Appendix E Traffic Control Device Design Guidelines

(New 11/27/12)

1.0 INTRODUCTION

The following module establishes guidelines which compliment the specifications set forth in Section 03000 – *Signals* of the City's Manual of Specifications and Standard Details (latest edition) and also Section 700 of the Virginia Department of Transportation (VDOT) Specifications for Road and Bridge Construction (latest edition).

This section provides the Design Engineer with the specific information and direction needed to prepare plans and specifications for construction of traffic signalization and related control devices in accordance with the requirements of the City of Lynchburg. These devices include traffic signals, intersection caution beacons, and school zone caution lights. The design guidelines are provided as a supplement and are not to supersede the Federal Manual of Uniform Traffic Control Devices (MUTCD). In addition to City guidelines and the MUTCD, some recommended design references include the Manual of Traffic Signal Designs, Traffic Signal Installation and Maintenance Manual (Institute of Transportation Engineers publications), and the Federal Highway Administration Traffic Control Devices Handbook.

Every effort has been made to make the information in this section as complete and accurate as possible. However, it must be recognized that due to the nature of this subject, providing a thorough set of guidelines that will cover all designs without exception is impossible. Additionally it is reasonable to expect that the guidelines and standards will be revised because of changes in policy or practices. As changes occur, this section will be amended to reflect current policy and practice. The Design Engineer should be completely familiar with this section and should request information from the City Traffic Engineer (CTE) concerning revisions, before commencing design.

2.0 TRAFFIC SIGNAL PLANS

2.1 The traffic signal plans shall consist, at a minimum, of the following sheets:

A. Cover sheet with project name, city project number, city engineering project number, location map, and signature blocks.

B. Survey sheet (plan sheet showing survey file only).

C. General Notes and Tabulation of Quantities sheet.

D. Signal Plan sheet.

2.2 The following information will be shown on the traffic signal plan sheet:

A. **Base Plan** – A base plan prepared from an accurate field survey will be used for the traffic control device plan sheet. The base plan will be prepared so that the full traffic control device installation appears on one plan sheet.

B. A North Arrow.

C. **Scale** – A written and graphic scale will be provided. Typical design scales are 1"=20' and 1"=25'.

D. **Legend** – The same legend symbols will be used consistently throughout the traffic control plan sheets in the plan set. Where the project only includes traffic signalization, and is not part of the road construction project, the legend will also be shown on the plan sheet. Symbols will be the same as those used by the Virginia Department of Transportation. (VDOT). Contract Traffic Engineering for a list of these symbols and a list of unique items not identified by VDOT.

E. **Title Block** – Each traffic control device plan sheet will include a title block. It will be located in the bottom right or right side of the sheet and will contain as a minimum the following information: the full name of the intersection, the type of plan sheet, date, and the CIP project number when applicable.

F. Timing Plan and Phase Sequence Diagram, including preemption phasing as applicable.

G. Coordination plan and communications plan and devices.

H. Signal Head Display Detail and Wiring Diagram.

I. Conductor Schedule by Conduit.

J. **Right-of-way** – All traffic control devices, including signing and pavement markings will be located in the right-of-way or in traffic control easements.

K. **Traffic Control Easements** – If traffic control easements are required, they will be shown on the plan with dimensions, along with the name of the property owner.

L. **Detection System Zones** – Detection zones shall be shown in the plan view. A shaded rectangle shall be drawn to depict the zone for which the overhead detection devices will detect approaching vehicles.

M. **Underground and Overhead Utilities** – the Design Engineer will identify and show all utilities in the vicinity of construction on the plan. IMPORTANT NOTE: The Design Engineer must try to ensure that the construction of the traffic control devices does not conflict with any existing or proposed utilities.

N. **Existing Traffic Control Devices** – All existing traffic signalization and interconnect cable facilities will be shown and identified on the plan. The plans will provide sufficient detail identifying all equipment where existing signalization is to be retained or removed.

O. **Signs** – All regulatory and warning signing, necessary for the operation of the traffic control device, will be shown on the plan sheet and identified on the Legend. The signing to be shown on a typical traffic signalization plan would include the following: Street Name signs, MUTCD R10-12 LTYOG signs,

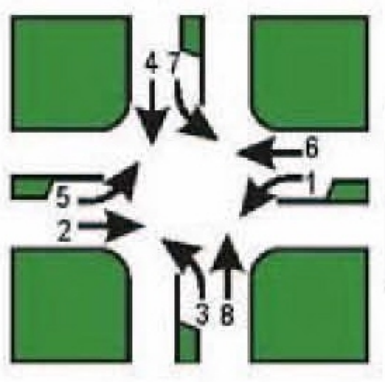
MUTCD W3-3 Signal Ahead signs; Pedestrian pushbutton signs, and NO TURN ON RED signs. The plan will also identify existing signing to be removed, such as STOP signs and post mounted street name signs.

P. **Proposed Pavement Markings** – The designer shall show any changes to the pavement markings on the plan sheet. All existing markings to remain shall be refreshed to 150 feet back from the STOP bar on all approaches as needed.

Q. Signal equipment and pole legend.

3.0 TRAFFIC SIGNAL PHASING

All vehicle and pedestrian traffic movements will be identified in accordance with the National Electrical Manufacturer's Association (NEMA) standards. Phase assignments for full eight-phase operation, with either protected or protected/permitted left turn movements, are made as follows:



When the left turn movement is permissive only, the phase number is not used. Here the left turn movement has the same phase number as the adjacent through movement. For example, on a major street running north-south, if the northbound left turn movement is permissive only, then the northbound left turn and northbound through movement will both be identified as Phase 6.

Pedestrian movements are not numbered, unless there are pedestrian signals or pedestrian view signal displays. If there are ped signals, they will be designated by placing a "P" in front of the corresponding signal phasing and movement.

The designer shall make all attempts to avoid using split phasing. However, if split phasing is unavoidable, then the movement that is to be served in the sequence first, will be assigned as Phase 3. The movement immediately following will be assigned as Phase 4.

