS) - This is a Department publication containing documentation for several types of traffic studies. This manual provides a systematic data collection procedure for the studies described.

Traffic Engineering Manual - This Department publication provides traffic engineering standards and guidelines to be used on the State Highway System.

7.2.1 Design Criteria

The **MUTCD** and the **Design Standards** should be consulted for sign location. All signs not bridge or barrier wall mounted and installed within the clear recovery zone, must be frangible or protected by an approved barrier. **Chapter 4, Roadside Safety** of this volume, contains detailed instructions on safety design.

Post sizes for single column signs are covered in the **Design Standards**. The supports for multipost signs are not in that reference and must be included in the plans. The designer must provide post sizes and length for each multipost sign. The Structures Design Office has written a program for personal computers that calculates post sizes and length for multipost signs. This program may be used for these calculations.

The design for all overhead sign structures and foundations shall be included in the plans. Refer to **Section 7.5, Foundation Design**, and **Chapter 29** of this volume for more information.

When specified, signs will be illuminated with 175 watt mercury vapor Deluxe White Lamps. The following table gives the number of luminaires for various sign widths. See the **Design Standards, Index 17505** for spacing details and mounting location.

Table 7.2.1.1 Number of Luminaires for Various Sign Widths

Sign Width (ft.)	To 10	To 21	To 32	To 43
Luminaires	1	2	3	4

7.2.2 Wind Loading Criteria - Signs

The wind loadings given below are based on the **AASHTO Standard Specification For Structural Supports for Highway Signs, Luminaires and Traffic Signals**. The Counties are listed by wind loading for the appropriate sign type.

GROUND SIGNS:

- 60 mph Alachua, Baker, Bradford, Calhoun, Clay, Columbia, Gadsden, Gilchrist, Hamilton, Holmes, Lafayette, Lake, Leon, Liberty, Jackson, Jefferson, Madison, Marion, Putnam, Sumter, Suwannee, Union, Washington
- 70 mph Bay, Citrus, DeSoto, Dixie, Duval, Escambia, Flagler, Franklin, Glades, Gulf, Hardee, Hendry, Hernando, Highlands, Hillsborough, Levy, Nassau, Okaloosa, Okeechobee, Orange, Osceola, Pasco, Pinellas, Polk, Santa Rosa, Seminole, St. Johns, Taylor, Wakulla, Walton
- 80 mph Brevard, Charlotte, Collier, Indian River, Lee, Manatee, Martin, Palm Beach, Sarasota, St. Lucie, Volusia
- 90 mph Broward, Miami-Dade, Monroe

OVERHEAD SIGNS: See **Chapter 29** of this volume.

7.2.3 No-passing Zones

The procedures required by the Department for determining the limits of no-passing zones are contained in the ***Manual on Uniform Traffic Studies, (MUTS)***. The requirements of this manual must be followed.

Limits of pavement markings for no-passing zones shall be established by one of the following methods:

1. On projects where existing roadway conditions (vertical and horizontal alignments) are to remain unaltered by construction, the no-passing zones study shall be accomplished as part of the design phase. This will be either by in-house staff or included in design consultant contracts.

The limits of the no-passing zones shall be included in the contract documents, and a note to this effect shown on the plans.

2. On projects with new or altered vertical and horizontal alignments, limits for no-passing zones shall be established during construction. The required traffic study and field determination of limits shall be performed through the design consultant as a post design service, or as part of a districtwide consultant contract for such services.

When this service is included as part of post design services, sufficient time shall be included to accomplish the required field operations without delaying or interfering with the construction process.

7.2.4 Use of Local Street Names on Guide Signs

The normal practice is to use route numbers on guide signs to designate roadways. In some areas, the local names for certain roadways are more familiar than the route number. For this situation, the local street name may be used. However, some roadways are known by more than one name as well as the route number. In many instances, the existing sign panel is not large enough to accommodate the street name and would require a new panel.

For these reasons, the decision to use local names on guide signs must be evaluated on a case-by-case basis. It is recommended that the District Traffic Operations Engineer be contacted for input in these decisions.

7.2.5 Signing and Pavement Marking Project Coordination

Coordination with other offices and other agencies is a very important aspect of project design. The offices discussed in this section are not intended to be an all inclusive list with which the designer should coordinate, but are those that are typically involved in a signing and marking project.

Roadway Design - The designer of a signing and pavement marking project receives the base sheets for design from the roadway designer, who can also provide any required cross sections. If the signing project is not an active roadway design project, base sheets may be obtained from existing plans.

Utilities - The District Utilities Engineer provides the coordination between the designer and the various utilities involved in the project. The Utilities Section can also identify potential conflicts with overhead and underground utilities or verify those which have previously been identified. The District Utilities Engineer should be contacted as early in the design phase as possible.

