Chapter 7

Traffic and ITS Design

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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 non-motorized, 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.

Projects including signing, lighting, traffic signals, pavement marking and ITS must comply with the Department's ***Standard Specifications***, ***Design Standards***, ***Traffic Engineering Manual*** ***(TEM)***, ***Structures Manual, Volume 3***, ***and*** ***Manual on Uniform Traffic Studies*** ***(MUTS)*** in addition to the following documents:

Manual on Uniform Traffic Control Devices ***(MUTCD)*** - This manual 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 marking. The requirements of the ***MUTCD*** must be met, as a minimum, on all roads within the State. Where the Department's documents indicate criteria which is more stringent than the ***MUTCD***, the FDOT criteria must be followed.

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

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

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

Refer to ***Chapter 29*** of this Volume for information regarding structural support requirements. Refer to ***Chapters 23, 24 and 25*** of Volume 2 for information regarding plan requirements.

7.1.1 Railroad-Highway Grade Crossing Near or Within Project Limits

Federal-aid projects with a railroad-highway grade crossing near or within the project limits should refer to ***Section 6.2.4***.

7.1.2 Attachments to Barriers

Refer to ***Chapter 4*** of this Volume for information regarding proposed attachments to bridge traffic railings, concrete median barrier walls, concrete shoulder barrier walls or the evaluation of existing attachments.

7.2 Signing

7.2.1 Design Criteria

Refer to the ***MUTCD**, **Design Standards***, and ***Chapter 4*** of this Volume for acceptable sign locations. Sign supports are to be breakaway unless the sign is bridge or barrier wall mounted, or placed outside the clear zone.

Provide a 4 feet clear width, not including the width of curb, when a sign is located within a sidewalk.

7.2.2 Overhead Signs on Freeways and Expressways

Section 2A.17 of the ***MUTCD*** lists thirteen optional conditions where overhead signs have value on freeways and expressways. This section specifies the specific conditions which will apply for certain locations. Locations other than those required by the ***MUTCD*** or noted below will utilize ground mounted signs.

Use overhead signs for freeway and expressway Exit Direction signs when any of the following conditions exists:

1. Interchange Spacing ≤ 3 Miles
2. Left Exit on a Freeway
3. Three or More Through Lanes (When Determined by the District Design Engineer to be Appropriate)

Use overhead signs for freeway and expressway Advance Guide signs when any of the following conditions exists:

1. Interchange Spacing ≤ 3 Miles
2. Left Exit on a Freeway
3. Freeway to Freeway Interchange (1/2 mile and 2 mile, 1 mile required by ***MUTCD***)

This criteria is not intended to restrict the use of overhead signs where there is insufficient space for post mounted signs or where there is restricted sight distance.

Place overhead advance guide signs over the shoulder with the edge of the sign aligned with the edge of the traveled way unless otherwise shown in the ***MUTCD***. Extend overhead exit signs over the ramp. If a barrier is present to shield another hazard, the upright should be located near the back of the barrier with proper setback for barrier performance.

7.2.3 Local Street Names on Guide Signs

Standard practice is to use route numbers on guide signs to designate roadways. When the local name for a roadway is more familiar than the route number, the local street name may be used. The decision to use a local name should be coordinated with the District Traffic Operations Engineer because it often requires a larger sign panel.

7.2.4 External Lighting of Overhead Signs

Provide external lighting of overhead signs only for the following conditions:

1. Horizontal curves with radii of 880 feet or less in rural areas.
2. Horizontal curves with radii of 2500 feet or less in urban areas.
3. In sag vertical curves with a K value of 60 or less.

Show sign lighting requirements on the Guide Sign Worksheet when sign lighting is required. Include sign lighting calculations in the Lighting Design Analysis Report.

7.2.5 Signs on Median Barriers and Traffic Railings

For information regarding attachments to barrier, refer to ***Section 4.5*** of this Volume. Utilize ***Design Standards, Index 11871*** when attaching the following permanent sign supports to a median traffic railing:

- No U-Turns (R3-1) w/ Official Use Only (FTP 65-06)
- Left Lane Ends (W9-1)
- Lane Ends Merge Right (W9-2)
- Merge Symbol (W4-2)

No other permanent signs are to be attached to median traffic railings. ***Design Standards, Index 11871*** may be used for temporary or work zone signs when ***Design Standards, Index 600*** cannot accommodate post mounted signs within existing conditions.

7.2.6 Signing Project Coordination

Coordination with other offices and agencies is a very important aspect of project design. The offices discussed in this section are those that are typically involved in a signing and marking project, however there may be other offices or agencies involved.

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

Utilities - The District Utilities Engineer provides the coordination between the designer and the various utilities that may be involved in the signing project. The Utilities Section may assist in identifying or verifying conflicts with overhead and underground utilities. 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 structure and foundation for overhead cantilever and overhead truss sign assemblies. The Engineer of Record should be contacted early in the design phase to allow adequate time for coordination with the Geotechnical Engineer in obtaining the necessary soils information.

Right of Way – Contact the State Outdoor Advertising and Logo Manager on any project affecting business logo structures. Refer to ***Section 13.5.5*** of this Volume for requirements and additional information.

Modification for Non-Conventional Projects:
Delete ***PPM*** 7.2.6 and replace with the following: **7.2.6 Signing Project Coordination** The Design-Build firm must submit a master signing plan with the Technical Proposal. The master signing plan can be on a roll plot.

7.2.7 Signing for Bridges with Steel Decks

Place Slippery When Wet signs (W8-5) in advance of all movable and non-movable bridges with steel decks. Refer to ***Section 2.1*** of the ***Traffic Engineering Manual***. This requirement applies only to temporary bridges.

7.2.8 Delineators, Object Markers and Express Lane Markers

An object marker is used to mark obstructions within or adjacent to the roadway. The ***MUTCD*** describes four object markers and how they are to be used. A Type 1 or Type 3 object marker is used to mark obstructions within the roadway. A Type 2 or Type 3 object marker is used to mark obstructions adjacent to the roadway. A Type 4 object marker (end-of-roadway marker) is used to alert users of the end of the road.

A delineator is a guidance device rather than a warning device. The ***MUTCD*** and ***Design Standards, Index 17345*** illustrate the use of delineators along the edge of freeways, expressways and interchange ramps. A delineator may be a flexible or a non-flexible type. District maintenance offices generally have a preference on which should be specified.

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

A delineator is also used to mark both rural and urban median openings. In general, flexible delineators are used on urban median openings and non-flexible are used on rural median openings. A high visibility median delineator should be used on traffic separators at the following locations:

- Multilane intersections where additional visibility is required for the marking of the traffic separator,
- Where the separator is obstructed due to crest vertical curves,
- Intersections where the alignment thru the intersection is not straight, and
- Where traditional flexible delineators are constantly being replaced.

Use high performance delineators only on urban roadways where the posted speed is 45 mph or less, and where;

- The delineator is being used to maintain lane position,
- The delineator is being used to restrict vehicle movements,
- The delineator is subject to being frequently hit.

An Express Lane Marker is similar to a high performance delineator except for the height and speed application. Express Lane Markers may be used on projects where it is not feasible to provide a physical barrier between managed and general use lanes. The ***Express Lanes Handbook*** published by the Systems Planning Office provides additional guidance on the use of Express Lane Markers.

The particular type of object marker or delineator must be identified in the plans by the use of the pay item.

Modification for Non-Conventional Projects:
Delete the last sentence and replace with the following: The particular type of object marker or delineator must be identified in the plans.

7.2.9 Roadside Flashing Beacon Assembly

Flashing beacon signs may be supported on single or double sign post configurations.

Refer to ***Design Standards, Index 11862*** for additional information.

7.2.10 Internally Illuminated Street Name Signs

Do not exceed 9 feet in width for an internally illuminated street name sign. For span wire systems, the sign must be mounted to the strain poles. On mast arm supports, the sign may be mounted to the support or to the arm. When mounted to the arm, the distance between the upright and the near side edge of the sign will not be greater than 10 feet.

