## Document Revision History

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1. INTRODUCTION

1.1 Purpose
This Design Manual is intended to guide designers through the steps needed to complete a set of plans and specifications for NaviGAtor ITS projects, including projects executed by GDOT or other jurisdictions in the State of Georgia. These steps include the following:

- Fiber optic cable trunk design
- Changeable message sign design
- CCTV system design
- Video detection system design
- Microwave radar detection system design
- Weather monitoring and reporting system design
- Ramp meter design
- Hub building design
- Hub equipment design
- Traffic control center design
- Specification development

The primary purpose of the Design Manual is to assist designers with ITS design for urban freeways, urban arterials, and rural roadways.

This Design Manual is revised from previous versions to now describe gigabit ethernet network design, including IP addressable devices in the field cabinets, hub buildings, and traffic control centers.

1.2 Intended Audience
This Design Manual was prepared for designers performing ITS design in the State of Georgia for GDOT or other jurisdictions. It is assumed the designer has a basic understanding of the components of GDOT’s NaviGAtor ITS.

1.3 Approved Abbreviations

<table>
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<tr>
<td>AC</td>
<td>Alternating Current (Power)</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation System</td>
</tr>
<tr>
<td>CADD</td>
<td>Computer Aided Design Development</td>
</tr>
<tr>
<td>CATV</td>
<td>Cable Television</td>
</tr>
<tr>
<td>CCB</td>
<td>Configuration Control Board</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit Television</td>
</tr>
<tr>
<td>CMS</td>
<td>Changeable Message Sign</td>
</tr>
<tr>
<td>DSL</td>
<td>Digital Subscriber Line</td>
</tr>
<tr>
<td>ECB</td>
<td>Electrical Communication Box</td>
</tr>
<tr>
<td>FOC</td>
<td>Fiber Optic Cable</td>
</tr>
<tr>
<td>FDC</td>
<td>Fiber Distribution Center</td>
</tr>
<tr>
<td>GBIC</td>
<td>Gigabit Interface Converter</td>
</tr>
<tr>
<td>GigE</td>
<td>Gigabit Ethernet</td>
</tr>
<tr>
<td>GP</td>
<td>Georgia Power Company</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
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1.4 **Organization of the Design Manual**

This *Design Manual* is divided into 14 chapters as follows.

1. Introduction
2. General Design Guidelines
3. ITS Communications Design
4. Changeable Message Sign Design
5. Closed Circuit Television System (CCTV) Design
6. Video Detection System (VDS) Design
7. Microwave Radar Detection System Design
8. Weather Monitoring and Reporting System Design
9. Ramp Meter Design
10. Hub Building Design
11. Hub Equipment Design
12. Traffic Control Center Design
13. Specifications
14. Appendices

Design chapters typically include the following sections:

1. Placement Guidelines
2. Field Location Considerations
3. Options
4. Pay Item Determination

Placement guidelines should be used during the concept and preliminary phases of a project. Field location considerations include items such as power service, pole locations, cabinet locations, ECB or PB locations, and splice points. Field location considerations, device and cable options selection, and determining the correct pay item numbers are essential elements of the design phase.
2. GENERAL DESIGN GUIDELINES

The project design begins with the concept phase. It is assumed that designers will have access to aerial photography survey and/or plan sheets showing new road construction. In this phase, designers determine the preliminary placement (or physical location) of ITS devices. The placement guidelines subsections contained in Chapters 3 through 12 provide guidance for the concept. During the concept phase, it is essential for designers to research whether there are other planned projects for the same section of roadway by coordinating with the GDOT offices of Planning, Urban Design, Road Design, and Maintenance.

2.1 General Device Placement Guidelines

After the concept review meeting, designers should conduct a field inspection at the beginning of the design phase to gain first-hand knowledge of the project location, proposed device locations, conduit routing, and power source locations. Device placement decisions should be made using the following criteria:

- Actual field conditions
- Maintenance accessibility
- Ability to route fiber to the device
- Accessibility of a nearby power source
- Protection of the device (possible relocation behind existing guardrail)
- Possibility of the device being a hazard to motorist

The ITS Design Manager will review all recommendations to move CMS or ramp meter locations. These devices should not be moved unless agreed upon by the ITS Design Manager.