Structures Design - The Engineer of Record for Structures Design provides the design of the sign structures for overhead cantilever and overhead truss sign assemblies. This includes the design of the foundation for these structures. The Engineer of Record must be contacted early in the design phase to allow adequate time for coordination with the Geotechnical Engineer in obtaining the necessary soils information.

Right of Way – The State Motorist Information Services Administrator must be contacted on any projects that may impact Interstate Logo Signs. See **Section 13.5.4** for requirements and additional information.

7.2.6 Foundation Criteria

Refer to **Section 7.5, Foundation Design**, for geotechnical requirements.

7.2.7 Signing for Bridges with Steel Decks

Slippery When Wet Signs (W8-5) shall be placed in advance of all movable and non-movable bridges with steel decks. Refer to **Section 2.1** of the **Traffic Engineering Manual (Topic No. 750-000-005)**. This also applies to temporary bridges.

7.3 Lighting

The designer responsible for a highway lighting project should be aware that the design must comply with various standards. In addition to the Department's Standard Specifications, the following standards should be consulted:

An Information Guide for Roadway Lighting, AASHTO - This is the basic guide for highway lighting. It includes information on warranting conditions and design criteria.

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, AASHTO - This specification contains the strength requirements of the poles and bracket arms for the various wind loadings in Florida as well as the frangibility requirements. All luminaire supports, poles and bracket arms must be in compliance with these specifications.

Design Standards - These indexes are composed of a number of standard drawings or indexes which address specific situations that occur on a large majority of construction projects.

7.3.1 Design Criteria

The ***AASHTO Guide for Roadway Lighting*** permits either the illuminance technique or the luminance technique to be used in the design of highway lighting. The luminance technique requires a more complex design process and knowledge of the reflective characteristics of the pavement surface used. These reflective characteristics change as the pavement ages and with variations in weather conditions. The Department has elected to use the illuminance technique for lighting design. The design values for light levels given by the ***AASHTO Guide for Roadway Lighting*** are maintained values. The light levels given in this criteria have been adjusted and are listed as average initial foot candle. This, in effect, sets the maintenance factor to be used in the calculation process to a value of 1.

Mounting height (M.H.) for conventional lighting is the vertical distance from the roadway to the light source, regardless of lateral placement of the pole. Pole setback is the horizontal distance from the edge of the travel lane to the pole.

Refer to ***Chapter 29*** of this volume for more information.

7.3.2 Pole Design Criteria

7.3.2.1 General

Chapter 2 of this volume specifies the minimum horizontal clearances for light poles. High mast lighting poles should not be located in gore areas within the runout length as defined in the **AASHTO Roadside Design Guide**. Engineering judgment should be used when locating high mast poles adjacent to bridges and high fills. All conventional height poles shall be frangible unless bridge or barrier wall mounted.

Frangible pole installations shall not be used in areas of heavy pedestrian traffic where the hazard of a falling pole is a greater hazard to others than it is to the motorist. See the **Design Standards** for frangibility requirements.

The installation of lighting in certain locations (e.g., adjacent to residential areas) may require the luminaires to be shielded. This is especially true for high mast poles.

Poles on bridges over open bodies of water or on causeway sections should be considered for dampers. These poles are subject to sustained winds of a critical velocity that may induce vibrations in the pole.

7.3.2.2 Standard Aluminum Light Poles

The Department has developed an aluminum light pole standard for Conventional Lighting. The standard provides details for 40, 45 and 50 foot luminaire mounting heights on poles mounted either at grade or on fills up to 25 feet in height, all of which accommodate fixture arm lengths of 8, 10, 12 and 15 feet. Pole, arm and foundation details have been developed for each combination of arm length and for 5 foot increments of luminaire wind design height. Standard Aluminum Light Poles have been designed for 80 and 100mph design wind speeds.

The manufacturer of the Standard Aluminum Light Poles will be pre-approved by the Department and added to the Qualified Products List (QPL). When the standard assemblies are used, neither design details in the plans nor Shop Drawing submittals are required. Special designs, for those locations where the Standard Aluminum Light Poles are not appropriate, will require the pole Fabricator's complete Shop Drawings and the Specialty Engineer's sealed calculations, all submitted as Shop Drawings in accordance with **Section 5** of the **Standard Specifications for Road and Bridge Construction**.

7.3.3 Foundations Criteria

Refer to **Section 7.5, Foundation Design**, for geotechnical requirements and **Chapter 29** of this volume for additional design information.

7.3.4 Wind Loading Criteria - Lighting

See **Chapter 29** of this volume.

7.3.5 Lighting Project Coordination

Coordination with other offices and other agencies is a very important aspect of project design. The offices discussed in this section are not intended to be an all inclusive list with which the designer should coordinate; instead it includes offices that are normally involved in projects.