The design of the street name sign must be in accordance with ***Traffic Engineering Manual, Section 2.2***. Utilize the following text attributes in descending order of preference:

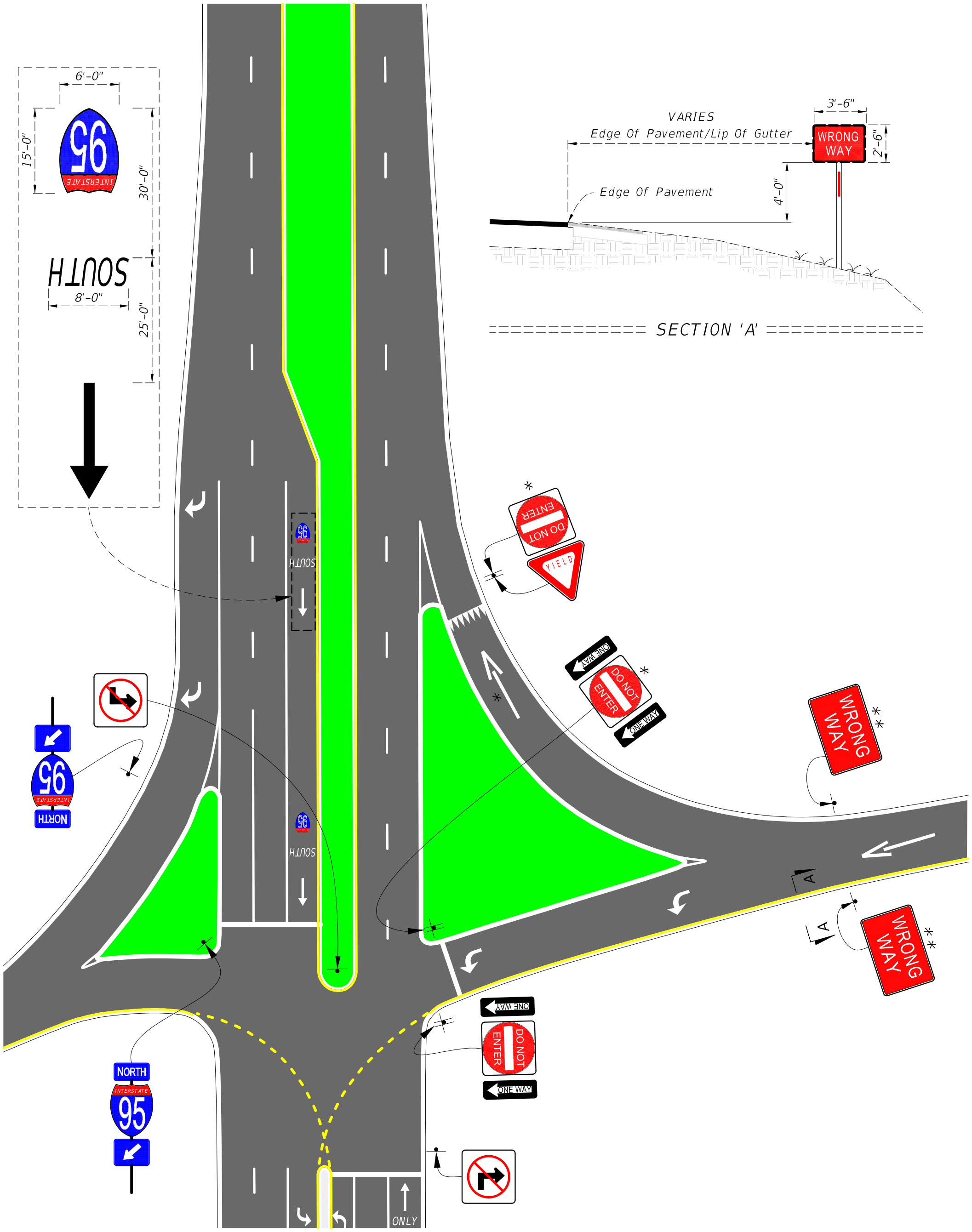
- 10-inch upper case with 8-inch lower case, Type EM font
- 10-inch upper case with 8-inch lower case, Type E font
- 8-inch upper case with 6-inch lower case, Type EM font
- 8-inch upper case with 6-inch lower case, Type E font

7.2.11 Exit Ramp Intersections

The standard for signing and pavement marking at exit ramp intersections is illustrated in **Figures 7.2.1** “Diamond Interchange Exit Ramp” and **7.2.2** “Partial Cloverleaf/Trumpet Interchange Exit Ramp” and described as follows:

1. Include MUTCD “optional” signs; second DO NOT ENTER, second WRONG WAY sign, and ONE WAY signs.
2. Include NO RIGHT TURN and NO LEFT TURN signs.
3. Use 3.5 feet by 2.5 feet WRONG WAY signs mounted at 4-foot height and include a retroreflective strip on sign supports.
4. Include 2-4 dotted guide line striping for left turns between ramps entrances/exits and cross-streets.
5. Include retroreflective yellow paint on ramp median nose where applicable.
6. Include a straight arrow and route interstate shield pavement marking in left-turn lanes extending from the far-side ramp intersection through the near-side ramp intersection to prevent premature left turns. Refer to ***Traffic Engineering Manual*** (***TEM***), Section 4.2.4 “Route Shields for Wrong Way Treatment” for additional information.
7. Include a straight arrow and ONLY pavement message in outside lane approaching the ramp exit.

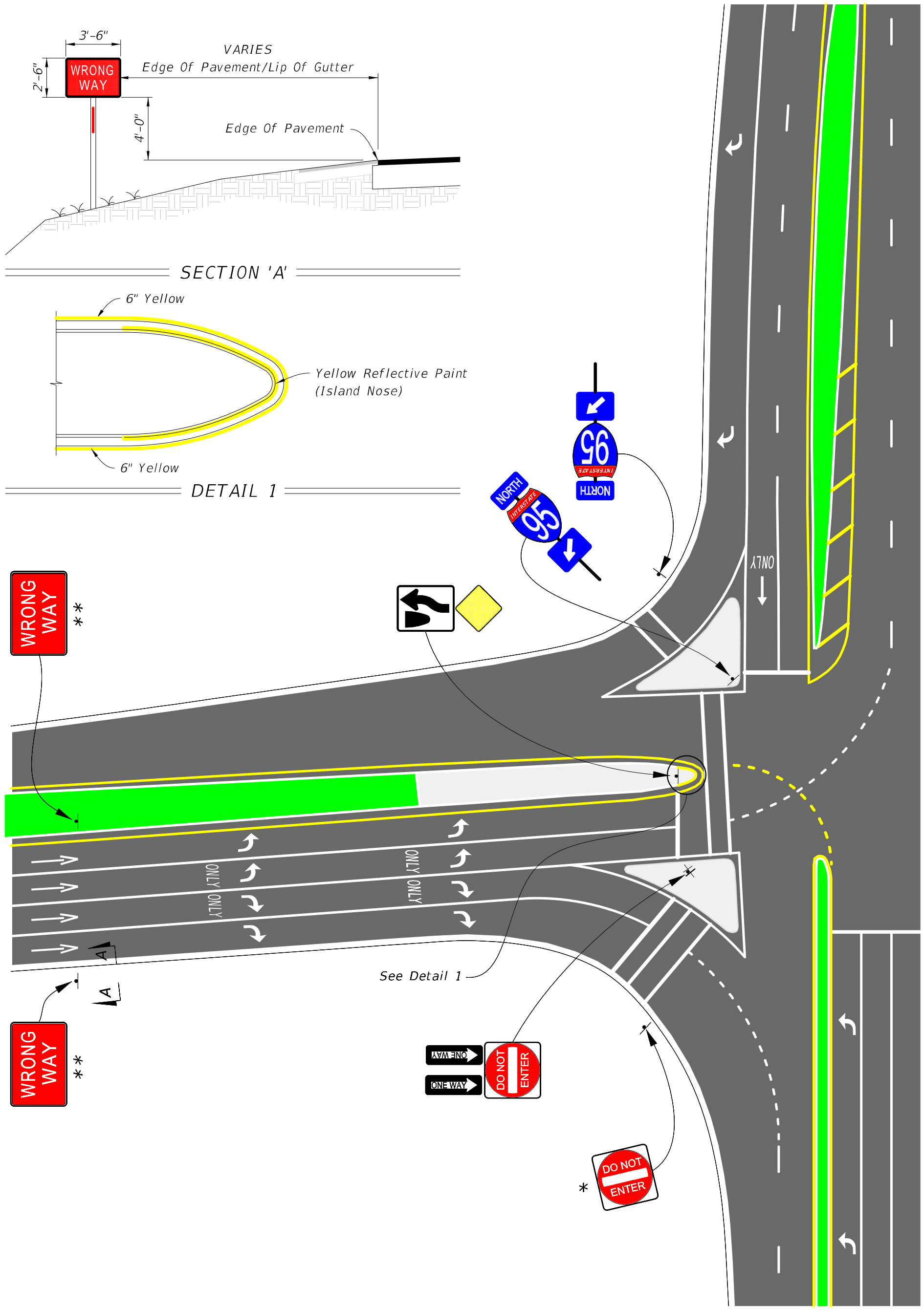
Figure 7.2.1 Typical Layout for Diamond Interchange Exit Ramp



*Include if connecting road is undivided; i.e. traversable median.

**Mount sign 4 feet above edge of pavement and include retroreflective strip.

Figure 7.2.2 Typical Layout for Partial Cloverleaf/Trumpet Exit Ramp



*Include if connecting road is undivided; i.e. traversable median.

**Mount sign 4 feet above edge of pavement and include retroreflective strip.

7.3 Lighting

7.3.1 Design Criteria

Use the illuminance method for all lighting design. The design values for light levels given by the ***AASHTO Roadway Lighting Design Guide*** are maintained values. These maintained values have been adjusted for Department assigned light loss and maintenance factors and are provided in ***Tables 7.3.1 - 7.3.7*** as required light level 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 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. It is for these reasons that the luminance technique is not allowed.

Mounting height (M.H.) for conventional lighting is the vertical distance from the roadway surface at the edge of the travel lane 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.

Do not tilt cobra head type fixtures. Pole top mounted fixtures may be tilted up to 5 degree for roadway lighting projects. Pole top mounted fixtures may be tilted in excess of 5 degrees when used at weight stations, agricultural stations and rest areas.

All lights not bridge or barrier wall mounted and installed within the clear zone, must be breakaway or shielded by an approved barrier. Refer to ***Chapter 4*** of this Volume for additional information on roadside safety design.