The designer shall avoid the use of right turn phasing, except where engineering judgment deems it necessary.

The designer shall be careful not to recommend a phasing scheme that results in

simultaneous right-of-way being assigned to conflicting movements, particularly pedestrian movements. For T intersections, if pedestrians may be present, then the designer shall be careful not to use green arrows that would preclude the pedestrians from having a walk phase, if pedestrian signals are present, or have an opportunity to cross concurrently with the side street (stem of the T) phase. At T intersections the designer should coordinate with the CTE to determine if green arrows or green balls should be used for the side street approach.

Initial controller timings for AM and PM periods, based on analysis of recent traffic counts, shall be included on the plan or general notes sheet. Yellow change and all red clearance intervals shall be based upon ITE calculations. No yellow clearance shall be less than 4 seconds for through movements and 3.5 seconds for left turn movements. All signalized intersections shall have at least 1 second of all red clearance between the major movements.

4.0 TRAFFIC SIGNAL DISPLAY AND WIRING

4.1 Traffic Signal Display Selection

A. All vehicle displays will be 12 inches, except for special applications noted elsewhere in this chapter.

B. All protected left turn signals will have green arrow, amber arrow, and red ball displays.

C. All traffic signal heads, visors, back plates, and pedestrian heads shall have either a durable, flat black finish or the standard yellow finish as specified by the plans.

D. At sharply skewed intersections, the designer should consider specifying standard signals with louvered visors, to shield the displays from conflicting movements.

E. All signal heads shall be LED.

F. Display characteristics of LED balls shall present the appearance of incandescent type bulbs. The lens shall show full illumination, not discrete points of light. LED arrows shall be IO look. The preferred signal lenses are those manufactured by Dialite (or equal).

G. Signal heads shall be polycarbonate (Indian/McCain/Eagle or approved equal).

H. Polycarbonate back plates, designed for the specific brand of signal head being used, will be provided for all signal heads.

4.2 Traffic Signal Head Wiring

Unless otherwise specified by the CTE, all cable used for wiring vehicle signals

will be 14AWG/5 or 7 conductor cables conforming to IMSA Specification 19-1 (stranded), 1991. The designer will confirm the plan notes or specifications as appropriate to satisfy this requirement.

A five (5)-conductor cable will be specified for a circuit serving a three (3)-section signal head used for through or protected turn movements. Unless otherwise noted, a seven (7)-conductor cable is to be specified for circuits operating a left turn head. This will simplify any future modification to convert the movement to a protected/permitted operation.

Cable runs will be continuous from the controller cabinet to each signal head. The designer will not specify the splicing of signal cables in hand holes or junction boxes, without prior written approval of the CTE.

5.0 VEHICLE DETECTION

Standard practice is to design all traffic signal installations to operate in a fully actuated vehicle detection mode. All new and modified traffic signal installations will use video detection unless otherwise approved by the CTE. Video detection zones will be placed on all through and left turn lane approaches. Detection zones in exclusive right turn lanes may also be necessary under certain conditions. The CTE must be contacted for a decision to use exclusive right turn lane detection.

5.1 Video Detection

The preferred method for detection is by overhead video camera. The designer shall use video detection for all signalization designs unless specifically directed otherwise by the CTE. Video detection equipment shall include overhead video camera, with zoom and focus features (and video monitor) accessible at the control. The City's currently preferred equipment is Aldis – Gridsmart when Insync adaptive traffic control unit is not used. When the Insync system is used the video detection is integral to that system and is Samsung. The video detection system shall in either event be compatible with the City's existing Video Detection equipment. A video monitor shall be supplied in each cabinet.

5.2 Loop Detection

In rare situations where video detection can not be provided due to intersection geometry or other restrictions, vehicle loop detectors may be required, but only with the approval of the CTE. Where loop detectors are necessary and have been approved, they shall be installed prior to the top course of pavement when possible. Presence loops will typically be 6 x 40-foot quadrapole type, VDOT Standard TD-1C. Pulse or call loops are to be 6 x 6-foot type, VDOT Standard TD-1B.

A. Types of Detection

1. **Presence** - Presence detection is typically shown for major street left turn movements and minor street through and left turn movements. The

presence detection zone will typically be 6 x 40 foot. Presence detection zone in each lane should extend a minimum of 30 feet behind the stop bar. The detection zone should extend forward of the stop bar a sufficient distance to detect a single vehicle that might pull forward of the stop bar. This coverage should provide detection to within 15 feet of the nearest cross street, through lane. Where a left turn lane is next to a raised median, placing the front of the detection zone even with the nose of the median is usually sufficient.

2. **Pulse** - Pulse, or call type detection, is typically shown for a major street through movements. A pulse detection zone is placed in each through lane ahead of the intersection. The number of detection zones and setbacks from the stop bar is determined by the posted approach speed limit and, will be as follows:

TABLE I - Speed - Detection Zone Setback

Speed Limit (mph)	Detection Zone Setback (ft.)
25	105
30	140
35	185
40	230
45	140, 285 *
50	110, 220, 340 *
55	100, 250, 400 *

* On approaches with posted speed limits of 45 mph or greater, multiple sets of detection zones are required.

The designer must be familiar with the following:

The City's preferred Basis of Payment and Method of Measurement for the installation of loop detector breaks down separate pay items for loop detector wire and saw cut.

Unless otherwise directed by the CTE, the designer is to specify a 12AWG loop detector wire, loosely encased in tubing that conforms to IMSA Specification 51-5, (1991). A note to this effect must be placed on the plans.

A one (1) inch conduit is to be shown between the pavement edge and the

adjacent junction box, where the loop wires are spliced to the loop detector lead in cable(s), for each loop detector saw slot. Further detail is depicted in VDOT Road and Bridge Standards, Standard TD-1, A, B, C, Loop Detector Installation Details.

The designer must inspect the existing pavement conditions to decide whether special installation procedures or materials are necessary where vehicle loop detectors are to be installed in existing pavements. Loops must not be designed so as to cross pavement patches, open cuts, pavement expansion joints, or asphalt to concrete pavement joints.

