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
7.2.8 Guidance on Use of Various Pavement Marking Materials 7-6
7.2.8.1 Maintenance of Traffic Applications....................7-6
7.2.8.2 Permanent Marking Applications 7-6

7.3 Lighting....................7-8
7.3.1 Design Criteria 7-8
7.3.2 Pole Design Criteria 7-11
7.3.2.1 General 7-11
7.3.2.2 Standard Aluminum Light Poles....................7-11
7.3.3 Foundations Criteria....................7-12
7.3.4 Wind Loading Criteria - Lighting....................7-12
7.3.5 Lighting Project Coordination....................7-12
7.3.6 Voltage Drop Criteria 7-13
7.3.7 Maintenance of Existing Lighting During Construction....................7-13

7.3.8 Grounding 7-14

7.4 Traffic Signals 7-15
7.4.1 Design Criteria 7-15
7.4.2 Certification and Specialty Items...............................7-16
7.4.3 Stop Line Location 7-16
7.4.4 Controller Assemblies 7-17
7.4.5 Left Turn Treatments 7-17
7.4.6 Signal Preemption...7-19
7.4.7 Intersection Design - Lane Configuration..................7-20
7.4.8 Signal Loops 7-23
7.4.9 Grounding and Electrical Bonding 7-23
7.4.10 Wind Loading - Traffic Signals 7-23
7.4.11 Foundation Criteria 7-24
7.4.12 Mast Arm Supports 7-24
7.4.13 Traffic Signal Project Coordination............................7-25
7.4.14 LED Light Sources 7-26
7.4.15 Pedestrian Countdown Signal Applications 7-26

7.5 Intelligent Transportation System (ITS) Components 7-27
7.5.1 Design Criteria 7-27
7.5.2 ITS Device Approval and Compatibility.....................7-28
7.5.3 Required Information 7-29
7.5.4 Motorist Information Systems...................................7-29
7.5.4.1 Dynamic Message Sign (DMS).................7-29
7.5.4.2 Highway Advisory Radio 7-30
7.5.5 Video Equipment...7-32
7.5.5.1 Closed-circuit Television Cameras 7-32
7.5.5.2 Video Display Equipment..........................7-33
7.5.6 Network Devices 7-33
7.5.6.1 Managed Field Ethernet Switch 7-34

7.5.6.2 Device Server 7-34
7.5.6.3 Digital Video Encoder and Decoder 7-34
7.5.7 Fiber Optic Cable and Interconnect 7-35
7.5.7.1 Fiber Optic Cable 7-35
7.5.7.2 Fiber Optic Conduit 7-35
7.5.7.3 Fiber Optic Splices and Terminations 7-36
7.5.7.4 Fiber Optic Cable Designating System 7-36
7.5.7.5 Fiber Optic Access Points 7-37
7.5.8 Infrastructure 7-38
7.5.8.1 Grounding and Transient Voltage Surge Suppression 7-38
7.5.8.2 ITS Pole and Lowering Device 7-38
7.5.8.3 ITS Field Cabinet 7-39
7.5.9 Vehicle Detection and Data Collection 7-39
7.5.9.1 Microwave Vehicle Detection System 7-40
7.5.9.2 Video Vehicle Detection System 7-40
7.5.9.3 Magnetic Traffic Detection System 7-40
7.5.9.4 Acoustic Vehicle Detection System 7-41

7.6 Foundation Design 7-43

Tables

Table 7.2.1 Number of Luminaires for Various Sign Widths 7-3
Table 7.3.1 Conventional Lighting - Roadways 7-9
Table 7.3.2 Highmast Lighting - Roadways 7-9
Table 7.3.3 Underdeck Lighting - Roadways 7-10
Table 7.3.4 Rest Area Lighting 7-10
Table 7.3.5 Mounting Height Restrictions 7-10

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.

AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals and ***FDOT*** **Structures Manual** - 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 7.6***, ***Foundation Design***, and ***Chapter 29*** of this volume for more information.

The type lamp for signs shall be specified in the plans. The following table gives the number of luminaires for various sign widths for 175 watt mercury vapor deluxe white lamps. See the ***Design Standards, Index 17505*** for spacing details and mounting location.

Table 7.2.1 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*** and ***FDOT Structures Manual.*** The Counties are listed by wind loading for the appropriate sign type.