Before going to the field inspection:

- Prepare a “To Do List” to optimize the data recording procedures.
- Obtain a copy of the most accurate and complete set of plans (base map) prior to going to the field.
- For the concept phase of a project with CMS and CCTV installations, prepare a roll plot of the base map. Clearly mark the proposed locations for CMS, CCTV, VDS/RDS, and ramp meters according to the spacing criteria outlined in their respective sections.
- Have all equipment ready, including, but not limited to a tape measure, roll tape, vertical measuring device, safety vest, safety cap, gloves, GDOT cabinet keys, flash lights, camera, and tools for opening pull boxes and electrical communication boxes. Contact the GDOT Project Manager to arrange access to existing ITS facilities.

While on the field inspection:

- Safety is a very important part of the device location and field data collection process. A large amount of time will be spent along the major freeways with heavy traffic flow. Safety precautions must be observed. Always wear high visibility clothing including safety vests and hard hats.
- As an added safety precaution, position yourself behind existing guardrails and/or stay as far back from the roadway shoulder as possible. Always face the traffic; never turn your back to the traffic.
- Confirm that all existing devices such as poles, cabinets, signs, overhead structures are clearly shown on the base map.
- Verify that all pull boxes are covered and cabinets are locked prior to leaving.
• Locate proposed devices such that they will not interfere with existing objects, such as signs or drainage structures.

• All proposed locations, especially those near bridges, should be carefully examined to ensure that the cabinet is easily accessible. Likewise, avoid locations where bucket truck or service vehicles could not be positioned correctly. If it is necessary to place a pole with cabinet on a steep slope, then provide a platform to enable cabinet access for a technician.

• At sites where boring or trenching may be required, locate ECBs and PBs such that trenching equipment can be properly set up.

• Take pictures and make sketches where appropriate.

2.2 NaviGAtor Guidelines for Establishing and Locating Freeway and Major Arterial Structure Identification (ID) Labels

All supports for all freeway ITS field devices will have placed on them a label on which will be the structure identification (ID) number. This is not the labeling system used for static signs and other roadside structures. Details associated with the label are as follows: All characters are to be centered horizontally and vertically.

• Letter Height: 4 inch Series “D”, with 2” spacing between lines labels

• Sheeting: Type I (enclosed lens)

• Colors: white letters/interstate green background

• Attachment height: plates attached at driver’s eye height (39” above nearest lane pavement surface) or 24” above any existing “maintenance” ID labels, and oriented facing the appropriate direction of traffic

Camera poles and butterfly type changeable message signs (CMS) mounted on the right shoulder will have an ID that reflects the interstate letter for the direction of travel. Only one label will be used. For example, a camera pole located on the right shoulder of I-75 Northbound at milepost 262.53 will have a label reading “NAV C 262_53”.

Overhead structures with devices located only above the right vertical support will have an ID that reflects the interstate or the arterial letter for the direction of travel. Labels will be placed on the right vertical support and on both sides of the left (median) vertical support. For example, an existing sign bridge on I-75 Northbound at milepost 262.53 with device(s) above the right side vertical support only would have a label “NAV C 262_53” which will be placed on the right vertical support and on both sides of the left vertical support.

Structures with devices located above the left vertical support only will have an ID that reflects the interstate letters for both directions of travel. Labels will be placed on the right vertical support and on both sides of the left vertical support. For example, a sign bridge on I-75 Northbound at milepost 212.53 with device(s) near the left vertical support only would have a label “NAV C/D 212_53” which will be placed on the right vertical support and on both sides of the left vertical support.

Structures with devices located above the right and the left vertical supports will have an ID that reflects the interstate letter for both directions of travel. Labels will be placed on the right vertical support and on both sides of the left vertical support. For example, an existing sign bridge on I-75 Northbound at milepost 262.53 with device(s) above both the right and left side vertical supports will have a label “NAV C/D 262_53” which will be placed on the right vertical support and on both sides of the left vertical support.
support. Any existing and/or new NaviGAtor Changeable Message Sign (CMS) located in the project limits will be labeled according to the scheme described in this paragraph. Any previous ID system will be replaced with the new system.