7.3.2 Design Methodology

Use the polygon method for all photometric calculations. Establish illumination points within the polygon at 15 foot intervals longitudinally and 5 foot intervals transversely along the roadway for roadway segments. Establish illumination points within the polygon at 5 foot intervals longitudinally and 5 foot transversely along the roadway for signalized intersections.

Refer to ***RCI Features & Characteristics Handbook***, Urban Classification – Feature 124 for additional information concerning urban designations Urban 1 through Urban 5.

7.3.2.1 Analysis Zones

Establish independent analysis zones for each signalized intersection and for each roadway segment between signalized intersections. Roadway segments and signalized intersection segments are to meet the criteria shown in ***Table 7.3.1.*** New or reconstructed signalized intersections located in Urban 3 or larger designated areas are to meet the criteria in ***Table 7.3.3***.

Analyze signalized intersection segments using one analysis zone bounded by the back of sidewalks and the signalized intersection stop bars on each approach.

The termini for each roadway segment will be either the lighting project limits or the signalized intersection stop bars. The boundary of each roadway segment is described as follows:

Flush Shoulder Facilities:

1. Analyze divided roadway segments with grassed medians using two analysis zones; i.e. one for each direction of travel. Each zone will be bounded by the outside and median shoulder points.

2. Analyze multi-lane undivided roadway segments using two analysis zones; i.e. one for each direction of travel. Each zone will be bounded by the outside shoulder point and the centerline of the roadway.

3. Analyze two and three lane roadway segments as one analysis zone bounded by the outside shoulder points.

Curb and Gutter Facilities:

1. Analyze divided roadway segments with grassed medians using two analysis zones; i.e. one for each direction of travel. Each zone will be bounded by the back of sidewalk and the back of the median curb and gutter.

2. Analyze multi-lane undivided roadway segments, including roadways with two-way left turn lane, using two analysis zones; i.e. one for each direction of travel. Each zone will be bounded by the back of sidewalk and the centerline of the roadway.

Freeway Facilities:

Establish independent analysis zones for the mainline roadway segments, ramp segments and crossroad segments at interchanges. Freeway segments are to meet the criteria in ***Table 7.3.2***.

The termini for each freeway mainline segment will be the lighting project limits. Logical termini for the other freeway segments will be determined by the designer. The boundary of each freeway segment is described as follows:

1. Analyze divided mainline roadway with grassed median using two analysis zones, one for each direction of travel; i.e. one zone for each direction of travel. Each zone will be bounded by the outside and median shoulder points.

2. Analyze barrier separated mainline roadway as one analysis zone bounded by the outside shoulder points of each direction of travel.

3. Analyze each ramp segment as one analysis zone bounded by the shoulder points. For interchange lighting where there is no continuous freeway lighting, the average illuminance criteria must be maintained to the end of the ramp tapers.

4. Analyze crossroad segments based on the criteria given above for flush shoulder or curb and gutter facilities.

7.3.2.2 Analysis for Pedestrian Lighting at Signalized Intersections

Pedestrian lighting criteria in ***Table 7.3.3*** applies to new or reconstructed signalized intersections located within Urban 3 or larger designated areas.

Vertical illuminance is the primary design value to be used to measure pedestrian visibility. Research has determined that visibility of pedestrians in crosswalks at intersections is a function of:

- the background illuminance,
- luminaire location in relation to the approach vehicle,
- luminaire mounting height,
- the distance from the luminaire to the crosswalk, and
- the photometrics of the luminaire.

The vertical illuminance calculation method to be used at intersections will be the variable light meter aimed toward the driver's location. This calculation will provide the vertical illumination level of a pedestrian which the driver sees approaching the crosswalk. This type of vertical illumination calculation is outlined in the *IESNA Design Guide for Roundabout Lighting (DG-19-08)*. When performing this calculation, the driver's location from the crosswalk must be established. Use the stopping sight distance for the nearside approach based on the posted speed of the near approach roadway. Use the stopping sight distance for the turning movement approaches based on the operating speed for each specific turning radius.

The vertical illuminance must be calculated for three movements for each intersection approach. The first is the thru movement and the near side crosswalk; the second is the right turn movement and crosswalk on the adjacent side street; and the third is the left turn movement and the crosswalk on the side street. ***Figures 7.3.1 through 7.3.3*** indicate each of these three movements and the corresponding crosswalk area that must be analyzed. The vertical illuminance grid points are to be on a line centered in the crosswalk with a horizontal point spacing of 1.65 feet at a height of 5 feet above the pavement. The grid points are oriented toward the approaching driver, which is different from the vertical grids for sidewalks where the grids are parallel to the main pedestrian flow.

Many of the design features of existing intersections limit the placement of lighting fixtures to meet the vertical illumination requirements of an intersection approach. Therefore, the criteria in ***Table 7.3.3*** will apply only to approaches where the placement of lighting fixtures can be accomplished without modification of the intersection design.