Roadway Design - Normally the designer of a lighting project receives the base sheets for lighting design from the roadway designer. The roadway designer can also provide any required cross sections. If the lighting project is not an active roadway design project, base sheets may be obtained from existing plans.

Utilities - The District Utilities Engineer provides the coordination between the designer and the various utilities involved in the project. This usually is limited to agreements with the power company for electrical service. The Utilities Section can also identify potential conflicts with overhead and underground utilities or verify those which have previously been identified.

The Utilities Engineer should be contacted as soon as pole locations are set and the electrical load has been determined. The designer should indicate a preferred location for the electrical service.

Drainage - When the locations of high mast poles are established, they should be checked with the Drainage Section to determine if high water level is a problem. High mast poles are often located in the center of interchange loops. These same areas may be used as drainage retention areas. Coordination with the Drainage Section will alleviate this type problem.

Structures Design - Conventional height poles require the standard base shown in the *Design Standards* and *Standard Specifications*. A foundation design is only required in special cases. High mast poles, on the other hand, require foundation designs for each location. Soil bores are required for this design. The Engineer of Record for Structures Design provides the foundation design for high mast poles. He or she must be contacted early in the design phase to allow adequate time for coordination with the Geotechnical Engineer in obtaining necessary soils information.

Chapter 14-64 of the *Department Rules* established the maintenance responsibility of lighting systems not on limited access or toll facilities as a local government function.

Normally the District Traffic Operations Engineer in conjunction with the District Utilities Engineer obtains the required maintenance agreements. The designer should coordinate with these offices to ensure that this activity is either underway or scheduled.

Any lighting project, especially high mast, adjacent to or in the vicinity of an airport, may be a potential problem. Any lighting project within 3 miles of an airport should be discussed with the Office of Public Transportation, Aviation Office to determine if a problem exists.

7.3.6 Voltage Drop Criteria

When determining conductor sizes for lighting circuits, the maximum allowable voltage drop from the service point on any one circuit is 7%.

7.3.7 Maintenance of Existing Lighting During Construction

The maintenance of existing lighting shall be the responsibility of the contractor only if the lighting is affected by the construction. The contractor should not be expected to replace lamps and pole knockdowns or to repair wiring if these problems are not caused by the construction work. As an example, a milling and resurfacing project should have no effect on the roadway lighting and the contractor should not be responsible for the maintenance of the lighting system.

The plans should specify the scope of the contractor's responsibility for the maintenance of existing lighting.

7.3.8 Grounding

The grounding requirements for lighting systems shall be as follows:

1. Install 20' of ground rod at each conventional height light pole and at each pull box.
2. Install 40' of ground rod at each electrical service point.
3. At each high mast pole, install an array of 6 ground rods 20' in length, as shown in the ***Design Standards, Index 17502***.

This information is covered in the ***Design Standards***. The above lengths of ground rod will be installed at each pole, pull box and service point, and the cost will be incidental to the unit or assembly being installed.

7.4 Traffic Signals

The designer responsible for a traffic signal project should be aware that the design must comply with various standards. In addition to the Department's **Standard Specifications**, the following standards should be consulted:

Manual on Uniform Traffic Control Devices (MUTCD), FHWA - The **MUTCD** was adopted by the Department as the uniform system of traffic control for use on the streets and highways of the State. The action was in compliance with **Chapter 316.0745** of the **Florida Statutes**. The **MUTCD** is therefore the basic guide for traffic signals. The requirements of the **MUTCD** must be met, as a minimum, on all roads in the State.

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, AASHTO and **Chapter 29** of this volume - These documents provide structural design criteria.

Design Standards - These standards are composed of a number of standard drawings or indexes which address specific situations that occur on a large majority of constructions.

Traffic Engineering Manual – This Department publication provides traffic engineering standards and guidelines to be used on the State Highway System.

7.4.1 Design Criteria

The design of traffic signal mast arms and foundations shall be included in the plans. Refer to **Section 7.5, Foundation Design**, and **Chapter 29** of this volume for more information.

The horizontal clearance requirements for signal poles and controller cabinets are given in **Chapters 2** and **25** of this volume. Final location of these devices should be based on safety of the motorist, visibility of the signal heads, ADA requirements, and access by maintenance. When these clearances cannot be met with standard mast arm designs, alternatives and special designs must be coordinated with the District Design Engineer.

The **MUTCD**, as noted above, has been adopted as the uniform system of traffic control for use on the streets and highways of the state. The **MUTCD** is the basic guide for traffic signal design; therefore, the traffic signal designer should be familiar with this document. The criteria in the following sections supplement the **MUTCD**.