Structures that span the entire roadway (both directions of travel) and, as a minimum, have device(s) located above the median vertical support, will have an ID that reflects the interstate letter for both directions travel (e.g., C/D). The ID labels will be placed on both shoulder vertical supports and on both sides of the median vertical support. A full span structure without devices mounted above the median vertical support will be treated as a structure that spans only one direction of travel and will follow the guidelines as described in the previous paragraphs.

Median mounted camera poles or butterfly type CMS will have a label reflecting both directions of travel (e.g., C/D) and will be placed on both sides of the vertical support structure. In cases where there is a wide median, only one label will be needed, oriented towards the direction of traffic to which the structure is closest.

Structures which span freeway entrance and exit ramps only and have devices located on them in any location will have an ID that reflects the interstate letter for the direction of travel. Labels will be placed on the right and left vertical supports.

### 2.3 Freeway Lettering Scheme

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### 2.4 Configuration Management Submittal Guidelines

The designer will be required to submit the proposed fiber allocation and network electronics design to the TMC Configuration Manager for approval. Refer to the current GDOT Configuration Management Manual (CM Manual) for the Configuration Management submittal guidelines.

### 2.5 Power Source Design and Placement

Power service availability is an essential element to ITS projects and needs to be properly addressed by the designer. This process starts during the concept phase because of the many layers of coordination that must take place.

1. Designers are responsible for coordinating with power companies to determine the power source locations.
2. Designers are responsible for showing power service locations and power service cable routing, from the power service location to the field device cabinet, on the plans. Designers should include the device station for proposed power service locations. The power service location is the demarcation point between GDOT and the power company. In many cases, the power service location will be a new power service pole immediately inside the right of way line. Coordination with the GDOT Office of Utilities is required for new power service installations.
3. The power companies are responsible for assisting the designers in locating appropriate power company poles to obtain power, and for assisting the Contractor at the time of construction.
4. The Contractor will be responsible for designing and installing the power service location and the power service conductor for the ITS devices.

Normally power service locations must be within ½ mile of the ITS devices served. For power service routing greater than ½ mile, consult with the power company representative to choose adequate power service locations. ITS devices in urban areas typically have power sources nearby so device locations should only need to be adjusted slightly or not at all. In rural locations, however, power source locations often control the location of the proposed ITS device. Hence, in rural locations, it is recommended to coordinate with the power company as early as possible in the concept phase.

For existing power service locations which will provide power for additional ITS devices, include a payment for “power service point” for any upgrades necessary to provide the additional power.

Take note of the presence of retaining walls, guardrails, or other intervening obstacles between the proposed ITS devices and the power services, as this may affect the locations for proposed ITS devices, the choice of power service points, or the routing for the power service conductor.
2.6 Guardrail Considerations

Designers must follow GDOT’s guardrail standards to determine when new guardrail is needed, where changes to existing guardrail are required, and how to design the guardrail. Situations that occur often on ITS freeway projects are described below:

Extending existing guardrails

If a new strain pole is placed behind existing guardrail (either upstream or downstream of the existing protected feature/object), verify the existing guardrail meets all current guardrail standards. This can be challenging because the designer will have to consider the existing feature/object that is being protected and the new support that will be installed. Following the GDOT guardrail standards, the appropriate length of guardrail needs to be designed both upstream and downstream of the objects. Note that when guardrail is extended, the anchor at the end being extended will be removed, new guardrail added, and a new anchor must be installed to current standards.

Closing the gap between two runs of guardrail

If the new guardrail is close to an upstream or downstream existing guardrail, designers should use engineering judgment and determine if the new guardrail should close the gap to create one continuous guardrail.

Shortening the guardrail post spacing

The offset from guardrail face to the ITS strain pole or object should generally be 6 feet. If this offset cannot be achieved, review the guardrail standards and determine if the allowable minimum post spacing can be reduced. In extreme cases, a barrier wall may be required.

2.7 ITS CADD Standards

It is intended that drawing produced by the guidance of these standards will

- Create a homogeneous appearance in all ITS Designs
- Show the consistent conventions and procedures used on each project
- Create a uniform design and presentation of construction information
- Establish a clear and precise method of communication
- Demonstrate a professional and quality appearance

MicroStation File Settings

All CADD work will be done in MicroStation using the current version being used by GDOT. The scale setting on the base map should be 1 inch to 50 feet. Each sheet should show approximately 1,500 feet of roadway with match lines. Text font for plan sheet callouts should be set to Font 103 - “Engineering”. A text height, width, and weight should be set to 5, 5 and 1 respectively. Text for match line labels and street name labels should be 1.5 times the size of plan sheet callouts, and otherwise the same. A “Filled” arrowhead setting is preferred for plan sheet callout leaders.