110 mph Alachua, Baker, Bradford, Clay, Columbia, Gadsden, Gilchrist, Hamilton, Hardee, Jackson, Jefferson, Lafayette, Lake, Leon, Madison, Marion, Polk, Putnam, Sumter, Suwannee, and Union

130 mph Bay, Brevard, Calhoun, Charlotte, Citrus, DeSoto, Dixie, Duval, Flagler, Franklin, Glades, Gulf, Hendry, Hernando, Highlands, Hillsborough, Holmes, Lee, Levy, Liberty, Manatee, Nassau, Okaloosa, Okeechobee, Orange, Osceola, Pasco, Pinellas, Sarasota, Seminole, St. Johns, Taylor, Volusia, Wakulla, Walton, and Washington.

150 mph Broward, Collier, Miami-Dade, Escambia, Indian River, Martin, Monroe, Palm Beach, Santa Rosa, and St. Lucie

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 7.6***, ***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.

7.2.8 Guidance on Use of Various Pavement Marking Materials

The Engineer should consider several factors before selecting the pavement marking materials to be used during the Maintenance of Traffic Operations or in application of the permanent markings.

7.2.8.1 Maintenance of Traffic Applications

The factors which should be considered in a Maintenance of Traffic (MOT) should include:

1. How long do the markings need to last?
2. Will the markings need to be removed or will they be covered by an asphalt course?
3. Cost.
4. Traffic Volumes.

Paint is normally used in MOT operations and is appropriate for short term operations lasting for approximately six months. When a MOT operation lasts between six months to a year under moderate traffic volumes, a high-build paint or hot-spray thermoplastic marking should be considered. If a MOT operation lasts for more than a year under heavy traffic volumes a refurbishment thermoplastic should be considered.

7.2.8.2 Permanent Marking Applications

The factors which should be considered for permanent marking should include:

1. How long do the markings need to last?
2. What are the traffic volumes?
3. Type of Surface.
4. Does the marking need to meet special requirements (audible & vibratory, contrast, etc?)
5. Cost.
6. If it is a refurbishment marking, what is the thickness and condition of the existing markings?

Thermoplastic is Departments primary material to be used for the permanent markings on asphalt surfaces. When used in conjunction with RPM's on centerline application, it provides excellent wet night visibility and long term performance at a reasonable cost. When used in an edge line application, it provides moderate wet night visibility and long term performance at a reasonable cost.

On concrete pavements and bridge decks contrast markings shall be used. Options include thermoplastic, tapes and two-component reactive materials. On concrete surfaces tapes are normally used for only centerline applications and are the preferred alternative. Two-component reactive or thermoplastic materials are normally used for edge line applications in conjunction with tape.

For guidance on contrast, audible & vibratory and other special use marking, contact the State Traffic Standards Engineer.

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:

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

AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, **and FDOT Structures Manual**- 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 Roadway Lighting Design Guide*** 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 Roadway Lighting Design Guide*** 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. Lighting criteria is contained in ***Tables 7.3.1 – 7.3.5***. Refer to ***Section 7.2.1*** for Overhead sign lighting criteria.

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.

Table 7.3.1 Conventional Lighting - Roadways

ROADWAY CLASSIFICATIONS	ILLUMINATION LEVEL AVERAGE INITIAL HORIZONTAL FOOT CANDLE (H.F.C.)	UNIFORMITY RATIOS	
		AVG./MIN.	MAX./MIN.
INTERSTATE, EXPRESSWAY, FREEWAY & MAJOR ARTERIALS	1.5	4:1 or Less	10:1 or Less
ALL OTHER ROADWAYS	1.0	4:1 or Less	10:1 or Less
* PEDESTRIAN WAYS AND BICYCLE LANES	2.5	4:1 or Less	10:1 or Less

Note: These values should be considered standard, but should be increased if necessary to maintain an acceptable uniformity ratio. The maximum value should be one and one-half values.

* This assumes a separate facility. Facilities adjacent to a vehicular roadway should use the levels for that roadway.