Each loop detector will be numbered on the plan to correspond to the vehicular approach NEMA phase number.

B. **Vehicle Loop Detector Wiring**

Loop detector lead-in cables are to be used to connect the vehicle loop detector to the control equipment in the controller cabinet. The type and number of cables are as follows:

1. **Type** - The designer will designate all loop detector lead-in cable(s) as 14AWG/2C(S) on the plans and specify that the cable(s) will conform to IMSA Specification 50-2, (1991).

2. **Number of Cables** - A separate loop detector lead-in cable will be shown for each presence loop detector. A separate loop detector lead-in cable **will be shown for each set** of pulse loop detectors. Exceptions to the above design practice may be necessary and allowed with prior approval by the CTE. Where traffic computer system sampling detectors are specified, a separate lead-in cable will be shown for each sampling loop.

6.0 PEDESTRIAN SIGNALS

6.1 Pedestrian Signal Display Selection

All new intersection design and construction will include pedestrian signals and pushbuttons across all legs of the intersection. Exceptions may be made to this requirement when the intersection geometry or other conditions make a pedestrian crossing undesirable. The pedestrian movement will typically be concurrent with a vehicle movement, but in certain cases may have to be served as an exclusive pedestrian movement as determined by the CTE.

Countdown heads shall be utilized. The Countdown Pedestrian signals will be LED Hand/Man Symbol Pedestrian Signal Head Assembly on the left with the countdown function on the right.

The countdown pedestrian signal heads shall be Dialite or approved equal and conform to VDOT standard SP-4. The preferred size is 16-inch display and shall

be LED. The signal head shall utilize the side by side display and must be compatible with the City's Naztec signal controllers. The signal head shall have automatic dimming with built in time delay, shall have internal conflict monitoring, and shall conform to all applicable Institute of Transportation Engineers (ITE) specifications.

6.2 Pedestrian Signal Head Wiring

Unless otherwise specified by the CTE, all cable for wiring pedestrian signals will be 14AWG/5 conductor cable conforming to IMSA Spec 19-1, (1991). The designer will confirm the plan notes or project technical specifications as appropriate to satisfy this requirement.

Cable runs will be continuous from the controller cabinet to the pedestrian signal head. The designer will not specify splicing of pedestrian signal wiring in hand holes or junction boxes without prior written approval of the CTE. Separate cable shall be run from the controller cabinet to each pedestrian head, unless otherwise specified by the CTE.

6.3 Pedestrian Pushbuttons, Signs, and Wiring

Unless otherwise specified by the CTE, all cable for wiring pedestrian pushbuttons will be 14AWG/2 conductor cable conforming to IMSA Spec 19-1, (1991). The designer will confirm that this requirement is included as a plan note or is in the project technical specifications.

The designer will include a pedestrian pushbutton on each corner of a pedestrian crossing that has pedestrian signals. The pedestrian pushbutton type shall be fully ADA compliant. Location of pushbuttons shall meet handicap accessibility requirements. Additionally, if the pedestrian crosswalk passes through the median, a pushbutton may also be located in the median if the median is wide enough and if the walk time exceeds the maximum feasible green split of the adjacent vehicular movement. When the international symbol "WALK/DON'T WALK" (SP-4) pedestrian displays are provided, the designer will specify a pushbutton sign conforming to the R10-3B (modified as show in the sample plan sheet)"Pedestrian Pushbutton Sign". The designer will include a plan note specifying the required MUTCD approved messages. When there are two (2) buttons located on the same corner, the preferred sign will include the street name on the sign that clearly designates which button the pedestrian is to choose for each crossing.

The designer will make sure that each pushbutton, located on the plans, is clearly delineated so that it is obvious to the Contractor where the pushbutton is to be located on the traffic pole. If the location cannot be clearly depicted, then a plan note must be added that either describes the pushbutton position or directs the Contractor to request guidance from the Engineer on placement of the pushbutton. The designer will locate the pushbutton on the signal pole or

pedestrian pedestal pole in the position closest to its corresponding crosswalk.

Pedestrian pushbutton cable will be continuous from the controller cabinet to the pushbutton. The designer will not specify splicing of this cable in hand holes or junction boxes without prior approval from the CTE. Separate cable shall be run from the controller cabinet to each pedestrian head, unless specified by the CTE.

Pushbuttons will be accessible from the sidewalk or vegetated access. Where sidewalk is existing or is part of the design, the sidewalk will be designed or extended so the pushbuttons are handicap accessible. The Contractor is responsible for integration of the 5-foot x 5-foot handicap landing areas and ramps with other traffic signal / pedestrian features.

7.0 CONDUIT SYSTEMS AND CONDUCTORS

7.1 Junction Boxes

The junction boxes are to be the VDOT Standard, JB-1C through JB-5C. For specific information, refer to the VDOT Road and Bridge Standards, (latest edition).

The design will include placing junction boxes at appropriate locations, providing access to the underground conduit/cable system. The locations will include, but will not be limited to, the points where loop detector splices are made, the intermediate locations in conduit runs greater than 300 feet, and at conduit terminal points.

Junction boxes should also be placed at each end of a road crossing. This does not apply to driveway entrances or where the cable is a direct buried interconnect cable passing through the conduit.

Junction boxes will be placed next to the interconnect cable terminal enclosure. This junction box is to be placed in-line with the interconnect conduit/ cable system and will be connected to the enclosure with a single conduit of the appropriate size for the incoming and outgoing interconnect cables.

Junction boxes will not be located in the roadway, driveway entrances or in handicapped pedestrian facilities. It is recommended that junction boxes should not be placed in a utility strip between the curb and sidewalk unless the utility strip is at least six (6) feet wide. Placement of junction boxes on sloping grades or directly behind a curb should also be avoided. Junction boxes may be placed in a sidewalk area, except in handicapped facilities as noted above.

When conduit “stub outs” from junction boxes are necessary, the designer must consider the intended use of these conduits, ensuring that their future access will not be hampered. The plans must provide clear direction to the Contractor regarding length and location of the conduit stub(s).