7.4.2 Certification and Specialty Items

Traffic signal equipment installed in Florida is required to be certified by the Department. The Office of Traffic Engineering in the Central Office is charged with the responsibility of certifying traffic control equipment. The designer of a traffic signal project, if requiring new equipment types or types not normally used, should contact Traffic Engineering in Tallahassee to determine the certification status of the equipment. Noncertified equipment cannot be used.

Standard Specifications have not been developed for all signal equipment. Some items are project dependent and the development of standard specifications is difficult. Specifications for these items must be developed on a project by project basis and included in the contract as a special provision. Some of these specialty items are included on the Department's approved products list. For these items, detailed specifications are not required. The Office of Traffic Engineering should be consulted on these items.

7.4.3 Stop Line Location

A stop line that is not properly located invites violation by the motorist. The **MUTCD** specifies the minimum and maximum distances from the signal head to the stop line for adequate visibility. The traffic signal designer must insure that this requirement is met.

Instead of relocating the signal heads, the stop lines at many intersections have been moved from their proper location to comply with these requirements. The tendency for the motorist is not to stop at the new stop line location, but rather to creep beyond the stop line. This could in some cases result in valid calls being dropped, thereby increasing delay and decreasing the overall efficiency of the intersection.

The first step in the design process should be to locate crosswalks and stop lines properly. Then the signal head location should be determined to meet the **MUTCD** requirements. This may require changing the mounting configuration. A box span, for example, may be required where a diagonal span would normally be installed.

7.4.4 Controller Assemblies

Controller Timings: The development of controller timings is a basic part of traffic signal design. A recent ruling from the Board of Professional Engineers stated that the development of timings is considered engineering and therefore requires the signature and seal of a professional engineer.

All traffic signal designs prepared for or by the Department shall include initial timings of all controllers. This is also true for signals to be included in local systems. If the timings in the plans are not implemented, it will be the responsibility of the agency providing the timings to insure they were prepared under the supervision of a professional engineer.

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. It is the responsibility of the signal design engineer to determine if the current design should include capabilities for future improvements.

Upgrade of Existing Controller Assemblies: For projects requiring an upgrade to an existing controller assembly, the assembly may either be expanded or replaced. Minor expansions include the addition of load switches, new controller timings, and/or new controller unit if the cabinet is properly wired. These may be made in the field; therefore, expansion is the logical choice. On the other hand, major expansions include cabinet rewiring or any work requiring the removal of the cabinet back panel. Major expansions shall not be made in the field and replacement of the assembly is required. The designer may wish to contact the District Traffic Operations Engineer before making the decision to expand or replace an existing controller assembly.

7.4.5 Left Turn Treatments

The guidelines given below should be followed when determining signal treatments for left turns.

1. Single Turn Lane
 - a. Restrictive/Permissive Phasing - A five-section cluster should be used for this location. The head 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.

- b. Restrictive 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 - Only restrictive phasing should be used. Permissive movements should not be allowed for dual turn lanes. 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 thru movement.
3. Separated Turn and Thru Lanes - Turn lanes that are separated from the thru lanes more than 12 ft. by a raised or painted island shall not be operated in the permissive mode.
4. Single Lane Approach on Stem of "T" - Two three-section heads are required as minimum. All indications must be circular in this situation.
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 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.

NOTE:

1. For all cases, the approach shall display "dual indications". This means that there must 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.

7.4.6 Signal Preemption

The engineer responsible for the design of a traffic signal project shall, as a matter of routine, check each intersection to determine if the need for signal preemption is present.

Intersections located in accordance with [Department Procedure 750-030-002](#) should be considered for preemption. Department signalization projects may also include preemption or priority systems for emergency vehicles or mass transit vehicles.

Refer to [Department Procedure 750-030-002, Signalization Preemption Design Standards](#), for more information.

7.4.7 Intersection Design - 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.

The results are dependent upon the traffic volumes used in the analysis. The traffic used for this calculation shall be the design hourly volume based on the 30th highest hour (K factor) and not a peak to daily (P/D) ratio based on a 24-hour count. The K factor volumes account for traffic variations through the year, and, in most cases, are higher than P/D volumes.

The K, D, and T factors convert the two-way AADT volumes to a one-way Design Hourly Volume (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. These percentages should then be applied to the DHV for each approach volume to determine the turning volumes that should be used for the turn lane design calculations. These values should be compared to the movement counts supplied by Planning and the greater of the two values used for the design of turn lanes. The District Planning Office should be contacted 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 the ***Design Standards, Index 301*** to the extent practical. The available queue length provided should be based on a traffic study.

The important factors that determine the length needed for 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**, 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.

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).

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7.4.8 Signal Loops

Traffic signal loops are detailed in the *Design Standards, Index 17781*. These loops are standard and will be appropriate for most locations.