Figure 7.3.1 Vertical Illuminance Calculation for Near Side Movement

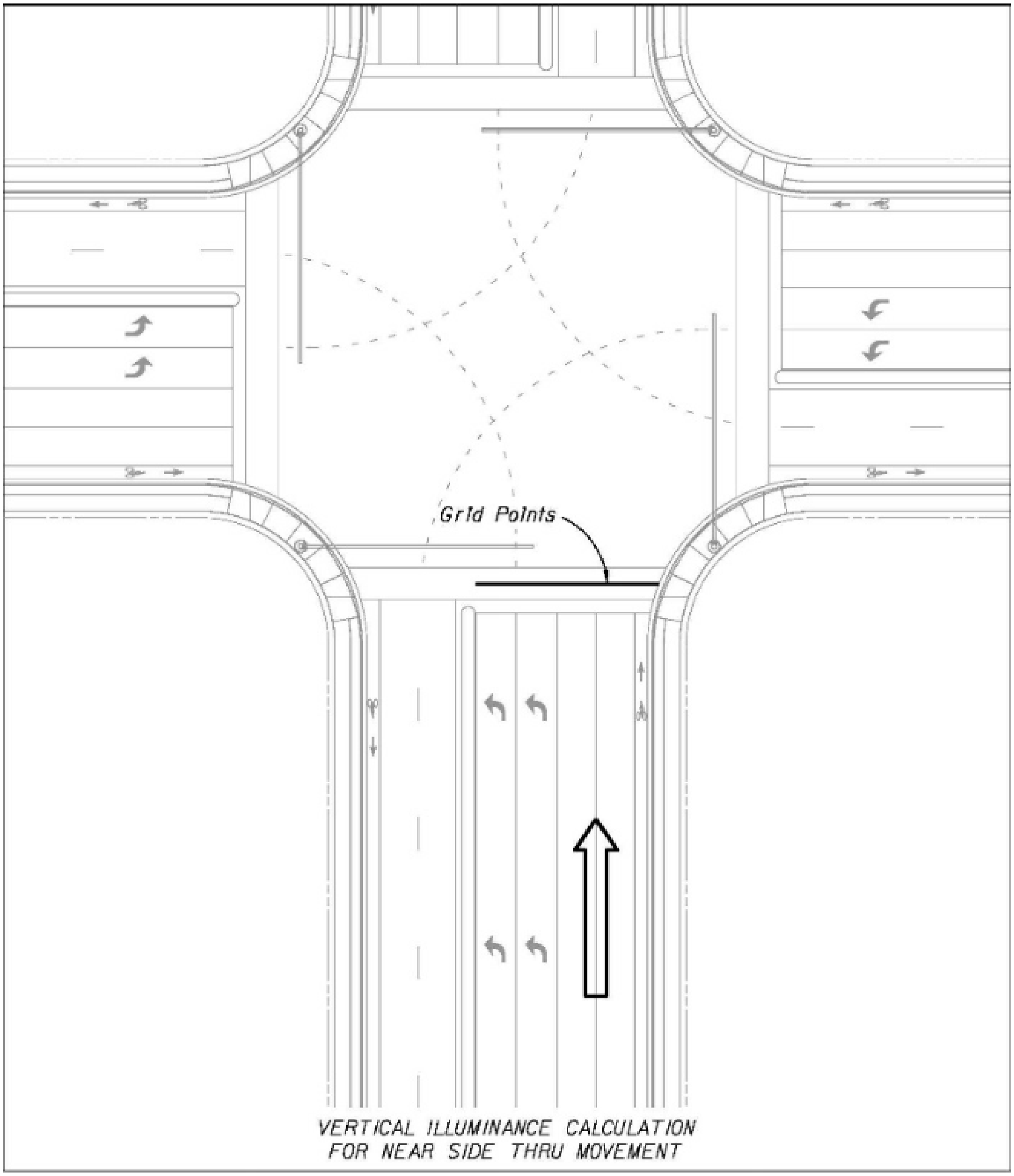


Figure 7.3.2 Vertical Illuminance Calculation for Right Turn Approach

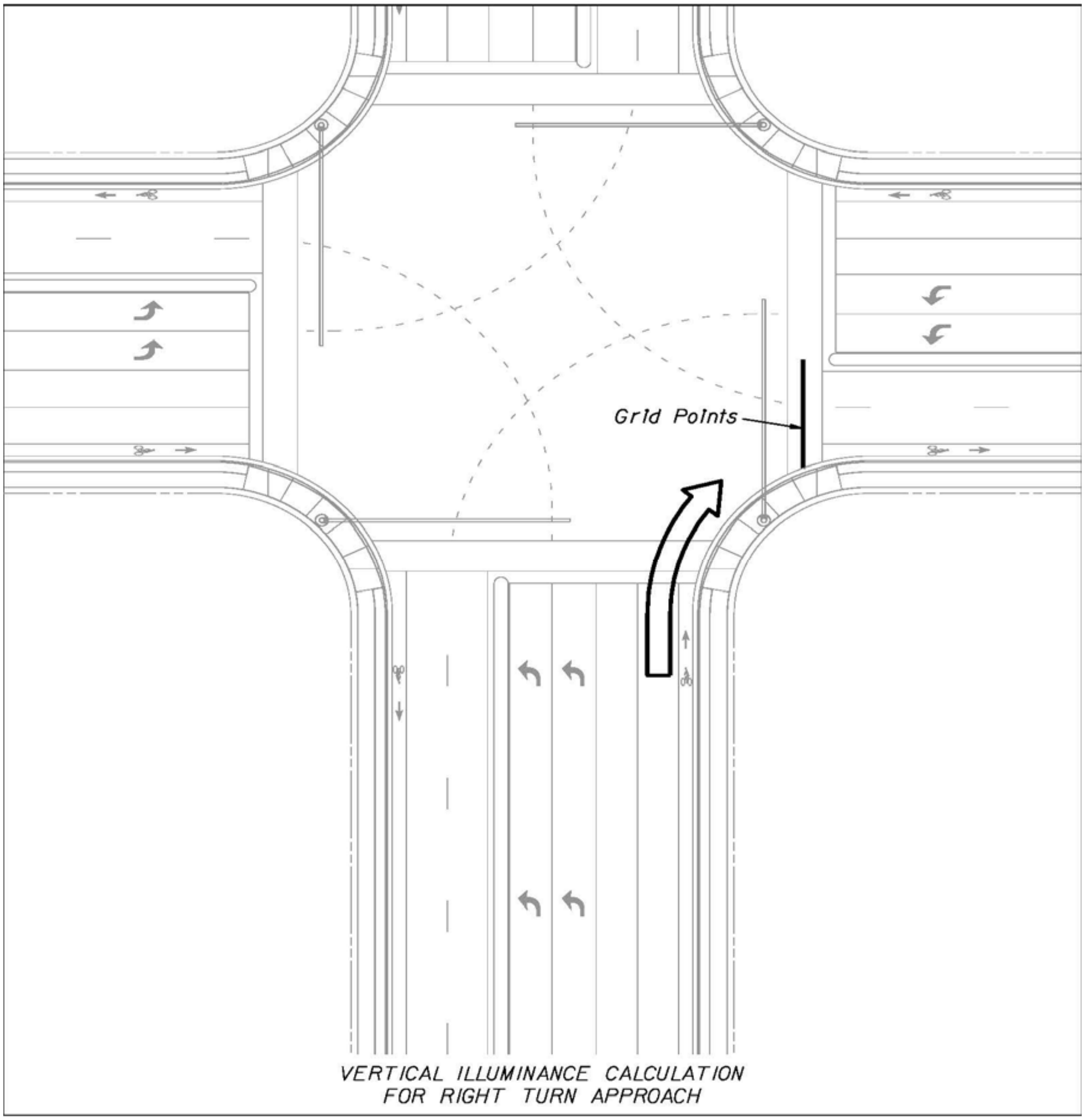


Figure 7.3.3 Vertical Illuminance Calculation for Left Turn Approach

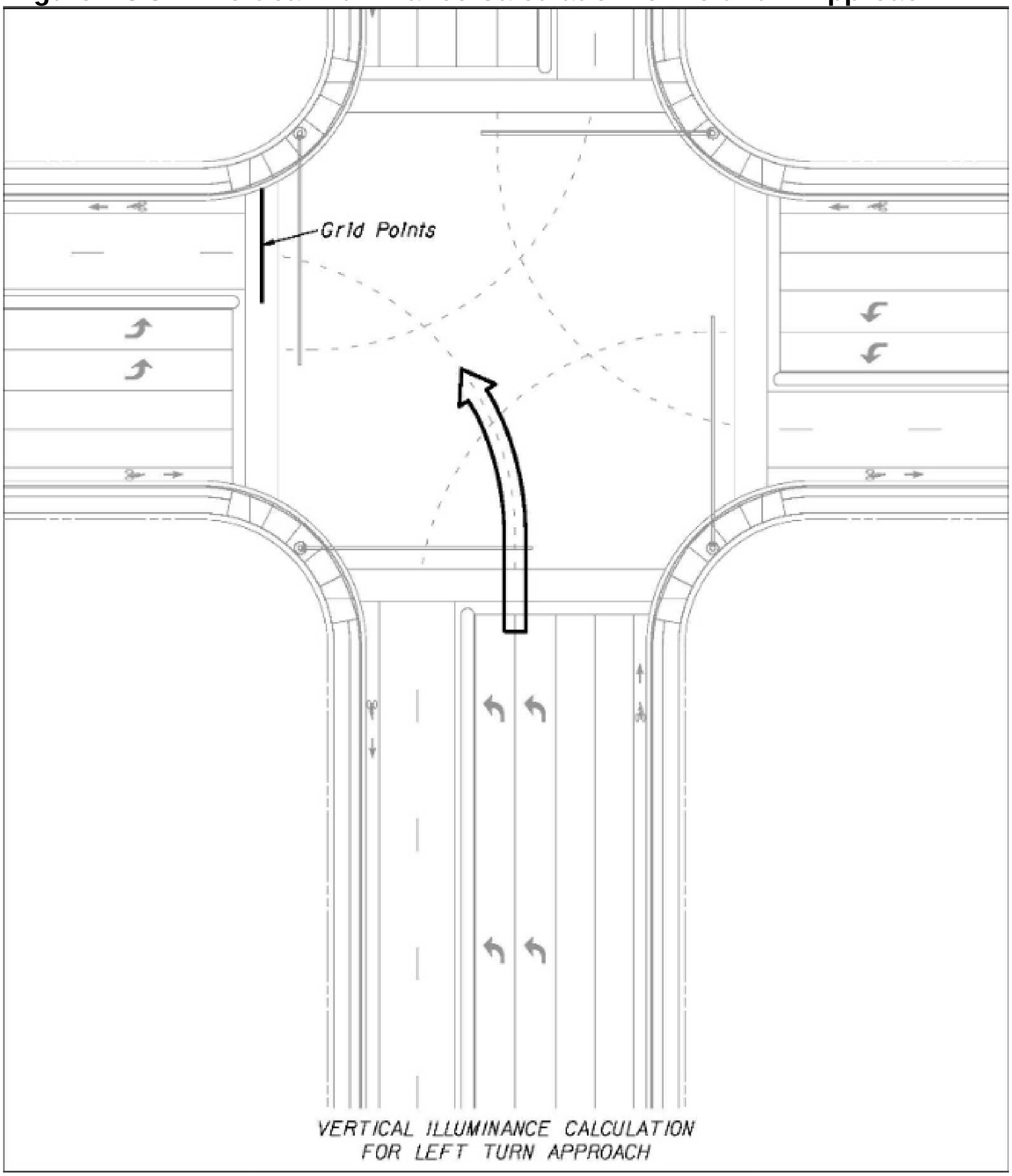
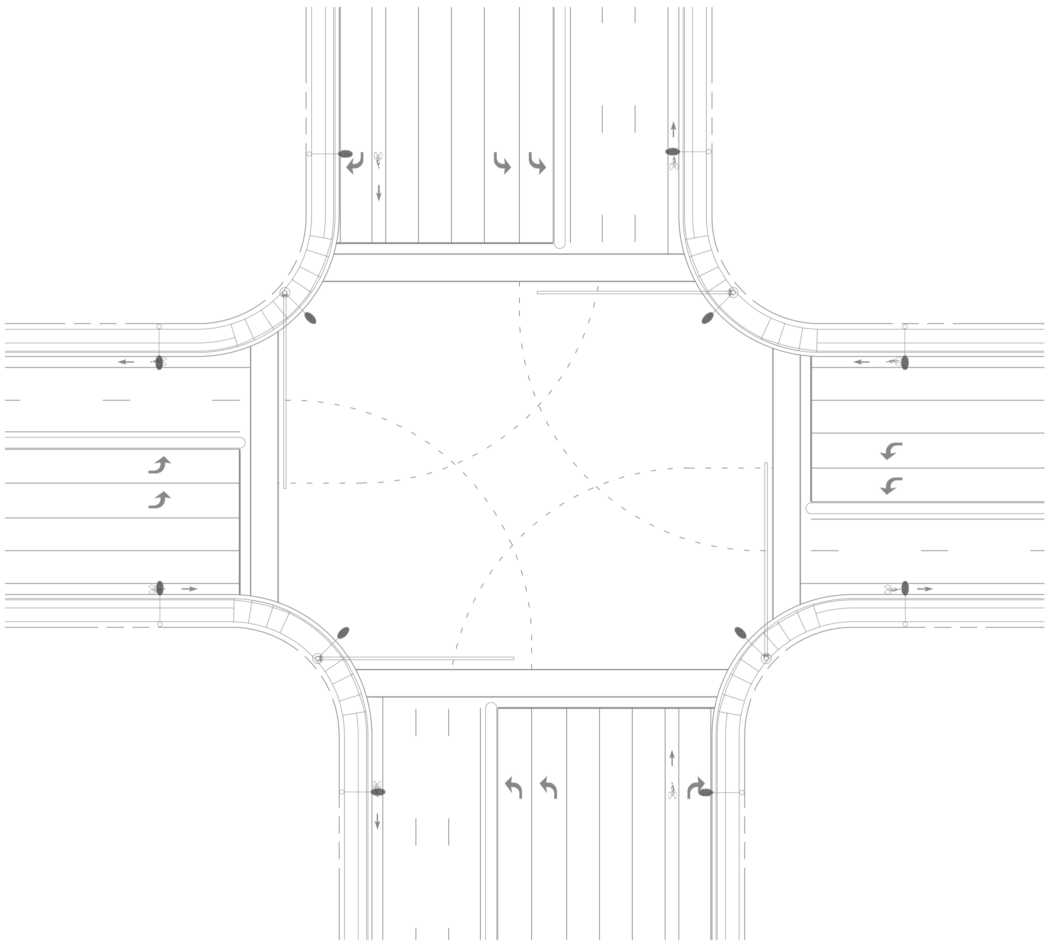