MicroStation Levels

All design work should be located in the basemap file that encompasses the entire project. Sheet files are needed only to enable sheet numbering, individual naming of sheets, and printing capability. The basemap file(s), proposed design files(s), and border file shall be referenced to all sheet files.

Refer to the latest version of the GDOT Electronic Data Guidelines for the correct MicroStation levels.
**MicroStation File Names**

Refer to the latest version of the [GDOT Electronic Data Guidelines](#) for the correct MicroStation file names.

**Symbols and Line Styles**

Symbols for existing and proposed devices, and the different lines styles with applications are included in the Appendix.
3. ITS COMMUNICATION DESIGN

There are currently several communications options available to designers, including fiber optic cable, leased data lines, wireless, and DSL. Designers should select the appropriate communications media that is best suited to each ITS project. In some circumstances, more than one communications method may be used to meet the specific needs and conditions of a project.

Fiber optic cable and accessories are specified in Section 935 Special Provisions. Conduit is specified in Section 682. Pull boxes and electrical communication boxes are specified on the details. Plan details used with fiber optic cable installations include:

- Conduit and Conduit Duct Bank Type 3 Installation Details
- Under Bridge Conduit Duct Bank Installation
- Conduit Installation at Drainage Structures
- Electrical Communication Box – Type 5 Details
- Pull Box Assembly and Installation Details (TS02)
- Fiber Routing Schematic (project specific)
- Hub Block Diagram (project specific)
- Device Allocation Details (project specific)
- Bridge Attachments for Conduits (project specific)

3.1 Placement Guidelines

3.1.1 Fiber Optic Cable - Urban Freeways

Fiber optic trunk cables should be located on both sides of urban freeways, or if the median is accessible and wide enough, a FO trunk cable can be installed in the roadway median. The advantage of installing dual FO trunk cables is the elimination of numerous bores and bridge crossings that would be necessary to provide communications connectivity to devices installed on the opposite side of the facility from a single FO trunk cable.

Conduit should be placed at the back of the clear zone for best protection from being damaged in the future. Crossovers connecting the two FO trunk cables should be designed at intervals of approximately 3 miles and should be designed to cross on existing bridges. If possible, these conduit crossovers will provide a convenient means to tie the two FO trunk cables, thus enabling device communications to be rerouted in the event that one of the FO trunk cables is cut. All bridge attachments must be approved by the Office of Bridge Design. When locations for bridge attached conduit are identified, a letter must be sent to the Office of Bridge Design specifying the locations as well as the number and size of conduits to be attached.

Pull Boxes (PBs) are typically spaced 800 to 1600 ft (with a desirable spacing of 1200 ft) apart on FO trunk cable sections. Device locations usually dictate the placement of PBs, because a PB is required for a drop cable splice at each device in most cases. Pullboxes are not rated for deliberate traffic and should only be placed in areas which are not expected to have vehicles routinely present. Electrical Communications Boxes (ECBs) are used when the conduit needs to be placed under the paved shoulder, such as near a bridge approach slab.

A conduit detection wire will be installed in the trench with the conduit or in a bore with conduit. This wire will enter all PBs and ECBs and have 5’ of the wire coiled in the PB or ECB. The conduit detection wire is paid for as incidental to the conduit and is specified in Section 682 of the Special Provisions.

Please see Section 2.1 for additional placement guidelines.

3.1.2 Fiber Optic Cable - Urban Arterial Streets and Highways

On urban arterials and highways, the fiber optic trunk cable is typically located on only one side of the road. Location of FO trunk cable should be determined by device location and clearance from utilities.
The feasibility of installing aerial cable should be reviewed with the GDOT Utilities Office and the utility companies occupying the utility poles early in the design process to make sure it is possible and to determine the extent of make ready work. The cost and time for make ready work may make this option cost prohibitive, in which case the FO trunk cable will be installed in underground conduit. Another element that needs to be determined as early as possible is whether any utility poles will need guy wires and anchors. If guy wires and anchors are required, designers must ensure there is enough right of way to install them. If there is inadequate right of way, then locating the cable aerially may be a difficult option to implement because ITS projects typically do not include right of way acquisition.