The traffic signals for each intersection should be individually designed. The requirement for type and placement of loops is a part of this design. The above standard allows for some variation in size and placement of the standard loops. These modifications are intended to be used only when required by the design of a particular location.

7.4.9 Grounding and Electrical Bonding

The grounding requirements for traffic signal components shall be as follows:

1. Install 20' of ground rod at each signal pole, mast arm, pedestrian signal, etc. and at each pull box.
2. Install 40' of ground rod at each electrical service and controller cabinet.

This information is covered in the *Design Standards* and specifications. The above lengths of ground rod will be installed at each component, and the cost will be incidental to the unit or assembly being installed.

The designer will not be required to add plan notes or develop quantities for ground rods and the use of the 620 pay item number for grounding electrode will not be required on the plans.

Design Standards, Index 17736 requires a bond wire connecting all poles, controllers, mast arms and pedestrian signal pedestals. This conductor is incidental to the cost of the signal installation.

7.4.10 Wind Loading - Traffic Signals

See *Chapter 29* of this volume.

7.4.11 Foundation Criteria

Refer to **Section 7.5, Foundation Design**, for geotechnical requirements.

7.4.12 Mast Arm and Monotube Supports

7.4.12.1 Mast Arm Supports

All new signals installed on the State Highway System that meet any of the following criteria (considered the mast arm policy area):

1. along designated coastal evacuation routes;
2. along the Strategic Intermodal System routes; or
3. along corridors within the approximate ten mile coastline boundary defined by the State Traffic Engineering Office Implementation Guidelines

shall be supported by mast arms with the signal head(s) rigidly attached to the mast arm. A span wire assembly may be used within this mast arm policy area only when it is impractical to use a mast arm or overhead rigid structure and a Design Variation has been approved in accordance with **Chapter 23** of this volume.

Mast arm signal supports or other types of rigid supports outside the mast arm policy area must be carefully considered before inclusion in a project. The districts have the flexibility to provide the total funding if funding is available. If funding is not sufficient, mast arm signal supports or other types of rigid supports outside the mast arm policy area can be installed by the Department with Maintaining Agency providing the funding for the cost difference between the proposed supports and strain pole supports typically installed by the Department.

In addition, an underground communication cable infrastructure shall be utilized for those signals operating as part of an advanced traffic management system on these designated corridors.

The signal support system used for signals located outside the mast arm policy area shall be selected after consideration of appropriate site conditions, design requirements and cost.

The Structures Design Office has developed a Traffic Signal Mast Arm Standard. The

standard includes single arm designs, with and without luminaires and double arm designs without luminaires. The standard designs include both 90 and 110 mph design wind speeds. A foundation and base plate design has been developed for each pole type.

The manufacturer of the standard mast arms will be pre-approved by the Department and added to the Qualified Products List (QPL). When the standard assemblies are used, design details in the plans or shop drawing submittals will not be required. Special designs, for those locations where the standard design is not appropriate, will require complete design details for the pole, arm and foundation to be included in the plans, and will require shop drawings.

Mast arm design will require close coordination between the signal designer and the Structures Office. If standard designs are utilized, the Structures Engineer shall review applicability of structural parts with site conditions. Early coordination is important.

The Signal Designer will provide the Structures Office a copy of the mast arm tabulation sheet that includes the following information:

1. The pole and arm locations
2. Elevations and offsets
3. Signal and sign sizes and locations on the mast arm

The Structures Office will analyze the data and determine the standard pole and arm configuration required, and complete the "Standard Mast Arm Assemblies Data Table" (Structures CADD cell table) for the plans. If a special design is required the Structures Office will provide the complete design details for the special mast arm assembly. A special design will require additional design time for either the Department or Consultant Structures Office. As noted above, the standard includes a foundation design for each pole. These designs were based on assumed soil conditions. The Structures Office will verify the project soil conditions to ensure the standard foundations are adequate. A special design will be developed if required.

The engineer responsible for signal design will seal the mast arm tabulation sheet and the Structures Design Engineer will seal the structures data table and special design details if required for the plans.

Refer to **Volume II, Chapter 24** for instructions on the mast arm tabulation sheet.

7.4.12.2 Standard Monotube Signal Structures

A single monotube span may be used in lieu of conventional mast arm or span wire signal structures at intersections where right of way, aesthetics or required Mast Arm lengths may be of concern, or where FDOT policy negates the use of Span Wire Assemblies.

The Standard Monotube Signal Structures include designs for four different span lengths and are applicable for mounting heights ranging from 19 to 23 feet, inclusive. A foundation and base plate design has been developed for each span length.

Manufacturers of Standard Monotube Signal Structures will be pre-approved by the Department and added to the Qualified Products List (QPL). When the standard assemblies are used, neither design details in the plans nor Shop Drawing submittals are required. Special designs, for those locations where the standard design cannot be utilized, will require complete design details for the poles, arm and foundations to be included in the plans, and will require shop drawings.