Figure 7.3.4 shows the typical lighting layout for a large intersection. The crosswalk and luminaire locations must be coordinated to optimize the vertical illumination level.

Figure 7.3.4 Typical Lighting Layout for Large Intersection



7.3.2.3 Analysis of Roundabouts

The criteria in ***Table 7.3.3*** will apply to all roundabouts where pedestrian features are provided. Calculate the vertical illuminance for the crosswalk on each near side approach and for each right turn movement in accordance with the methodology outlined in ***Section 7.3.2.2***.

7.3.2.4 Analysis of Midblock Crosswalks

The criteria in ***Table 7.3.4*** will apply to all midblock crosswalks. Calculate the vertical illuminance for the crosswalk on each near side approach in accordance with the methodology outlined in ***Section 7.3.2.2***.

Table 7.3.1 Conventional Lighting – Roadways and Signalized Intersections

ROADWAY CLASSIFICATIONS	ILLUMINATION LEVEL AVERAGE INITIAL HORIZONTAL FOOT CANDLE (H.F.C.)	ILLUMINATION UNIFORMITY RATIOS		VEILING LUMINANCE RATIO
		AVG./MIN.	MAX./MIN.	**Lv**(max)/**L**avg
INTERSTATE, EXPRESSWAY, FREEWAY & MAJOR ARTERIALS	1.5	4:1 or Less	10:1 or Less	0.3:1 or Less
ALL OTHER ROADWAYS	1.0	4:1 or Less	10:1 or Less	0.3:1 or Less
***SIDEWALKS AND SHARED USED PATHS**	2.5	4:1 or Less	10:1 or Less	------

Note: * These values are intended for facilities separate from the roadway. Use illumination levels of the roadway for facilities within the range of the proposed or existing light poles.

Table 7.3.2 High Mast Lighting - Roadways

ROADWAY CLASSIFICATIONS	ILLUMINATION LEVEL AVERAGE INITIAL (H.F.C.)	ILLUMINATION 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 Signalized Intersection Lighting
Urban 3 to Urban 5 Designated Areas*

ROADWAY CLASSIFICATIONS	ILLUMINATION LEVEL AVERAGE INITIAL FOOT CANDLE		ILLUMINATION UNIFORMITY RATIOS		VEILING LUMINANCE RATIO
			AVG./MIN.	MAX./MIN.	Lv(max)/Lavg
MAJOR ARTERIALS	Horizontal (H.F.C.)	3.0	4:1 or Less	10:1 or Less	0.3:1 or Less
	Vertical (V.F.C.)	2.3**	N.A.	N.A.	N.A.

Notes: * Urban 3 to Urban 5 Designated Area are defined in the ***RCI Features & Characteristics Handbook,*** *Urban Classification – Feature 124, Urban Size*

** Vertical illumination value is only valid for new projects or where the intersection is being reconstructed. The vertical illumination is a target value and may not be achievable for all traffic movements.

Table 7.3.4 Midblock Crosswalk Lighting

AMBIENT LUMINANCE	VERTICAL ILLUMINATION LEVEL AVERAGE INITIAL FOOT CANDLE (V.F.C.)
LOW	2.3
MEDIUM & HIGH	3.0

Table 7.3.5 Sign Lighting

AMBIENT LUMINANCE	ILLUMINATION LEVEL AVERAGE INITIAL (H.F.C.)	ILLUMINATION UNIFORMITY RATIOS
		MAX./MIN.
LOW	15 - 20	6:1
MEDIUM & HIGH	25 - 35	6:1

Table 7.3.6 Underdeck Lighting - Roadways

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

Notes:
1. The light levels for underdeck lighting should be equal to the adjacent roadway lighting.
2. The only luminaire to be used for underdeck lighting is a wall mount fixture.

Table 7.3.7 Rest Area Lighting

AREA ILLUMINATED	ILLUMINATION LEVEL AVERAGE INITIAL (H.F.C.)	ILLUMINATION 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

7.3.3 Lighting Justification

Lighting benefits motorists by improving their ability to see roadway geometry and other vehicles at extended distances ahead. This results in greater driver confidence and improved safety, particularly in inclement weather.

The procedure for roadway lighting justification is found in Chapter 14 of the ***MUTS***.

All interchanges on the interstate highway system are to be lighted to assure consistency and to meet driver expectations. A warrant analysis will be required but will not be used as the determining factor for the installation of lighting at these interchanges.

7.3.4 Lighting Project Coordination

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

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

Utilities - The District Utilities Engineer provides the coordination between the designer and the various utilities that may be involved in the project. The Utilities Section may assist in identifying or verifying conflicts with overhead and underground utilities.

The Utilities Engineer should be contacted as soon as pole locations are set and the electrical load has been determined. The designer should coordinate with the utility company providing power on the preferred location for the electrical service.

Drainage - Coordinate with the Drainage Section to assure that high water tables, stormwater retention areas, or other water bodies will not be a problem with the proposed location of light poles and the light pole pull boxes.

Structures Design - Standard foundation design for conventional and high mast light poles are provided in the ***Design Standards***. A foundation design is only required in special cases. The Engineer of Record for Structures Design determines the foundation design for high mast poles based on soil information. The Engineer of Record should be contacted early in the design phase to allow adequate time for coordination with the Geotechnical Engineer in obtaining soil borings.

Coordinate locations and attachments of lights and conduits on bridge structures with the bridge structural designer. Include light and conduit locations, and attachment details in the plans. Refer to ***Structures Design Guidelines***, ***Section 1.9*** for details and restrictions related to bridge attachments.

Typically, 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 present a potential problem. Coordinate with the District Aviation Coordinator when a project is within 5 miles of an airport.

Modification for Non-Conventional Projects:
Delete ***PPM*** 7.3.4 and replace with the following: **7.3.4 Lighting Project Coordination** The Lighting Engineer of Record is responsible for all necessary coordination.

7.3.5 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%.

7.3.6 Existing Lighting During Construction

The maintenance of existing lighting will 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 must specify the scope of the contractor's responsibility for the maintenance of existing lighting.

7.3.7 Grounding

The grounding requirements for lighting systems, as shown in the ***Design Standards*** are 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***.

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

7.4.1 Design Criteria

The lateral offset requirements for signal poles and controller cabinets are given in ***Chapter 4*** of this Volume. Final location of these devices must be based on the safety of the motorist, visibility of the signal heads, ADA requirements, and access by maintenance.

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

7.4.2 Certification and Specialty Items

Traffic control signals and devices installed in Florida are required to be certified by the Department. The Traffic Engineering and Operations Office in the Central Office is charged with the responsibility of certifying traffic control equipment. If requiring new equipment types or types not typically used, contact Central Office Traffic Engineering to determine the certification status of the equipment. Noncertified equipment cannot be used.

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 ensure 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.

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 on state and local roadways must include initial timings of all controllers in the plans set. If the timings provided 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 in the field will not be allowed and replacement of the assembly is required. Contact the District Traffic Operations Engineer before making the decision to expand or replace an existing controller assembly.

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

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. Protected/Permissive Phasing

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

Option #2: A flashing yellow arrow signal indication may be used. A flashing yellow arrow must use a separate four section head positioned over the center of the left turn lane.

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

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

3. Separated Turn and Thru Lanes – For signal operation guidelines for separated left turn and thru lanes, see ***Section 3.2 of the Traffic Engineering Manual***.

4. Single Lane Approach on Stem of "T" – Two three-section heads are required as minimum.

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.

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

NOTE:

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

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

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

7.4.6 Signal Preemption

Check each intersection to determine if there is a requirement for signal preemption. Refer to ***Department Procedure 750-030-002*** for information on the conditions for which preemption is required, or should be considered.

Modification for Non-Conventional Projects:
Delete ***PPM*** 7.4.6 and coordinate requirements with the local maintaining agency.

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. For this calculation use the Design Hourly Volume (DHV) based on the Department's Standard K factor and not a peak to daily (P/D) ratio based on a 24-hour count.