Table 7.3.2 Highmast Lighting - Roadways

ROADWAY CLASSIFICATIONS	ILLUMINATION LEVEL AVERAGE INITIAL (H.F.C.)	UNIFORMITY RATIOS	
		AVG./MIN.	MAX./MIN.
INTERSTATE, EXPRESSWAY, FREEWAY & MAJOR ARTERIALS	0.8 to 1.0	3:1 or Less	10:1 or Less
ALL OTHER ROADWAYS	0.8 to 1.0	3:1 or Less	10:1 or Less

Table 7.3.3 Underdeck Lighting - Roadways

LUMINAIRE TYPE	LIGHT SOURCE	MOUNTING LOCATION
PIER CAP	150 watt to 250 watt HPS	Pier or Pier Cap
PENDANT HUNG	150 watt to 250 watt HPS	Bridge Deck

Note:
1. The light levels for underdeck lighting shall be equal to the adjacent roadway lighting.
2. Underdeck lighting is accomplished by mounting either pier cap or pendant hung fixtures under the bridge structure.
3. Pier cap luminaires should be installed when bridge piers are located less than 15 ft. from edge of travel lane.
4. Pendant hung luminaires shall be mounted to the bottom of the bridge deck and should suspend where 50% of the lamp is below bridge beam.

Table 7.3.4 Rest Area Lighting

AREA ILLUMINATED	ILLUMINATION LEVEL AVERAGE INITIAL (H.F.C.)	UNIFORMITY RATIOS	
		AVG./MIN.	MAX./MIN.
ENTRANCE & EXIT	1.5	4:1 or Less	10:1 or Less
INTERIOR ROADWAYS	1.5	4:1 or Less	10:1 or Less
PARKING AREAS	1.5	4:1 or Less	10:1 or Less

Table 7.3.5 Mounting Height Restrictions

LUMINAIRE WATTAGE	LIGHT SOURCE	MOUNTING HEIGHT (MIN.) (FEET)
150	High Pressure Sodium (HPS)	25
200	High Pressure Sodium (HPS)	30
250	High Pressure Sodium (HPS)	30
400	High Pressure Sodium (HPS)	40
750	High Pressure Sodium (HPS)	50
1000	High Pressure Sodium (HPS)	80

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. Standard Aluminum Light Poles have been designed for 110, 130 and 150 mph 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 7.6***, ***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.

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.

AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, FDOT Structures Manual 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 7.6***, ***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).

THIS PAGE LEFT BLANK INTENTIONALLY

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 7.6, Foundation Design***, for geotechnical requirements.

7.4.12 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 110, 130 and 150 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.

7.4.13 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 all indications.

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 the safety, efficiency, mobility, security, and integration of transportation systems. 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 useful information to motorists. Lastly, the designer needs to ensure that the ITS project is consistent with the FDOT regional ITS architecture, and that the project reflects the application of system engineering management principles.

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 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.

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 SunGuide^{SM} 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 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. In some instances the DMS could be used to display other messages, such as AMBER Alerts or traveler information related to special events, emergencies, and incidents impacting mobility and safety. 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 this remote control capability.

The DMS should be positioned and illuminated to be readable from the roadway, taking into account the display characteristics of DMS technology (e.g., the vertical and horizontal viewing angles of the LED displays).

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. Consider increased spacing when conditions allow.
   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.
5. Placement in advance of system interchanges.
6. Placement along key commuter or evacuation corridors.

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

7.5.4.2 Highway Advisory Radio

A highway advisory radio (HAR) system design should include all the equipment necessary for the operator to record verbal messages from onsite or remote locations, and to continually broadcast live, prerecorded, or synthesized messages from roadside transmission sites. HAR designs also include highway signs with remotely operated flashing beacons to notify motorists of HAR broadcasts.

The designer should be aware of the Federal Communications Commission (FCC) regulations in ***CFR Title 47, Part 90.242***, pertaining to the operation of travelers' information stations. Additional information on licensing issues, frequency allocation, and other specifics can be obtained by contacting the FDOT ITS Telecommunications Office.

Radio waves are also propagated through the ground and grounding components are used to ensure peak performance. This necessitates a well-designed and well-constructed ground field, a circular space radiating from the antenna location. This design is critical to the successful operation of the HAR site, and may require a significantly sized circle around the antenna mast. An array of wiring emanating from the antenna mast radiates outward; ground assemblies at the end of each wire or cable are drilled into the ground.

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

1. Ability to transmit a meaningful message that can be received by motorists traveling through the broadcast zone.
2. Placement prior to freeway interchanges that offer alternate routes.
3. Placement in advance of high crash locations and traffic bottlenecks.
4. Placement that accommodates access for service and maintenance.
5. Placement along key commuter or evacuation corridors.