Selecting the proper sized junction box is important to ensure that there is an adequate area for entry of conduits and cables as well as for the splicing of vehicle loop detectors. The following chart is provided to assist in selecting junction box size.

TABLE II - Junction Box Size

VDOT ST'D	CONDUITS ENTERING THE BOX	COMMENTS
JB - 1C	A single 2" or 3" conduit plus 1 or more 1" conduits	A conduit termination point where loop detectors are spliced
JB - 2C	A single 2" conduit and a 3" stub out, or	Electrical service point of connection
	A maximum of two conduits up to 3 inches in diameter each or	Interconnect cable
	A maximum of two conduits up to 3" in diameter each plus 1 or more 1" conduits	Loop detection system
JB - 3C	Three conduits up to 3" in diameter plus one or more 1" conduits	Junction boxes in the median and on corners of intersections
JB - 4C	typically not used	typically not used
JB - 5C	Four or more conduits up to 4" in diameter	Typically used as the first junction box next to the control cabinet when all the cables are routed to it in a mast arm installation

7.2 Conduit

A. **Installation** - All signal, detector, and electrical service conductors and cables that are installed underground will be placed in conduits. Direct burial will be permitted for interconnect cable only, when directed by the CTE.

Conduit installation is placed into one of the three following categories:

1. Trenched - conduit installed in an earth area,

2. Open Cut - conduit installed in existing pavement area and the pavement structure is to be open cut, or

3. Jack/Bore and Directional Bore - conduit installed underneath existing pavement area without disturbing the existing pavement structure.

B. **Product** - Conduit is specified as either Galvanized Rigid Steel (GRS), PVC, or High Density Polyethylene (HDPE). Excepting HDPE runs, whenever there is direct connection from the cabinet to junction box, or from junction box to junction box, a spare conduit shall be provide to accommodate future needs. The applications of each are as follows:

1. **Galvanized Rigid Steel Conduit (GRS)** will be specified for:

   Conduit for risers placed on the surface of wood or steel poles.

   Conduit between the edge of pavement and junction box for loop wires. Conduit for loop wires will be one (1) inch in diameter.

   Conduit for electrical service conductors between the controller cabinet and the point of connection. Conduit placed for electrical service conductors will be 1¼ inch diameter GRS, with the following exception: Conduit placed under roadway pavement for roadway service conductors will be GRS conduit a minimum of two (2) inches in diameter.

2. **PVC Conduit** will be specified for:

   PVC Schedule 40 conduit encased in a steel sleeve will be specified under all roadway pavement and under driveway entrances. Conduit placed under roadway pavement will be a minimum of three (3) inches in diameter, regardless of the cable fill area.

   PVC Schedule 80 conduit will be specified for all other non-pavement areas, unless otherwise directed by the Project engineer. The minimum conduit diameter will be two (2) inches.

   NOTE: There is a commonly used fitting that couples PVC conduit directly to galvanized, rigid steel conduit. Consequently, when it is necessary to make this type of transition, a junction box is not required. It is not required that the Contractor use this type of coupling for these transitions.

3. **High Density Polyethylene (HDPE) Conduit** will be specified for:

   Specify HDPE for conduit placement where the directional bore method is used beneath existing pavement. HDPE conduit and directional bore is preferred over the alternative Jack and Bore or a steel pipe sleeve.

7.3 Conductor Cable

The designer will ensure that the plans provide the types of conductor cable for wiring the items listed below:

TABLE III - Conductor Cable

Item	Conductor Cable Type
Vehicle Signals, 12"	14 AWG with 5 or 7 conductors, conforming to IMSA Spec 19-1 (1991)
Vehicle Signals, 8"	14 AWG/5 conductor, conforming to IMSA Spec 19-1 (1991)
Pedestrian Signals	14 AWG/5 conductor, conforming to IMSA Spec 19-1 (1991)
Vehicle Loop Detector	12 AWG/1 conductor, conforming to IMSA Spec 51-5 (1991)
Loop Detector Lead-In	14 AWG/2 conductor (shielded), conforming to IMSA Spec 50-2
Pedestrian Pushbutton	14 AWG/2 conductor, conforming to IMSA Spec 19-1 (1991)
Internally Illuminated Traffic Control Signs and Street Name Signs	12 AWG/3 conductor, conforming to IMSA Spec 19-1 (1991)
Flashing Warning Beacons	14 AWG/3 Conductor, Conforming to IMSA Spec 19-1 (1991)
Video Detection Cable	Parallel construction of on polyvinyl chloride (PVC) jacketed RG59U and one PVC jacketed five conductor 18 AWG cable, under an oval black flame retardant PVC jacket with nylon zipper string.
Emergency Preemption Cable	As required for manufacturers specifications.

Provide a pay item note that the conductors shall be bundled and shall have the “zipper string” feature in the insulated jacket.

8.0 CONTROLLER, CABINET AND EQUIPMENT

Traffic signal controllers shall be NAZTEC TS2 Type 2 Controllers with 4 port Ethernet face plate. Traffic signal controller cabinets shall be NAZTEC TS1 or TS2 Cabinet

Assembly. All furnished control equipment must completely interface and be compatible with the Traffic Management Center's NAZTEC StreetWise Lite computer system. The Controller shall come equipped with Broadband communications connection equipment to include broadband modem, Ethernet Switch, and radio (Intuicom 5 GHZ or equal) or cell communications devices. Contact the CTE for cellular communications specifications.

Traffic signal installations are typically designed to house the control equipment in a ground mounted cabinet. However, where there is a limited right-of-way and signal phasing will permit, a pole-mounted cabinet may be necessary. A VDOT Standard CF-1 controller cabinet foundation will be specified on the plans for ground mounted cabinets. Pole-mounted cabinets are typically specified for intersection flashing beacons, school zone caution lights, emergency traffic signals, downtown applications, and warning beacon installations. When the designer considers a pole mounted cabinet for a full traffic signal installation, the CTE must be contacted for review and approval. The designer will specify the appropriate VDOT standards for pole mounted cabinets on the plans.