The K, D, and T factors convert the two-way AADT volumes to a one-way Design Hourly Volume. 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***. 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). The introduction of right turn lanes can impact pedestrian crossing distances at signalized intersections; therefore, additional analysis may be required to weigh the impacts of increased pavement width and signal operations.

7.4.8 Signal Loops

Traffic signal loops are detailed in the ***Design Standards, Index 17781*** and are suitable for most locations.

The traffic signal design for each intersection must include the requirement for type and placement of loops. ***Design Standards, Index 17781*** allows for minor modifications in size and placement of the loops. These modifications are used only when required by site conditions for a particular location.

7.4.9 Grounding and Electrical Bonding

The grounding requirements for traffic signal components, as shown in the Design Standards, are 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.

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.

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 Mast Arm Supports

Meet the following criteria for new signals installed on the State Highway System:

1. Intersections within the ten mile coastline boundary, as defined by the State Traffic Engineering Office Implementation Guidelines (aka mast arm policy area):

   Signals must be supported by galvanized mast arms, with the signal head(s) rigidly attached to the mast arm, along corridors within the ten mile coastline boundary. When it is impractical to use a mast arm or overhead rigid structure within the ten mile coastline boundary, a two point span wire assembly with adjustable hangers must be used and a Design Variation must be approved in accordance with ***Chapter 23*** of this

Volume. The Department will cover the cost for a galvanized mast arm only. If the Local Maintaining Agency wants a painted mast arm, they must provide the additional funding and commit to cover the maintenance cost.

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

2. Signalized Intersections outside the ten mile coastline boundary:

   Signals along all corridors outside the ten mile coastline boundary must be supported by two point span wire assembly with adjustable hangers. If the Local Maintaining Agency prefers a mast arm, they must provide funding for the incremental increase in construction cost, and if the requested mast arm is to be painted, they must also commit to cover the maintenance costs.

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

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

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

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

7.4.11 Traffic Signal Project Coordination

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

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

Utilities - The District Utilities Engineer provides the coordination between the designer and the various utilities that may be involved in the project. The Utilities Section may assist in identifying or verifying conflicts with overhead and underground utilities.

The designer should coordinate with the utility company providing power on the preferred location for the electrical service.

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

Coordinate locations and attachments of traffic signals and conduits on bridge structures with the bridge structural designer. Include traffic signal and conduit locations and attachment details in the plans. Refer to ***Structural Design Guidelines***, ***Section 1.9*** for details and restrictions related to bridge attachments.

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

Modification for Non-Conventional Projects:
Delete ***PPM*** 7.4.11 and replace with the following: **7.4.11 Traffic Signal Project Coordination** The Traffic Signal Engineer of Record is responsible for all necessary coordination.

7.4.12 LED Light Sources

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

7.4.13 Pedestrian Countdown Signal Applications

The countdown pedestrian signal is the standard head device on all projects that include pedestrian signal installations. Refer to ***Traffic Engineering Manual, Section 3.9***, for criteria related to pedestrian signal installation and operation.

7.4.14 Number of Signal Heads for Through Lanes

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

7.4.15 Backplates

Install louvered backplates on all signal sections for all approaches. Retroreflective backplate borders are required for all backplates where the posted speed for the approach is 45 mph or greater. Retroreflective borders are recommended for all backplates where the posted speed for the approach is less than 45 mph.

7.4.16 Span Wire Assemblies

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

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

Modification for Non-Conventional Projects:
Delete the last two sentences of the above paragraph.

7.5 Intelligent Transportation System (ITS) Components

The plans preparation information provided in this section applies to the placement and installation of ITS devices and systems along Florida's roadways. Specifications for traffic control devices, including ITS device requirements as adopted by the Department are published by the State Program Management Office and are available online at the FDOT Web site. Plans involving ITS devices must also include provisions for grounding and surge suppression to protect equipment and to 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 must be familiar 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.

If the project involves Intelligent Transportation Systems (ITS) technologies, requirements specified in FDOT Procedure (Topic Number: 750-040-003) must be followed. This is to ensure compliance with Code of Federal Regulations (CFR) Chapter 23 Part 940 Section 940.11, and Department requirements. Authorization of federal funds for construction or implementation of the project, and subsequent reimbursement of approved expenditures cannot proceed until after compliance with this procedure is demonstrated. Lateral offset requirements for poles, sign structures, field cabinets, and communication hubs for deployments must conform to those provided in ***Chapter 4*** 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 are traffic control devices and follow approval requirements discussed in ***Section 7.4.2***.

Ensure that 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. Incorporate features and functions that allow interoperability with other ITS deployments throughout the region and state including existing Regional Transportation Management Center (TMC) hardware and software. 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® 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 (mounting height, attachment type, position along roadway) and installation requirements (including communication, cabinet details, and power), roadway geometrics, street names, construction stationing, milepost information or reference points, right of way lines, location of utilities, and presence of other roadside features such as vegetation, landscaping, or existing devices that may impact device locations in the field.

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)

DMS sign types include walk-in, front-access, or embedded with monochrome (typically amber text), full-color, or tri-color displays. Select the appropriate sign type based upon project-specific needs.

Design the DMS and support structure in accordance with ***Chapter 29*** of this Volume. The DMS should be centered over the roadway on mid- or full-span structures.

The DMS should be positioned to be legible from the roadway, taking into account the display characteristics of DMS technology (e.g., the vertical and horizontal viewing angles of the LED displays). Placement of a DMS installation should be determined by project-specific needs, as well as the following general design criteria:

1. The DMS design should take into account the message library proposed for use on the project, including text and graphics. Utilize DMS capable of displaying minimum character heights per the MUTCD, Section 2L.04.
2. Placement on freeways prior to interchanges that offer alternate routes.
    a. In advance of 1-mile exit signing.
    b. Maintain minimum 800-foot spacing between existing and planned overhead static sign panels and other signs, per the MUTCD. DMS should be installed on support structures without any static signage, except for changeable message elements. Consider increased spacing when conditions allow.
    c. Maintain minimum of 1450-foot distance from decision points (meets MUTCD/AASHTO Green Book requirements).
    d. In advance of interchanges where interstates meet to allow for advance messaging of traffic conditions on both roadways. Consider locations that are two exits before major interchanges as well as immediately prior to the interchange.
3. Placement on arterials prior to major intersections and interchanges.
    a. At a distance approximately 1/4 to 1/2 mile in advance of major intersections and interchanges.
    b. At a location at least 600 feet from adjacent signalized intersections.
    c. At a location where the DMS is continuously visible to motorists for at least 600 feet.
    d. At a location where no existing or planned guide signs exist within the 600-foot minimum visibility distance.
    e. At a location with minimum interference from lighting, adjacent driveways, side streets, or commercial signage.
    f. At locations where no historical neighborhoods exist.
4. Placement in advance of high crash locations and traffic bottlenecks.
5. At a location where sufficient space is available between the edge of travel lanes and the right of way limits. The space must be wide enough to allow the DMS structure to be located within the right of way limits, while meeting the minimum clear zone requirement.
6. At a location where no conflict with underground or overhead utilities exists.
7. Placement that accommodates access for service and maintenance.
8. Placement in advance of major system interchanges.

9. Placement along key commuter or evacuation corridors.
10. At a location downstream of rural interchanges in order to inform entering traffic of conditions ahead.

The sign housing 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 must 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 must also include highway signs with remotely operated flashing beacons to notify motorists of HAR broadcasts.

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

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.
6. Placement of flashing beacon signs within the HAR coverage area prior to exit signs or DMS associated with an interchange.
7. Wood poles are often recommended by HAR manufacturers for antenna mounting to reduce interference that may occur with conductive poles. Check antenna requirements of proposed HAR manufacturers.

7.5.4.3 Road Weather Information System

Locate the environmental sensor station (ESS) associated with the road weather information system (RWIS) where its weather observations will be the most representative of the roadway segment of interest.

The poles or structures on which weather instruments are mounted are frequently installed within a range of 30 to 50 feet from the roadway's edge to avoid the effects of passing traffic (e.g., heat, wind, splash), yet still be able to detect the weather conditions affecting motorists there. The location of ESS poles, towers, or other structures must conform to the lateral offset requirements in ***Chapter 4*** of this Volume.

Avoid standing water or locations where billboards, surrounding trees or other vegetation would affect the weather measurements. Median placement of an ESS on a divided highway is generally not feasible unless the median is 100 feet or wider. For more siting criteria, refer to the ***FHWA's Road Weather Information System (RWIS) Environmental Sensor Station Siting Guidelines**, **Publication No. FHWA-HOP-05-026***.

Consider the communication link the RWIS installation requires for transmitting the weather data. FDOT RWIS deployments commonly utilize Ethernet communications over a fiber optic network. Satellite-based data collection packages using standards for National Oceanic and Atmospheric Administration (NOAA) and certification standards version 2 (CS2) certification for Geostationary Operational Environmental Satellite (GOES) transmission have also been deployed as part of a statewide wind speed warning system. Use of satellite-based systems must be coordinated with the FDOT ITS Telecommunications Office.

7.5.5 Video Equipment

7.5.5.1 Closed-circuit Television Systems

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 for traffic and incident management. Cameras are also required for visual confirmation of dynamic message signs and ramp signal operation, as well as security purposes.