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. A camera should be strategically located 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, bridges), as feasible.
4. Camera structures must be placed in accordance with ***Section 2.11***.
5. Device placement should be such that it accommodates access for service and maintenance with minimal to no impact on traffic. For instance, the use of lowering devices to allow cameras to be lowered from the pole top to ground level for servicing with little or 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 ***Volume 9*** of the ***FDOT Structures Manual*** should also be used as design criteria for CCTV structures and their associated foundations.

7.5.5.2 Video Display Equipment

Video display equipment is utilized in the TMC for viewing CCTV images and other information obtained from field locations. It is important to develop a display system design plan that is based on a detailed, documented analysis of the control center room dimensions, the operator's console desk layout, various distances from the operator's seating position to the video wall display, and the viewing angles to the display wall at the proposed mounting height for the display supporting structure.

The designer should consider any potential limitations introduced or imposed by existing facility construction that may hinder the installation of the video wall display. The video display components should be capable of being brought into the TMC control room and assembled in place without the Contractor having to make modifications to existing doorways, walls, floors, or ceilings.

7.5.6 Network Devices

Network devices utilized in ITS include a variety of Internet Protocol (IP)-addressable electronic equipment used for the collection and dissemination of video, traffic data, and other information.

Due to the critical nature of the network equipment described below, the complexity of the electronics, and harsh environmental conditions at installation locations, designs utilizing network devices should facilitate immediate replacement of defective or damaged units with minimal system downtime.

Consideration should be given to designs that promote open architecture, non-proprietary systems, as well as survivability and reliability. Designers should consider solutions that provide immunity to single-point failure and implement redundant paths for reliability and survivability.

7.5.6.1 Managed Field Ethernet Switch

The managed field Ethernet switch (MFES) is an environmentally hardened field device that provides Ethernet connectivity from the remote ITS device installation location to the ITS network trunk interconnection point. Local connections from nearby Ethernet field devices or other cabinet electronics to the MFES are generally accomplished using CAT5e or CAT6 UTP cables connected to RJ-45 Ethernet ports on the MFES. However, when planning connections of the MFES to other Ethernet devices beyond a distance of 300 feet, fiber optic cabling from optical ports on the MFES is generally the preferred method. The designer should also consider fiber optic connection to devices outside the local cabinet if the design requires additional protection from transients or interference that may be induced on copper-based interconnects.

The design should provide an Ethernet port for the connection of each remote ITS field device. Field devices that typically connect to an MFES include, but are not limited to, CCTV camera systems, HAR field assemblies, vehicle detection systems, DMS, road weather information systems (RWIS), and traffic controllers.

7.5.6.2 Device Server

The device server encapsulates serial data in network packets and transports the packets across IP networks. Designs generally include device servers when remote field devices must connect to an Ethernet network, yet only possess serial communication interfaces.

Equipment that may require the use of device servers includes, but is not limited to, HAR field assemblies, DMS, vehicle detection systems, RWIS stations, and other low-speed data output devices

7.5.6.3 Digital Video Encoder and Decoder

Digital video encoders (DVEs) and digital video decoders (DVDs) are specialized network-based hardware devices and software that allow data signals and analog video to be encoded to digital format and transmitted across IP networks. These networks are designed so that the digitized video and data packets the DVE produces and places on the network can be reconstructed (decoded) by hardware-based and software-based DVDs also attached to the network.

When designing a video and data transmission system incorporating DVE and DVD hardware with existing or planned network infrastructure, ensure that the system can transport video and data from multiple remote field locations simultaneously to multiple monitoring locations. If applicable, the designer should also seek to maintain video, data, and switching interoperability with legacy systems.

7.5.7 Fiber Optic Cable and Interconnect

The following sections describe the various fiber optic facilities that are used for device control and data communications between ITS field devices, TMCs, regional transportation management centers (RTMCs), and other identified stakeholder facilities. Designs that include network facilities should meet project-specific needs, as well as include the following information:

1. Facility diagrams illustrating facility routes.
2. General network topology.

7.5.7.1 Fiber Optic Cable

Fiber optic cable is utilized in the statewide ITS network infrastructure to provide data and device control communications between TMCs, RTMCs, ITS devices, and other identified stakeholder facilities. The designer should refer to Department specifications for material requirements of fiber optic cable and related material.