Monotube Signal Structure design requires close coordination between the signal designer and the structures engineer. The structures engineer must determine the applicability of the standard structural parts with the specific site conditions. Early coordination is important.

The signal designer will provide the structures office a copy of the signalization plans that will include the "Monotube Tabulation Sheet" that will itemize the following information:

1. Pole locations
2. Elevations and offsets
3. Signal and sign size and location on the Monotube Signal Structure

The structures engineer will analyze the data and determine which standard monotube configuration is required. As noted above, the standard includes a foundation design for each monotube signal structure. These designs were based on conservative, pre-assigned soil conditions. The structures engineer will verify the project soil conditions to ensure the standard foundations are adequate. A special foundation design, for the Standard Monotube Signal Structure, will need to be developed only in circumstances where poorer soil conditions are encountered.

7.4.13 Traffic Signal Project Coordination

Coordination with other offices and other agencies is a very important aspect of project design. The offices discussed in this section are not intended to be an all inclusive list with which the designer should coordinate, instead it includes offices that are normally involved in projects.

Roadway Design - Normally the designer of a signal project receives the base sheets for design from the roadway designer. The roadway designer can also provide any required cross sections. If the signal project is not an active roadway design project, base sheets may be obtained from existing plans.

Utilities - The District Utilities Engineer provides the coordination between the designer and the various utilities involved in the project. This usually is limited to agreements with the power company for electrical service. The Utilities Section can also identify potential conflicts with overhead and underground utilities or verify those that have previously been identified.

The Utilities Engineer should be contacted early in the design phase. The designer should indicate a preferred location for the electrical service.

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

Pedestrian Coordinator - The pedestrian coordinator should be consulted to be sure that all of the pedestrian concerns have been fully addressed.

7.4.14 LED Light Sources

The standard light source for signal indications has been the incandescent lamp. The Department is now adopting the Light Emitting Diode (LED) as the standard for the red indication. The yellow and green indications will continue to use the incandescent lamp. This will be the Department standard for traffic signals; however, if requested by the local maintaining agency and approved by the District Traffic Operations Engineer, the incandescent lamp may be used for all indications. For those situations where the standard arrangement is not used, the information should be shown on the plans and the pay item number will be coded as a special.

7.4.15 Pedestrian Countdown Signal Applications

Countdown pedestrian signal head devices are considered to be the Department's preferred installation on all projects that require pedestrian signal head devices. When these devices are proposed for use, the Department must coordinate with the local maintaining agency prior to installation. The Department's *Traffic Engineering Manual, Section 3.9*, contains specific criteria for their installation and operation.

7.5 Intelligent Transportation System (ITS) Components

Intelligent transportation system (ITS) designs utilize electronics, communications, or information processing systems singly or in combination to improve the efficiency and safety of a surface transportation system. ITS components are devices and subsystems that provide certain specialized functions within an ITS system. These devices are typically deployed to obtain information (including traffic data, video imagery, weather information, and other information relevant to roadway management) from field sites along Florida's Intrastate Highway System. This information is transmitted to transportation management centers (TMCs) and associated control facilities, where traffic managers use it to assess conditions, respond to incidents, and conduct other activities. ITS components also provide various means of disseminating travel-related information and alerts to motorists concerning traffic or weather conditions they may encounter.

The inclusion of new ITS design guidelines in this chapter will occur as statewide minimum specifications for ITS devices are finalized and adopted by the Department. Because this is an ongoing process, those individuals seeking the latest information on ITS device design requirements and specifications should contact the ITS Section in the Traffic Engineering and Operations Office.

The plans preparation information provided in this section applies to the placement and installation of ITS devices and systems along Florida's limited-access and non-limited-access corridors. ITS device requirements as adopted by the Department are published by the State Specifications Office and available online at the FDOT Web site. The ITS project designer is advised that plans involving ITS devices must also include provisions for grounding and surge suppression in order to protect ITS equipment and ensure human safety.

7.5.1 Design Criteria

ITS design criteria, in general, require that devices and systems be able to gather, analyze, and distribute accurate information to support the overall goal of improving roadway efficiency and safety. Designers must consider the strengths and limitations of various technologies for collecting, analyzing, and disseminating information, and select devices that are most appropriate for a specific application. Many ITS devices have specific placement and configuration requirements that must be met for the equipment to perform properly. Designers are strongly encouraged to familiarize themselves with the strengths and limitations of various devices and technologies prior to incorporating them into their designs. Other general considerations for ITS designs include promoting safety for road

users, monitoring traffic and travel conditions, supporting traffic management operations, providing equipment access for maintenance personnel, and disseminating the most useful information possible to motorists.