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 on the interstate should be located to obtain a complete view of roadway features including lanes, shoulders, ramps, emergency stopping sites, and accident investigation sites. Cameras at interchanges should be able to view arterial traffic.
2. Camera location should provide the ability to view any nearby DMS for message verification.
3. Camera location should provide the ability to view crossing features (e.g., streets, rail, bridges).
4. Lateral offset to camera structures must be in accordance with ***Chapter 4*** of this Volume.
5. Device placement should accommodate service and maintenance access with minimal impact on traffic. For example, 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.

Coordinate the CCTV placement with other design features to assure a clear unobstructed view. Position the camera to reduce the risk that critical views will be blocked by the mounting structure.

Designs and plans must specify camera mounting height. Mounting height should be determined 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.

Refer to ***Design Standards, Index 18111*** or ***Index 18113*** for CCTV camera pole and foundation requirements.

7.5.5.2 Video Display Systems

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 video 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.

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 having to make modifications to existing doorways, walls, floors, or ceilings.

7.5.6 Network Devices

Network devices include a variety of Internet Protocol (IP)-addressable electronic equipment used for the collection and dissemination of video, traffic data, and other information. Coordinate with the local District's IT staff to obtain network specific requirement and information for communication network design. Network devices designed on a project must be compatible with existing network equipment currently in operation.

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 network trunk interconnection point. Consider distance limitations for common Ethernet media types when developing the design. 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.

Provide an Ethernet port for the connection of each planned ITS field device along with spare capacity.

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 include vehicle detection systems, RWIS stations, and other low-speed data output devices.

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 must meet project-specific needs, as well as include the following information:

1. Facility diagrams illustrating facility routes.
2. General network topology.
3. Network diagrams, including communication hub details
4. External network connections and demarcation points

Include special provision ***SP0071101-Tolls*** in the contract documents when there are existing communication cables that transmit toll system information near areas where work is to be performed. This special provision expands requirements for preservation of property to specifically address repair of toll collection system components damaged by the contractor. The special provision also makes the contractor responsible for revenue loss that results from such damage.

7.5.7.1 Fiber Optic Cable

Fiber optic cable is utilized in FDOT's statewide network infrastructure to provide data and device control communications between TMCs, RTMCs, ITS devices, and other identified stakeholder facilities.

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.

Indicate in the plans the innerduct type, size, and quantity when specific conduit is required. Proposed conduit systems should avoid chronic wet locations.

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. Plans must identify splice points and provide splicing diagrams that detail the interconnection of specific fiber strands to be constructed, their origination and final destination points, and expected link loss.

Plans must identify existing fiber optic cables in the vicinity of the work and the location of the nearest full splices in the existing cables, including distance in each direction. This information is necessary to identify the cable(s) and splice(s) that would need to be reconstructed in the event they are damaged during construction. Damaged cables are replaced to the nearest existing full splices.

Fiber optic cables must be terminated using a fiber patch panel (FPP). The FPP allows connection of optical fibers to the electronic equipment and devices located throughout the network. Coordinate selection of connector types and other fiber optic system components with the local District ITS staff.

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, locate wire, access points, and buried cable warning tape.

The design and construction of the designating system should meet the following functional requirements based on project needs:

1. Provide visual notification of the presence of the conduit.
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 (locate wire) attached to the conduit system for conductive facility locating.
4. Provide above-ground access to the locate wire.

7.5.7.5 Pull, Splice, and Junction Boxes

Provide access points using pull, splice, or junction boxes according to the type, size, and quantity necessary for the project. Consider the following minimum functional requirements for access points:

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 sufficient space for entry and routing of the fiber optic cables.

Place access points at the following locations:

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 turns in the conduit system.

Splice boxes are preferred for access points on fiber optic cable backbone routes. Access or fiber splices to existing fiber optic backbone cables must only be made at the nearest existing splice box. Use pull boxes for 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 Lightning Protection

Effective grounding and lightning protection is generally achieved through a combination of three primary techniques: proper bonding and installation of grounding rods, air terminals, and surge protective devices (SPDs). These three methods work concurrently to protect ITS equipment installed in the field and must be incorporated, as applicable, in ITS design plans.

When developing plans that include these systems consider existing geological and other physical characteristics (e.g. rock formations, underground utilities, gravel deposits, soil types and resistivity, and groundwater) at proposed installation locations that may affect the design or layout of grounding systems. . Include in the plans any pertinent survey data gathered during plans development, such as soil resistivity measurements.

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. Provide details in the plans related to cable routing and other installation details required to maximize the efficiency of grounding and SPDs.

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

1. Follow best practices defined in the NFPA 780 Standard for the Installation of Lightning Protection Systems and NFPA 70, National Electric Code.
2. Place SPD equipment so that grounding connections are as short and straight as possible.
3. Conductor routing must avoid bending and provide physical separation between low-voltage and high-voltage signal paths.
4. Avoid routing unprotected wires or grounding wires parallel or adjacent to protected wiring.

7.5.8.2 CCTV Pole and Lowering Device

Provide a lowering device for pole-mounted devices where height precludes easy access using a bucket truck. Coordinate with the local District ITS office on the use and selection of lowering devices.

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 (e.g., air terminal, etc.).

Consider the placement of all devices on the pole and how they may affect the ability to utilize the lowering device. Use of lowering device should not require an operator to stand directly beneath the equipment while it is being lowered.

7.5.8.3 ITS Field Cabinet

Base the location of the cabinet on safety of the motorist, visibility of roadside devices, and safe access by maintenance staff. ITS field cabinets can be base mounted on a concrete pad, structure mounted, or pole mounted. Coordinate placement with existing and proposed drainage features to prevent cabinet flooding. Consider safety features such as service slabs and railings for cabinets placed at locations with slopes steeper than 1:2.

Size the cabinet to accommodate the equipment to be installed inside. In addition, the cabinet size should account for ease of access to the equipment and the ability to achieve proper ventilation. The placement of devices in the cabinet must be consistent throughout a project. If a specific cabinet orientation or door swing is required, this can be shown in the plans.

7.5.8.4 Equipment Shelter

The lateral offset to equipment shelters must be in accordance with the requirements of ***Chapter 4*** of this Volume***.***

Though equipment shelters are prefabricated in large part, include the following in the plans:

1. Details of the site layout, including the shelter dimensions, site preparation work, fencing, landscape, conduit and pull box installation, as well as details for electrical, lighting, grounding, alarm, and HVAC systems necessary to accommodate the types and quantity of equipment the shelter will house.

2. Details that illustrate the equipment layout inside the shelter, including positioning of overhead cable trays, the quantity and placement of standard EIA/TIA 19-inch racks, demarcation and patch panels, and the equipment placement within each rack.

3. Details of back-up power systems such as UPS, generator, fuel tank, security cameras, security alarms, and other security features.

7.5.9 Vehicle Detection and Data Collection

Perform a technology assessment and select a vehicle detection technology that supports the data collection needs for the project.

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.

For vehicle detection systems, such as those utilizing video, microwave, magnetic field, or AVI 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.

7.6 Pavement Markings

Pavement marking design must comply with ***FDOT Standard Specifications, FDOT Design Standards, FDOT Traffic Engineering Manual (TEM)*** and ***FDOT Manual on Uniform Traffic Studies (MUTS).***