The designer must take into consideration the following criteria when deciding where to locate the controller cabinet:

A. The cabinet should be located near an available electrical service source.

B. The cabinet should be located in a position where it is not vulnerable to traffic.

C. Traffic movements should be directly visible to a service technician while performing timing adjustments or maintenance of the cabinet control equipment.

D. The cabinet door should be on the side away from traffic and should open away from traffic.

E. It should not be placed in a traffic island or where the approach is unpaved.

F. It should not be located in an area subject to flooding.

G. Parking a maintenance vehicle near the cabinet should be possible.

H. The concrete maintenance pad should be large enough to accommodate a technician who is performing work in the cabinet.

9.0 INTERCONNECT CABLE

The City currently has two (2) coordinated signal systems. One is in the downtown area and the other is an insync system along Wards Road on the south end of the City. The City desires to coordinate systems along Fort Avenue and Timberlake Road, Graves Mill Road, Rivermont Avenue, Kemper Street, Campbell Avenue, Lakeside Drive and Old Forest Road, and Memorial Avenue and Langhorne Road. Special consideration shall

be given to installation of new or replacement of existing signals in the vicinity of these locations. The designer shall request direction from the CTE regarding required interconnect, communication devices, and other special considerations.

10.0 TRAFFIC SIGNAL POLES AND FOUNDATIONS

All poles are to be painted black. Specifications for painted treatments shall be per VDOT specification 411 of the current VDOT Road and Bridge Specifications manual. Traffic signal poles are to be located where an applicable VDOT clear zone criterion is satisfied. The structure will be protected where the required clear zone setback cannot be provided. Reference VDOT Clear Zone criteria per the VDOT Road Design Manual Appendix A, Tables A-2-1 and A-2-2. Prior to construction, all proposed locations of signal poles/foundations must be field approved by the CTE.

The designer will make every effort to place signal poles behind and clear of the sidewalk area.

On road construction projects, the location of signal poles will be identified with a Station and Offset. If there is more than one baseline noted in the plans close to the signal pole, the Station and Offset must identify the respective baseline.

Wherever possible, the designer should consider the use of combination signalization/streetlight poles. When joint use poles are specified, the signal plans will show the street lighting electrical conduit(s) that are necessary for the lighting conductors. When combination poles are planned, the designer shall provide a detail in the plans showing luminaire arm height, orientation, and if for future use by others. AEP should be contacted to coordinate the power service type and location for the luminaire before the plans are submitted for review.

Lighting, signal, pedestal poles, sign posts, and overhead and bridge-mounted sign structures will be designed according to AASHTO's Standard Specification for Structural Supports for Highway Signs, Luminaries, and Traffic Signals. For joint use traffic signal/lighting poles, the design analysis will use luminary ratings of 1.65 square feet effective projected area (Cd 1.0) and 60 pounds of weight per luminaire.

The following criteria are used when designing signal pole selection and placement:

A. Mast Arm Poles

1. Specify mast arms in 2-foot increments.

2. Show luminaire arm(s) on traffic signal plans.

3. The outboard signal head on a mast arm should be shown mounted between one (1) and two (2) feet from the end of the arm.

4. Specified mast arm mounted signals are to be installed in accordance with VDOT Standard SM-3.

5. The design will take into account the following maximum allowable deflections:

   a. **Pole** - 1% of pole length under dead load conditions.

   b. **Mast Arm** - 3% of arm length under dead load conditions and the arm will not deflect below the horizontal plane more than 7% under dead load and wind load conditions.

B. **Steel Strain Poles**

1. Steel stain poles should only be used if the geometrics prohibit the use of mast arm poles. Use of steel strain poles requires approval of the CTE.

2. Specify the length of pole in two (2)-foot increments. Select a length using the following criteria:

   a. 16 feet of clearance from tether wire / bottom of signal heads (whichever is lower).

   b. Five (5)-foot signal head height.

   c. 5% span sag.

3. Span attachment shall be a minimum of 18 inches below the top of the pole (see VDOT Standard WD-1).

4. Specify that the wiring and rigging are to conform to VDOT Standard WD-1.

C. **Wooden Poles** - **Wooden poles are usually used for temporary installations.**

1. Plans must show the down guy wires.

2. Specified length of pole in five (5)-foot increments.

3. Select a length using the following information:

   a. One (1) foot in the ground for every six (6) feet above ground.

   b. 16-foot clearance to tether wire/bottom of signal heads (whichever is lower).

   c. 5-foot signal head height.

d. 5% span sag.

4. Span attachment is to be minimum of 18 inches below the top of the pole (see VDOT Standard WD-2).

5. Select a class of pole using engineering calculations that substantiate proper loading and allowable stress of the material.

6. Specify that the wiring and rigging conform to VDOT Standard, WD-2. 4).

D. Span Wire Installations

1. Specify one-half (½) inch diameter span wire for all span wire installations.

2. Specify a one-quarter (¼) inch diameter tether wire for all span wire installations and that the tether rigging will conform to VDOT Standard TA-1.

3. For temporary span wire installations, specify that the cable rings are to be used by the Contractor to attach the cables to the span. Also, it should be specified that an amount of extra cable will be coiled either at each signal or at the pole when adjustments in the locations of the signals will be needed due to construction. The Design Engineer must specify the length of cable to be coiled.

4. Specify that the span wire mounted signal heads will conform to VDOT Standard SW-1.

5. All five (5)-section signal heads are to be shown on the plans as one-way mounted. Two, three (3) section signal heads may be shown as a two-way mount. *Do not design a three- (3) or four- (4) way mounting configuration.*

Shop drawings shall be provided for the foundation designs for each traffic signal pole foundation. The design will be based on the soil date collected from the soil boring done at each foundation location. The designer will require a test boring for each foundation location. All designs will be for drilled foundations. Spread footings will not be accepted.