For vehicle detection systems, such as those utilizing video, microwave, magnetic field, or acoustic technologies, the designer should consult with the device manufacturers to ensure that placement and installation plans facilitate proper operation of a particular device type. Be aware of a technology's capabilities and limitations in a given location in order to create a design that is capable of achieving the required levels of detection accuracy.

The horizontal clearance requirements for poles, sign structures, field cabinets, and communication hubs for ITS deployments should conform to those provided in **Chapters 2** and **25** of this volume. Any deviation or alternative or special design must be coordinated with the District Design Engineer.

7.5.2 ITS Device Approval and Compatibility

ITS devices sold or installed in Florida are required to be evaluated by the Traffic Engineering and Operations Office's Traffic Engineering Research Laboratory (TERL) prior to their use on the state's highways. The evaluation of ITS devices by the TERL will occur as statewide minimum specifications for ITS devices are finalized and adopted by the Department. Designers should consult the FDOT Approved Product List (APL) for the device types requiring evaluation and the currently approved devices. If the designer wishes to utilize a new device type or a device not on the APL, they should contact the TERL in Tallahassee to determine the appropriate course of action. Non-approved equipment cannot be used.

Designs should ensure that ITS devices which share communications networks or provide related functions are compatible with each other and will not interfere with the operation of other devices or systems. In addition, designs should incorporate features and functions that allow interoperability with other ITS deployments throughout the state. Examples of general design characteristics that promote interoperability include:

1. Systems and products based on open architectures and standards.
2. Systems and products that are scalable and nonproprietary.
3. Compatibility with the Department's SunGuideSM Software System directly or via support of one or more of its related Interface Control Documents (ICDs).

7.5.3 Required Information

The basic information necessary for ITS plans includes device placement and installation requirements (including communication and power interconnect), roadway geometrics, street names, construction stationing or milepost information, right-of-way lines, location of underground utilities, and presence of other roadside features or existing devices that may impact ITS device locations in the field.

The requirements for a complete set of ITS project plans are found in **Chapter 29 of Volume 2**.

7.5.4 Motorist Information Systems

7.5.4.1 Dynamic Message Sign (DMS)

The DMS is an electronic sign capable of displaying more than one message, which is changeable manually, by remote control, or by automatic control. The DMS should be positioned and illuminated to be readable from the roadway. The DMS is intended primarily to advise approaching motorists of freeway conditions, such as road construction or a traffic incident ahead, so that they can take appropriate action. A DMS generally displays messages that can be selected or modified by electronic means from a TMC or other central command location. As such, system designs utilizing DMS must also include designs for a communication infrastructure that supports remote control of the sign from a central location.

The DMS and its support structure must meet the wind load requirements as specified in **Chapter 29** of this volume and comply with the AASHTO 1994 Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals (50-year reoccurrence).

Placement of a DMS should be determined by project-specific needs, as well as the following general design criteria:

1. Ability to communicate a meaningful message that can be read and comprehended by motorists within a brief time period (dictated by the sight distance characteristics of the location and the design features of the sign). This is also dependent upon the posted speed limit of the roadway.
2. Placement prior to freeway interchanges that offer alternate routes.

- a. In advance of 1-mile exit approach signing.
 - b. Maintain minimum 800-foot spacing between existing and planned overhead static sign panels and other signs, per the MUTCD.
 - c. Maintain minimum of 1450-foot distance from decision points (meets MUTCD/AASHTO Green Book requirements).
3. Placement in advance of high crash locations and traffic bottlenecks.
 4. Placement that accommodates access for service and maintenance.

The design should illustrate the location, placement, and typical details of the following DMS components:

1. DMS display.
2. DMS controller.
3. DMS support structures (includes external walkways, safety railings, ladders, etc.).
4. DMS mounting brackets and hardware.
5. Cabling, interconnect and related communication devices.
6. Grounding and transient voltage protection details.
7. Structure-mounted or ground-mounted cabinets for system electronics and interconnect.

The sign enclosure must be mounted with a minimum vertical clearance height as specified in **Table 2.10.4**.

7.5.5 Video Equipment

7.5.5.1 Closed-circuit Television Cameras

Closed-circuit television (CCTV) systems consist of roadside cameras, communication devices, as well as camera control and video display equipment at one or more remote monitoring locations that allow surveillance of roadway and traffic conditions

CCTV device placement and overall system design should be determined by project-specific needs, as well as the following general design criteria:

1. Strategically locate cameras to obtain a complete view of the freeway (keeping all ramps in mind) and to view the arterial traffic.