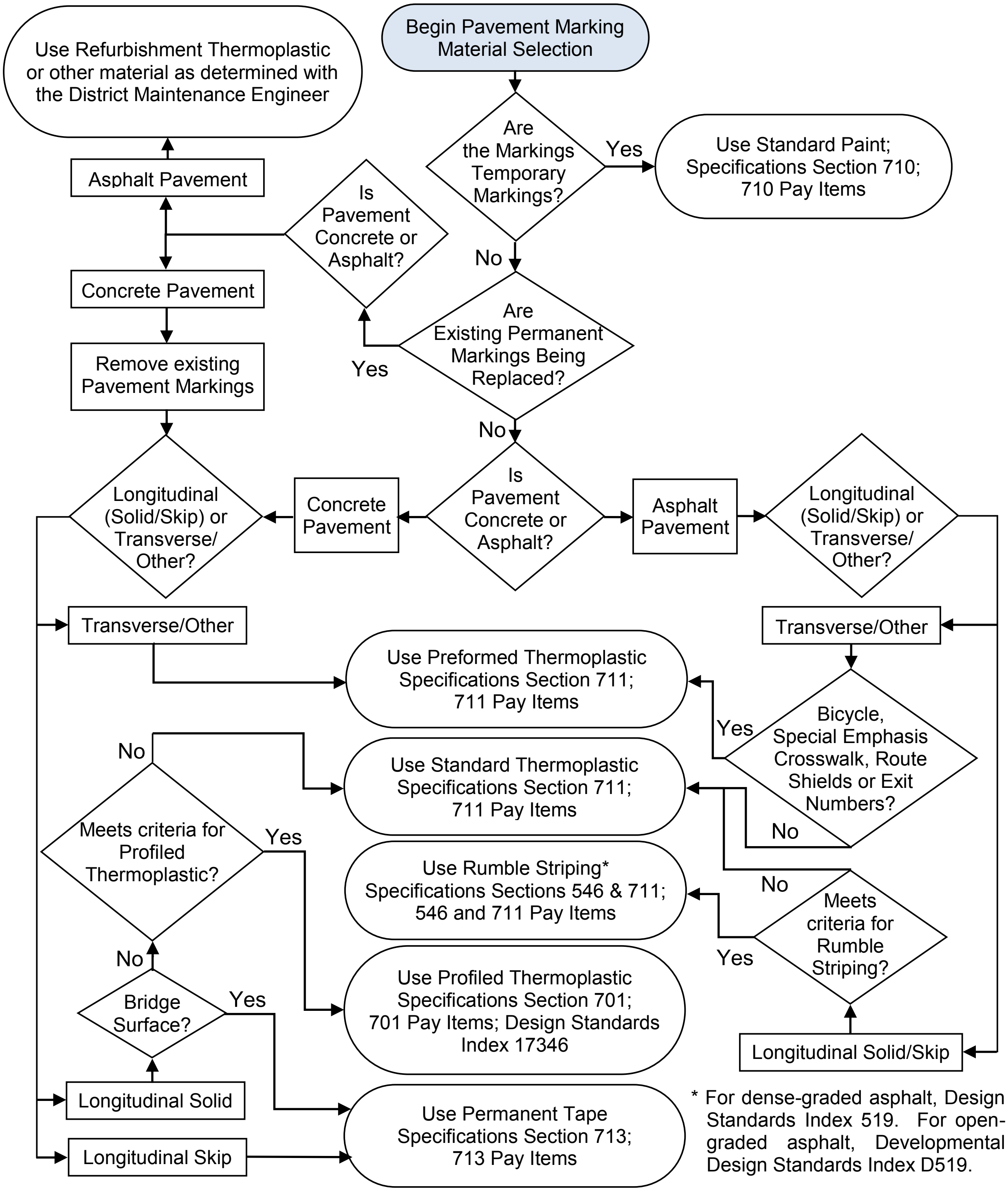
Manual on Uniform Traffic Control Devices (MUTCD) - The ***MUTCD*** was adopted by the Department as the uniform system of traffic control for use on the streets and highways of the State. This action was in compliance with ***Chapter 316.0745*** of the ***Florida Statutes***. The ***MUTCD*** is therefore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

7.6.1 Selection of Pavement Marking Material

Use the flowchart shown in ***Figure 7.6.1*** as a tool to assist in determining the appropriate pavement marking material.

Once the pavement marking material is selected from ***Figure 7.6.1***, verify the project meets the criteria discussed in ***Sections 7.6.1.1*** through ***7.6.1.6***.

Figure 7.6.1 Pavement Marking Material Selection



* For dense-graded asphalt, Design Standards Index 519. For open-graded asphalt, Developmental Design Standards Index D519.

7.6.1.1 Standard and Refurbishment Thermoplastic

Use Standard Thermoplastic traffic stripes and markings unless Rumble Striping, Profiled Thermoplastic, Preformed Thermoplastic or Permanent Tape is required. Standard Thermoplastic is not used on bridge structures with concrete riding surfaces due to vibration and durability issues.

Refurbishment Thermoplastic is the placement of new thermoplastic material on existing pavement markings. Refurbishment Thermoplastic is not to be used on concrete riding surfaces; i.e. concrete pavement and bridge structures. Remove existing stripes and markings from concrete surfaces before placing new stripes and markings.

The performance of Refurbishment Thermoplastic has been evaluated by the Department for a period of 36 months. Coordinate with the District Maintenance Engineer to determine if Refurbishment Thermoplastic is appropriate. If Refurbishment Thermoplastic cannot be applied without exceeding the maximum thickness of 0.15 inch, remove the existing stripes and markings before placing new stripes and markings.

Coordinate with the District Maintenance Engineer to determine if black paint contrast is required for skip lines, messages and arrows.

Modification for Non-Conventional Projects:
Delete the last two paragraphs above and see the RFP.

7.6.1.2 Rumble Striping

Rumble Striping provides an audible and vibratory effect and is used on asphalt pavement as a countermeasure for lane departures and centerline crossover crashes. Rumble Striping is created by utilizing the grinding process as shown in ***DDS***, ***Index D519***. Thermoplastic markings are installed over the ground-in rumble strips producing "Rumble Striping". Contrast marking is not used with Rumble Striping.

For flush shoulder roadways with a posted speed of 50 mph or greater, see Usage Criteria in the ***Instructions for Developmental Design Standards (IDDS)*** for Index D519 (IDDS-D519) to determine if the Index D519 should be requested and used on the project.

7.6.1.3 Profiled Thermoplastic

Profiled Thermoplastic provides an audible and vibratory effect and is used on concrete pavement as a countermeasure for lane departure and centerline crossover crashes. Contrast marking is not used with Profiled Thermoplastic markings.

Use Profiled Thermoplastic for edge line(s) and centerline striping on flush shoulder roadways with a posted speed of 50 mph or greater. Do not exclude sections of the project where the posted speed has been reduced due to restricted horizontal or vertical geometry (i.e. Advisory Speed). Refer to ***Design Standards, Index 17346*** for additional information.

Use Profiled Thermoplastic on concrete limited access roadways with concrete shoulders in lieu of shoulder ground-in rumble strips. Refer to ***Design Standards, Index 518*** for additional information.

Profiled Thermoplastic markings may be used for edge lines on two-lane roadways that do not have paved shoulders.

Profiled Thermoplastic markings may be used for edge lines on bridges with narrow shoulders as a countermeasure for barrier impacts.

7.6.1.4 Preformed Thermoplastic

Use Preformed Thermoplastic on all pavement types for the following markings:

- Bicycle Markings and Shared use Path Markings (see ***Design Standards***, ***Index 17347***)
- Special Emphasis Crosswalks (see ***Design Standards***, ***Index 17346***)
- Route Shields (see ***TEM***)
- Ramp Exit Numbers (see ***Design Standards***, ***Index 17346***)

Use Preformed Thermoplastic on concrete riding surfaces (i.e., concrete pavement and bridge structures) for the following markings:

- White dotted Lines (2'-4') with trailing black contrast; i.e. 2 feet white Preformed Thermoplastic plus 2 feet black Preformed Thermoplastic. Use only the alternating skip pattern.

- Arrows, Messages and Symbols. Black contrast border is required for design speeds 45 mph and less. Black contrast block is required for design speeds greater than 45 mph.

7.6.1.5 Permanent Tape

Use Permanent Tape on all concrete riding surfaces (i.e. concrete pavement and bridge structures) for the following markings:

- White skip lines (10'-30') with trailing black contrast; i.e. 10 feet white tape plus 10 feet black tape. Use only the alternating skip pattern.
- White dotted lines (6'-10') with trailing black contrast; i.e. 6 feet white tape plus 6 feet black tape. Use only the alternating skip pattern.
- White dotted lines (3'-9') with trailing black contrast; i.e. 3 feet white tape plus 3 feet black tape). Use only the alternating skip pattern.
- Yellow skip lines (10'-30'). Do not use contrast.

Use Permanent Tape for centerlines and edge lines on bridges with concrete riding surfaces. Do not use contrast.

Remove existing stripes and markings from concrete surfaces before placing new permanent tape.

7.6.1.6 Two Reactive Components

Two Reactive Components may be used as an alternative to Standard Thermoplastic markings for edge lines and skip lines on asphalt pavement and only edge lines on concrete pavement.

Two Reactive Components pavement markings may be feasible for large projects. The use of Two Reactive Components pavement markings must be approved by both the District Maintenance Engineer and the District Construction Engineer.

For existing asphalt pavement, contact the District Maintenance Engineer to determine if black paint contrast is required for skip lines, messages and arrows.

Modification for Non-Conventional Projects:
Delete the last two paragraphs above and see the RFP.

7.6.2 Work Zone Pavement Markings

Use Standard Paint for work zone markings on asphalt and concrete pavement. The performance of Standard Paint has been evaluated by the Department for a period of 6 months.

Use Removable Tape for transitions on the final asphalt surface.

Consider using Refurbishment Thermoplastic when a work zone phase is expected to last for more than a year under heavy traffic volumes.

7.6.3 Refurbishment Applications

For refurbishment markings, consider the following factors:

- Service life of pavement
- Thickness and conditions of existing markings
- Traffic volumes
- Cost of markings
- Other special requirements such as contrast needs or rumble striping

7.6.4 No-Passing Zones

Follow the procedures contained in the ***Manual on Uniform Traffic Studies, (MUTS)*** for determining the limits of no-passing zones.

Limits of pavement markings for no-passing zones will 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 will be accomplished as part of the design phase. The limits of the no-passing zones will be shown on the plans.

2. On projects with new or altered vertical and horizontal alignments, limits for no-passing zones will be established during construction. The required traffic study and field determination of limits will be performed by the designer during post design. Sufficient time must be included to accomplish the required field operations without delaying or interfering with the construction process.

7.6.5 Pavement Marking Project Coordination

Coordination with other offices and agencies is a very important aspect of project design. The offices discussed in this section are typically involved in a signing and marking project, however there may be other offices.

Roadway Design - The designer of pavement marking project receives the base sheets for design from the roadway designer. Base sheets may be created from existing plans when the pavement marking project is not part of an active roadway design project.

Modification for Non-Conventional Projects:
Delete ***PPM*** 7.6.5 and see the RFP.

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