11.0 ELECTRICAL SERVICE

The electrical service source, point of connection and VDOT Standard Service type will be identified on the plans. This will include the conduits, cables, risers, junction box(es), and disconnect/safety switch per the applicable VDOT Standard.

Service run from AEP source to Disconnect and Controller Cabinet shall be via underground metal (GRS) conduit. Preferred mounting locations of Meter and Disconnect shall be: Signal Pole (SE-3B), AEP pole (if permitted) or separate riser (SE-5). The meter and disconnect shall not to be located on, or immediately adjacent to the Controller Cabinet.

Electrical service shall be designed to accommodate one disconnect (breaker) for cabinet electronics power, and a separate disconnect (breaker) for ancillary power.

The designer will be responsible for meeting with AEP representatives to determine the appropriate service locations. This will include determining and showing on the plans all additional conduits and junction boxes needed by AEP to install lighting on combination poles.

12.0 SIGNING FOR TRAFFIC SIGNALS

A. Show all MUTCD R10-12 signs on the span wire or mast arm, next to each 5-section, protected/permitted left turn signal head. **Do not use these signs for permitted left turn only movements.**

B. Street Name signs will be shown mounted on the mast arms, unless specified by the CTE.

C. Mast arm mounted, Street Name signs should generally be shown mounted to the mast arm, midway between the first two (2) signal heads.

D. When a mast arm is not positioned perpendicular to a street, it may be necessary to show the street name sign as being pole shaft mounted. The designer shall advise the CTE if this condition exists.

E. When an exclusive pedestrian movement is included in the signal phasing, a RIGHT TURN YIELD TO PEDESTRIAN sign should be shown to mitigate conflict with right turn movements during the protected pedestrian phase.

13.0 EMERGENCY PREEMPTION EQUIPMENT

Each new traffic signal installation will be designed and equipped with emergency vehicle preemption equipment, except when the approach is from a private driveway or as specified by the CTE, that detects emergency vehicles on all approaches to the intersection. The equipment will be optically activated and will completely interface with and have the same features and functions of existing City of Lynchburg emergency preemption systems. The existing system consists of the 3M, Model 700 Series Detectors, System Chassis, Phase Selectors and Emitters, with vehicle identification and logging feature. Confirmation lights are required.

The location and type of each optical detector and corresponding conductor cable and the controller cabinet will be shown on the Traffic Signal Plan. In addition, the Traffic Signal Plan **Phase Sequence** diagram will include a sequence for each emergency vehicle preemption plan.

14.0 UNINTERRUPTIBLE POWER SUPPLY

Uninterruptible Power Supply is required for all new signal installations. The primary purpose of the system will be to provide emergency power for the traffic control system

and associated equipment in the event of a utility power failure or when the utility power is outside of the programmable voltage and frequency range of the UPS system. This system shall be housed in a separate cabinet directly adjacent to the controller. The Clary SP 1250 LE is the current City standard for the uninterruptible power supply.

15.0 PAVEMENT MARKINGS FOR TRAFFIC SIGNALS

Pavement markings may be shown on traffic signal plans. If presentation of proposed pavement markings results in a cluttered plan sheet, then it is generally suggested to prepare a separate pavement marking plan sheet. Contact the CTE for guidance regarding this matter.

When the permanent pavement markings are not shown on the signal plans, the plans will show the following information:

A. Stop bar locations (Stop bars shall be 24 inches wide thermoplastic).

B. Crosswalks (12 inches wide thermoplastic).

C. Arrows and legends identifying lane usage (thermoplastic).

D. Lane lines (4 inches wide thermoplastic yellow or white as specified).

Existing pavement markings within 150 feet of the intersection shall be refreshed depending on their condition. The designer shall call this to the attention of the CTE for guidance as to whether or not this will be required.

16.0 ADAPTIVE TRAFFIC SIGNAL CONTROL SYSTEM

Adaptive Traffic Signal Control System (ATSCS) is required for all new traffic signal installations. This system shall be InSync or approved equal, following are the specifications required for said ATSCS:

16.1 OVERVIEW

This work shall consist of furnishing, configuring and placing into operation an adaptive traffic signal control system which detects and collects vehicle data by processing video images and automatically optimizing the changing of traffic signals to instantly adapt to real-time traffic demand. The adaptive traffic control system selected will be deployed and currently operating at a minimum of 20 independent, noncontiguous corridors in the United States.

The system shall have remote monitoring and configuring capability using IEEE 802.3 standards. The equipment shall meet the NEMA environmental, power and surge ratings according to the latest NEMA Specifications. The system shall include all equipment listed as shown on the plans and described in this special provision and shall include any incidental items necessary for the satisfactory operation of the system. This special provision shall be in addition to the standard specifications.

16.2 SYSTEM COMPONENTS

A. Material Adherence to Quality Standards

Equipment and material shall be of new stock unless the contract provides for relocation of existing units or use of units furnished by others.

New equipment and material shall be the product of reputable manufacturers and conform to all relevant requirements including the requirements of Caltrans 170, ICEA, IMSA, ITE, MUTCD, NEMA, RETMA, NEX and regulations of the National Board of Fire Underwriters, as applicable, and meet the approval of the engineer.

B. System Compatibility

The adaptive traffic control system must be compatible with all major makes and models of traffic controllers and cabinets, including but not limited to those associated with NEMA, Caltrans, TS-1, TS-2, Econolite, McCain, Peek, Naztec and other prominent controllers manufactured currently or in the last 15 years. The system will not require the replacement of a traffic controller or modification thereof.

C. System Components

The adaptive traffic control system shall consist of color video cameras enclosed in secure housings, a shelf- or rack-mounted processing unit, software and license for system control via a web browser such as Microsoft Internet Explorer on any authorized computer, and a switch with the capability of independently networking a minimum of four (4) video cameras and the processor.

The adaptive traffic control system shall include a separate processor unit (PU) mounted in the traffic cabinet that connects to the controller which is running in free mode. The processor shall intercept traffic calls and place calls passively to the traffic controller.