2. Camera location should provide the ability to view any nearby DMS for message verification.
3. A camera's location should provide the ability to view crossing features (i.e., streets, rail, waterways), as feasible.
4. Preference should be given to locating camera structures outside the clear zone whenever possible to alleviate the need for guardrail or other protective barriers.
5. Device placement that accommodates access for service and maintenance. For instance, the use of lowering devices to allow cameras to be lowered from the pole top to ground level for servicing with little to no disruption of traffic.

Designs and plans should consider and illustrate camera mounting height. Mounting height should be selected based upon project specific needs, as well as the following general design criteria:

1. Required viewing distance.
2. Roadway geometry and lane configuration.
3. Roadway classification (i.e., arterial or freeway).
4. Life-cycle cost, including maintenance impacts.
5. Environmental factors, such as glare from the horizon or from headlights.
6. Vertical clearance.

All camera housings, enclosures, lowering devices, and mounts must be designed to withstand sustained wind loads and gust factors according to **Chapter 29** of this volume.

CCTV camera poles should also be designed and installed according to the requirements of **Section 641, Prestressed Concrete Poles**, or **Section 649, Steel Strain Poles, Steel Mast Arms and Monotube Assemblies**, in the **FDOT Specifications**, and as depicted in **Index 17723** and **Index 17725** of the **Design Standards**.

Designs for support structures and foundations should be based on the **PPM** guidelines, the **Design Standards**, and on the **AASHTO LTS-4** standard with current addenda. The wind load requirements as specified in **Table 29.1** of this volume should also be used as design criteria for CCTV structures and their associated foundations.

7.5.6 Infrastructure

7.5.6.1 Grounding and Transient Voltage Surge Suppression

Effective grounding and surge suppression is generally achieved through a combination of three primary techniques: proper bonding and installation of grounding rods, use of air terminals, and the application of a transient voltage surge suppressor (TVSS). These three methods work in concert to protect ITS equipment installed in the field and should be incorporated, as applicable, in ITS designs and plans.

Designs and plans should consider existing geological and other physical characteristics at proposed installation locations that may affect the design or layout of grounding systems. Information such as locations of rock formations, buried utilities, gravel deposits, soil types and resistivity, and presence of groundwater should be considered when developing plans that include these systems. Any pertinent survey data gathered during plans development, such as soil resistivity measurements, should be noted on the plans.

Placement and layout of grounding arrays should be planned in such a way that grounding paths from the down cable to the primary electrode are as straight as possible. Where practical, plans should provide detail related to cable routing and other installation details required to maximize the efficiency of Grounding and TVSS.

Grounding and TVSS device placement and overall system design should be determined by project-specific needs, as well as these general design criteria:

1. Follow best practices defined in the NFPA 780 Standard for the Installation of Lightning Protection Systems.
2. Place TVSS equipment so that grounding connections are as short and straight as possible.
3. Cable routing should avoid excessive bending and provide physical separation between low-voltage and high-voltage signal paths.
4. Avoid routing unprotected or grounding wires parallel or adjacent to protected wiring.

7.6 Foundation Design

For foundations for standard conventional Roadway Lighting Poles, refer to the **Design Standards, Index 17515**. Refer to the **Design Standards, Index 17503** for foundations for non-standard conventional Roadway Lighting Poles. **Section 715** of the **Specifications** allows the screw type foundation as an alternate. The Geotechnical Engineer shall determine whether the soil characteristics meet the requirements of **Section 715**. If it is determined that the soil conditions do not allow the use of the screw type foundation as shown in **Section 715**, a note shall be added to the plans stating: "Use of the screw type foundation is not allowed on this project."

The **Design Standards, Index Nos. 17743 and 17745** include foundations for standard Mast Arm Assemblies, and **Index 17746** includes foundations for standard Monotube Signal Structure assemblies. Unique site circumstances may require the foundation variables to be modified from the foundations shown. If special designs are required, the Geotechnical Engineer shall provide the soil information to be used by the District Structures Design Engineer during the design phase of the project.

The foundation design and drawings where special foundations are required for locations where standard Mast Arm Assemblies and Standard Monotube Signal Structures are used and for overhead sign structures, high mast light poles, and traffic signal strain poles shall be the responsibility of the Structures Engineer of Record (EOR). The Geotechnical Engineer shall provide the EOR the following soils information (this information may be derived from the borings of other nearby structures or from roadway borings):

1. Soil Type
2. Effective Unit Weight of the Soil
3. Seasonal High Water Table Elevation
4. Effective Friction Angle of the Soil (if applicable)
5. Cohesion Value (if applicable)
6. Allowable Bearing Capacity (if applicable)

The above soils information shall be included in the plans. Additionally, Soil Boring Data Sheets shall be included in the plans, except for strain poles. This will provide the Contractor with the conditions for which the foundations were designed as compared to actual on-site conditions and establish criteria for any future analysis of the foundations.

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