7.5.7.2 Fiber Optic Conduit

The type of fiber optic cable installation will determine the design for the conduit needed. For example, use polyvinyl chloride (PVC), fiberglass, or high-density polyethylene (HDPE) conduit for fiber optic cable that is exposed or placed underground along the roadway. Use HDPE SDR 11 conduit underground along the interstate. Use a UV-rated, flexible conduit to protect the cable in above-ground installations.

The design of the conduit should depict all required fittings and incidentals necessary to construct a complete installation. The conduit system should allow the fiber optic cable to maintain the minimum bend radius after installation.

7.5.7.3 Fiber Optic Splices and Terminations

Fiber optic splices provide a continuous optical path for transmission of optical pulses from one length of optical fiber to another. Designs and plans should identify splice points and provide splicing diagrams that detail the interconnection of specific fiber strands, their origination and final destination points, and expected link loss. The preferred method of presentation is a graphical format.

Fiber optic terminations connect the optical fibers housed within a cable to a fiber distribution panel (FDP) or a fiber patch panel (FPP). The FDP and FPP help connect the optical fibers to the electronic equipment and devices located throughout the network. Therefore, all fiber optic terminations should include the installation of a FPP or a FDP. Field terminations also include the installation of fiber optic connectors to the optical fibers if factory-installed connectors are not used.

7.5.7.4 Fiber Optic Cable Designating System

The fiber optic cable designating system provides visual notification of the presence of the underground fiber optic conduit/cable system, and provides a mechanism for electronically locating the physical presence of the conduit system below ground. The designating system provides a means to identify, locate, and protect the statewide fiber optic network between RTMCs, TMCs, ITS devices, and other facilities.

The designating system may consist of several components, including electronic markers, above-ground route markers, tone wire access points, buried cable warning tape, underground tracers, and tone wires. Design the designating system to support both high-power, office-based tone generators and portable field tone generators.

The design and construction of the designating system should consist of furnishing and installing the type, size, and quantity of system components as specified by the project, and meeting the following functional requirements based on project needs:

1. Provide visual notification of the presence of the conduit installed on FDOT projects.
2. Inform the public of potential hazards and provide contact information for conduit system marking prior to planned excavation.
3. Provide an end-to-end electrical conductor (tone wire) attached to the conduit system for conductive facility locating.
4. Provide above-ground access to the tone wire.

7.5.7.5 Fiber Optic Access Points

Fiber optic access points consist of splice boxes and pull boxes. They are utilized to provide access to the statewide fiber optic conduit system for the installation, operation, and maintenance of fiber optic cables between RTMCs, TMCs, ITS devices, and other identified stakeholder facilities. More information about pull and junction boxes is provided in ***Section 635*** of the ***FDOT Specifications***.

Access point items should be planned and designed according to the type, size, and quantity necessary for the project. Design the access points to meet the following minimum functional requirements:

1. Provide at-grade access to fiber optic cables housed within conduit systems used for FDOT ITS communications.
2. Provide assist points to aid in fiber optic cable installation.
3. Provide protection for the fiber optic cable.
4. Provide adequate space for storing cable slack/coils and splice enclosures.
5. Make certain that pull boxes and splice boxes provide sidewall entry of the fiber optic cables.

Fiber optic access points should be placed at the following locations unless otherwise directed by the Engineer:

1. All major fiber optic cable and conduit junctions.
2. At all planned or future splice locations.
3. Every 2,500 feet in a continuous straight conduit section if no fiber optic cable splice is required.
4. At a maximum of 1,000 to 1,500 feet in metropolitan areas.
5. On each side of a river or lake crossing and at each end of a tunnel.
6. On each side of an above-ground conduit installation (i.e., attachment to bridge or wall).
7. All 90-degree turns in the conduit system.

Use splice boxes as the preferred access points on fiber optic cable backbone routes. Use pull boxes as the access points when the conduit system extending from the backbone to the ITS field devices requires an access point to house only fiber optic drop cables.

7.5.8 Infrastructure

7.5.8.1 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.

7.5.8.2 ITS Pole and Lowering Device

For installations of pole-mounted devices where height precludes easy access using a bucket truck, consider using a lowering device.