The adaptive traffic control system must include in its base product standard Internet protocol (IP) cameras which allow for real-time images to be viewed remotely via the Internet using a standard browser, not proprietary software. The video cameras shall be digital cameras and their video feeds shall be available over standard Internet Protocol (IP) connection in Motion JPEG and MPEG 4 formats using the latest IP technology. All camera views shall be obtainable simultaneously without cable swaps. The system shall be capable of displaying post-processed video on a web browser such as Microsoft Internet Explorer. The engineer shall have the option to view one camera at a time, all cameras at an intersection, or some or all of the cameras along an arterial in a single browser window.

D. **Processing Unit (PU)**

1. **General**

The PU may be rack or shelf mounted and shall be modular in design. It shall support on-site configuration using a USB keyboard and VGA monitor, or remote configuration over an IP Network. It shall support on-site backup to/restore from a USB Memory Stick for rapid replacement. The PU shall contain at least 4 USB ports to allow simultaneous connection of keyboard/mouse and storage devices.

2. **Communications**

Communications from the PU to any computer shall be through RJ45 (8P8C) connector over a regular IP network connection at the installation location or over a network. The computer shall have the capability to download detection data as well as the real-time detection information needed to show detector actuations. The user shall also have the capability of connecting directly to the detection cameras over the IP network and display post-processed and pre-processed color video in the MPEG 4 and MJPEG format.

3. **Compatibility with NEMA Standards**

The PU shall be available with NEMA TS1/TS2 detector interface. Output levels shall be compatible with the NEMA TS1 and NEMA TS2 Type 2 standards.

4. **Historical Split Information**

The PU shall store historical split information and shall compute and deploy optimized signal splits based on historical split information when the system goes into fog mode or emergency mode.

5. **Free Mode Controller Operations**

The PU shall input optimized detector calls into a controller that is running in free mode.

6. **Suspension of Inputs When Needed**

The PU shall suspend, for the necessary time, its inputs to a controller when calls of a higher priority are put in to the controller by pedestrians, preemption vehicles or the pre-determined parameters set by traffic officials.

7. **Transmission of Information to Adjacent Intersections**

The PU shall automatically send all necessary information to system processors at adjacent upstream and downstream intersections in order to facilitate the progression of traffic flow along the arterial.

8. **Optimization of Traffic Flow**

   The adaptive traffic control system must be able to assess volume and delay in real time to optimize signalization. The PU shall optimize the flow of traffic at both intersections and arterials based on the possible states of traffic rather than required splits, cycles and offsets. The system must be able to perform adaptive calculations without regularly relying on recalculating offsets to perform adaptive operations.

   The sequences of phase pairs is not set but rather dynamic allowing for serving one phase twice before first serving another phase once. The system must have the ability to adjust green time without a per cycle maximum permitted adjustment. The system must be able to operate without, and without being dependent upon, any traditional timing plans.

9. **Pedestrian Calls**

   The PU shall incorporate the optional capability to include pedestrian calls in the optimization algorithms.

10. **Time Clock Synchronization**

    The PU shall keep accurate time using a mechanism that synchronizes the clocks at least weekly.

11. **Time of Day Operation**

    The PU shall be capable of functioning in a detector mode or adaptive mode selectable by time of day and day of week.

E. **Vehicle Detection**

1. **General**

   The video detection system shall be included and provide flexible detection zone and/or count sensor placement anywhere and at any orientation within the combined field of view of the image processors. Preferred presence detector zone configurations shall be a box or polygon across lanes of traffic placed parallel with lanes of traffic. A single detector zone shall be able to replace multiple conventional detector loops. Detection zones shall be capable of overlapping. Detection zones shall detect multiple vehicles within a single detection zone.

2. **Detection Zones**

   The detection zones shall be created by using a pointing device and a graphical user interface (GUI) displayed on any computer connected directly to the PU or a GUI available to any authorized remote terminal over IP network connection. It shall be possible to add, edit or remove previously defined detector configurations to fine-tune detection zone placement.

3. **Detection System Outputs**

When a vehicle is detected by crossing a detection zone, there shall be a visual change on the video display, such as a change in color or intensity, thereby verifying proper operation of the detection system. The system shall compute and display real-time queue information per lane. The system shall compute and store traffic volumes, stopped time delay, and Level of Service per phase and display such information on demand over an Internet Browser.

4. **Detection System Performance Standards**

Overall performance of the video detection system shall be comparable to inductive loops. Using camera, optics and in the absence of occlusion, the system shall be able to detect vehicle presence with 95% accuracy under normal (day and night) conditions and with only a slight deterioration in performance under adverse (fog, snow, rain) conditions. During extremely adverse conditions or camera failures the system shall default to emergency mode or fog mode. The processor shall store historical split information and shall compute and deploy optimized signal splits based on historical split information when the system goes into fog mode or emergency mode.

5. **Camera Operation**

The camera shall automatically function in a special mode at night and the processor shall utilize such images and conduct image processing after filtering out a high degree of reflected and ambient lighting. The PU shall change image parameters such as sharpness and contrast based on the lighting conditions.

6. **Camera Notifications**

The system shall be able to automatically generate notifications to one or more email addresses and other communication devices when a camera has failed or the view is obstructed (e.g. fog or ice).

F. **Video Camera and Housing**

1. **General**

The PU supplier shall furnish the video camera for traffic detection. The camera shall produce a usable color video image of vehicles under normal roadway lighting conditions regardless of time of day. Usable video in color shall be produced for scenes with a minimum luminance of 0.65 lux at aperture f-value 1.0.

2. **Camera System Sensing and Video Streams**

The camera system shall use a CCD sensing element and shall deliver MJPEG and MPEG 4 video streams simultaneously.

3. **Camera Lens and Control**

   The camera shall include an electronic shutter or auto iris control based upon average scene luminance and shall be equipped with an auto iris lens.

4. **Camera Focal Length**

   The camera shall have a variable focal length. The maximum aperture of the lens shall not be smaller than f1.8 and the minimum aperture shall not be larger than f360.