If designs call for a lowering device to be attached to an existing pole or similar structure, ensure that the design includes external conduit for housing the cabling, the necessary mounting box hardware at the top of the structure, and any other component details required for installation. Do not create designs that would require an operator to stand directly beneath equipment while it is being lowered.

The designer should consider the placement of all devices on the pole and how they affect the ability to utilize the lowering device.

7.5.8.3 ITS Field Cabinet

ITS field cabinets are designed and furnished to house any combination of several ITS devices installed along the roadway, including managed field Ethernet switches, hub switches, device servers, digital video encoders, vehicle detection system electronics, DMS communication devices, CCTV camera hardware, and power supplies for these items.

Final location of the cabinet should be based on safety of the motorist, visibility of roadside devices, and access by maintenance. ITS field cabinets can be base mounted on a concrete pad, structure mounted, or pole mounted.

The cabinet should be sized appropriately to accommodate the equipment to be installed inside. In addition, the cabinet design should take into account the ease of access to the equipment and the ability to achieve proper ventilation in order to maintain an internal operating environment that does not exceed the operating temperature ranges for the devices housed inside.

7.5.9 Vehicle Detection and Data Collection

The FDOT uses vehicle detectors along roadways to collect traffic information. Data from these detectors are used in the TMCs to initiate traffic control measures. There are various kinds of detectors available, each with its unique attributes and limitations. The four types described here are considered nonintrusive because their operation does not interfere with the flow of traffic, and installation does not require altering the roadway surface.

Prepare a design that details a complete detection assembly, including all other necessary components to be supplied and constructed. Detail in the drawings the exact location and placement of system components, and include installation details for the required cables. Design the cabling installation according to the manufacturer's recommendations.

7.5.9.1 Microwave Vehicle Detection System

The Microwave Vehicle Detection System (MVDS) is installed above ground on the side of the road (i.e., side-fire) for multilane detection, or over the travel lanes for single lane coverage only. This detection system uses a FCC-certified, but non-site licensed, low-power microwave radar beam to measure vehicle presence, volume, speed and occupancy.

7.5.9.2 Video Vehicle Detection System

The Video Vehicle Detection System (VVDS) measures vehicle presence, volume, occupancy, and speed by analyzing video signals generated by the video camera used to detect traffic.

Besides vehicle detection, the VVDS can also function as a roadway surveillance device. When surveillance capability is desired, dual-use VVDS systems are used. In the surveillance mode, these systems automatically turn off the vehicle detection functions.

The recommended deployment geometry for optimal video detection and surveillance requires that there be an unobstructed view of each travel lane where detection and surveillance are required. Though optimal results can be achieved when the cameras are directly above the travel lane, the cameras are not required to be directly over the roadway.

Cameras can be positioned so they can view either approaching or receding traffic or both in the same field of view. The preferred orientation for optimal detection is the view of approaching vehicles because there are more high-contrast features on vehicles viewed from the front than from the rear. Cameras should be positioned high enough to minimize the effects of occlusion from closely spaced vehicles and to avoid glare from the horizon.

7.5.9.3 Magnetic Traffic Detection System

The Magnetic Traffic Detection System (MTDS) relies on magnetic sensors or probes that are placed in conduits under the road surface. A probe is a transducer that converts changes in the vertical component of the earth’s magnetic field to changes in inductance in a loop. Vehicles on the road surface increase the vertical component of the earth’s magnetic field at the detection point when they move over the sensor. The increased magnetic field changes inductance in a loop connected to the sensor, and the system converts this input into traffic data.

7.5.9.4 Acoustic Vehicle Detection System

The Acoustic Vehicle Detection System (AVDS) utilizes a passive acoustic sensor that measures traffic parameters by detecting vehicle-generated acoustic signals. The AVDS can be mounted over the travel lane on a bridge or a mast arm, or on roadside poles or sign structures for a side-fire mounted configuration.

Acoustic detection systems measure traffic flow parameters for five adjacent lanes on a lane-by-lane basis. The system can identify acoustic signals from approaching vehicles with a different signal level and a different wave front angle (i.e., arrival angle) than that of passing vehicles that are leaving the detection area. The system also processes acoustic signals generated by stationary (i.e., idling) vehicles in real time.

The detection system can also be used to emulate a dual-loop speed trap configuration for speed measurement.

THIS PAGE LEFT BLANK INTENTIONALLY

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.

THIS PAGE LEFT BLANK INTENTIONALLY