5. **Camera Environmental Parameters**

   The camera shall be able to operate under harsh environmental conditions, including temperatures -30F (-34C) to 165F (74C), heavy rain, and ice. The enclosure shall allow the camera to be adjusted in the field during installation.

6. **Camera Enclosure**

   The enclosure shall be equipped with a sun shield that prevents sunlight from directly entering the lens. The sun shield shall include a provision for water diversion to prevent water from flowing in the camera field of view.

7. **Camera System Access**

   The camera system shall be Ethernet-centric. The system shall be capable of delivering MPEG-4 and MJPEG video to the switch in the cabinet. The user shall be able to access the camera directly over the network and configure the camera parameters using a standard Internet Browser.

G. **Cable**

1. **Ethernet Cable**

   Any Ethernet cable run outside of the traffic cabinet shall be environmentally hardened, shielded, and outdoor rated 350 MHz Category 5e cable. The cable shall be riser rated, 24 AWG solid copper, have Polyolefin insulation, UV and oil resistant PVC jacket. Pair 1 shall be Blue, White/Blue, Pair 2 shall be Orange, White/Orange, Pair 3 shall be Green, White/Green and Pair 4 shall be Brown, White/Brown. The operating temperature shall be from -40° C to +70° C. The cable shall conform to the following standards: ISO/IEC 11801 Category 5e, NEMA WC 63, and ANSI/TIA/EIA 568-B.2 Category 5e. The cable shall be without splicing or joints for any single run. The contractor shall obtain instructions from the manufacturer about alternate architecture when length of a single run of CAT 5e cable exceeds 320 feet.

2. **RJ-45**

The RJ-45 plug connectors shall be used at both the camera and cabinet ends. The supplier of the video detection systems shall approve the Category 5 cable, RJ-45 connector and crimping tool and the manufacturer's instructions must be followed to insure proper connection.

3. **Power Cable**

Power cable shall be 14 AWG three-conductor cable. This cable shall comply with the requirements of IMSA Specification 19-1.

H. **System Software**

The system shall include software that detects vehicles in multiple lanes using the video image and existing detection in combination. The software shall automatically account for changes in scene including but not limited to lighting conditions or adverse weather. The engineer would have the dual benefit of defining detection zones via a web interface accessible from any regular computer with an IP network connection or using a computer physically connected to the network (which may include a laptop computer). A minimum of 12 detection zones per camera shall be available. The detections zones must be capable of counting multiple vehicles within a single detection zone. The system software shall communicate to an existing signal controller passively, allowing the signal controller to still handle emergency pre-empts. The software shall determine and display real-time queue lengths along each approach.

The software/hardware shall have the capability to seamlessly intercept existing detection status. The combination detection logic shall work as follows:

- If existing detection is positive and video detection is negative, the result shall be positive.
- If existing detection is negative and video detection is positive, the result shall be negative.
- If existing detection is negative and video detection is negative, the result shall be negative.

The adaptive traffic control system shall not rely on the central server or central software for regular operations.

1. **Access to Detection System Data**

The video detection system shall be programmable via a web browser using the same IP network connection that delivers the video camera output and thus allow the engineer to have complete control of the system without being physically present at the intersection. It shall provide still image and real time detection displays in color video to a remote computer using a web browser such as Microsoft Internet Explorer. The

system shall collect real-time traffic data such as vehicle counts, stop delay and level of service. Real-time and historical statistical information must be available to the engineer in graphical and/or tabular form as and when required.

16.3 ADAPTIVE TRAFFIC CONTROL OPERATIONS

A. General

The adaptive traffic control module shall be contained within the PU. The PU shall communicate with neighboring PUs over an IP network. The PUs shall communicate information such as the green and red status of signal, queue lengths, and traffic volumes in real time. Based on such information received from adjacent signals and local traffic data, the PU shall optimize the phasing sequence, duration, and initiation of movements in order to optimize traffic flow on arterials as well as arterial networks.

B. Optimization of Green Time Allocation

The adaptive traffic control shall not use common cycle lengths but use principles of robotics and artificial intelligence to optimize traffic flow. The optimization shall be real time using the principles of a finite state changing machine and shall not involve switching between cycle lengths or timing plans. The system shall not be in transition at any time but shall respond to real-time inputs with changing of states. Guaranteed arterial progression shall be created using dynamic green bands. Non-arterial traffic at each intersection shall be served adequately without interfering with the green bands.

C. Configuration of Signal Control

The supplier’s engineers shall configure the adaptive traffic signal control system for optimal operation of the arterial or arterial network. Traffic flow and anomalous traffic conditions shall be programmed into the adaptive traffic signal control system.

D. Configuration via IP Network

The parameters for the adaptive traffic signal control shall be capable of being configured remotely over the IP network. Parameters are adjustable via a web browser capable of running Java, such as Internet Explorer. The software shall also display traffic signal green status and up to 48 camera views. All configuration information shall be stored in easily backed-up and humanly readable XML files.

E. Monitoring of Arterial

The system shall allow monitoring via a web browser such as Microsoft Internet Explorer on any authorized computer. It shall be possible to view a single camera, multiple cameras from a single intersection, or multiple cameras from multiple intersections. This system must be capable of

displaying these views even under limited network bandwidth. It must be possible to format these views to support different size viewing screens.

F. **Self-Monitoring of Arterial**

The system shall be able to automatically generate notifications to one or more email addresses when it detects disruption of the communications network, failure of PUs, intersections going into flash, or other such events that would impact the operation of the arterial.

16.4 INSTALLATION

The adaptive traffic control system shall be installed as recommended by the manufacturer and as documented in the installation materials provided by the supplier. A factory certified representative from the supplier shall be on-site at the beginning of installation.

16.5 WARRANTY AND SUPPORT

A. **Warranty Period**

The adaptive traffic control system software shall be warranted to be free of defects in material workmanship for a minimum of three (3) years, and hardware for a minimum of two (2) years.

B. **Technical Support**

During the warranty period, technical support shall be available from the supplier via telephone within four (4) hours of the time a call is made by the user. This support shall be available from factory certified personnel or factory certified installers.