If underground conduit must be used, conduit should be located outside of the paved area and back of curb for curbed sections and outside of the clear zone in non-curbed sections if possible. Designers should obtain underground utility information and locate conduit on side of road with the least utility conflicts. Designers should also consider any widening projects currently programmed in the STIP.

The requirements for PBs and detection wire are the same as required in Section 3.1.1. Designers should also take into consideration potential future device locations and ensure that PBs are located close to these locations. The amount of fiber optic cable slack, listed in special provision 935, is increased for arterials because there is a higher frequency of cable changes due to intersection improvements, land development, utility relocations, new devices, etc.

### 3.1.3 Fiber Optic Cable - Rural

See above Section 3.1.1.

If conduit must be used, it should be located outside of clear zone and away from sign structures. If excess clearing and grubbing is not required, conduit should be located just inside the ROW line.

The requirements for PBs and detection wire shall be the same as required in Section 3.1.1.

### 3.1.4 Fiber Optic Cables for Local Agencies

In some cases, installing an extra fiber optic cable will greatly benefit a local agency at a negligible cost to the project. Therefore, designers should investigate whether the local agencies within their project limits can justify a local agency cable installed along the roadway.

Designers should first discuss the addition of a local agency cable with the ITS Design Manager. If the ITS Design Manager approves the concept, then designers need to discuss the additional cable with the local agency and determine their intended use of the cable. If a decision is made to install the cable but the local agency is not sure of the cable size, use a 24-fiber cable.

The local agency FO cable should be routed along the freeway in one of the empty conduits in the conduit duct bank. The cables generally run continuously along the freeway from hub building to hub building or from hub building to a pull box at a cross street (point to point). At major cross streets selected by the local agency, the cable runs from a freeway pull box up to a pull box on the shoulder of a cross street. The cable is then coiled in the pull box, routed back to the freeway, and then run down the shoulder of the freeway with the other trunk cables. Designing a continuous cable with pull boxes at the cross streets enables maximum flexibility for accessing and using the cable in the future. Placing the pull box on the cross street allows the local agency to access the cable from an arterial street rather than on the freeway, which would require them to obtain a permit. Additionally, this design keeps GDOT’s cables separate from the local agency’s cable. Local agency cables that enter a hub should be terminated on a dedicated FDC that is used only to terminate the local agency cable, see Section 11 for more details.

Before local agency cables are installed, an agreement between the local agency and GDOT for fiber ownership and maintenance must be executed in case the fiber is damaged during future excavations. The printline of the local agency cable should be labeled with the maintaining agency/owner of the cable to avoid any confusion during maintenance.
3.1.5 Wireless and DSL Communications
This section is a placeholder and will be included in a later revision.

3.2 Field Location Considerations

3.2.1 Conduit

3.2.1.1 Urban Freeways
Conduit should be installed at the back of back of the clear zone, where it will be well protected from future excavation. When conduit is installed under the paved or graded shoulders, the contractor has two installation options: open trench installation or boring. When conduit is installed outside the shoulder, either open trench installation, boring or plowing may be used. When conduit is installed under the travel lanes or under ramps, boring is required.

When using open trench installation outside of the paved shoulder, the conduit duct bank will be installed such that the top of the duct bank is at a depth of 48” below grade. However, if this depth cannot be achieved due to underground obstacles then the top of the duct bank may be installed at a shallower depth but not less than 18”, as shown in the Installation Details.

When boring under paved shoulders, travel lanes, or ramps, designers compute the appropriate bore diameter needed to accommodate the conduit to be located in the directional bore. For instance, a 6” diameter bore is typically used for conduit duct bank type 3. When drawing the boring runs on the plans, designers should not show the conduit route with sharp bends since a boring machine cannot perform sharp conduit bends. Also, the boring rig will require a work area of approximately 25 feet in length to position the rig for the bore.

For bridge crossings, the preferred method of crossing is to bore underneath the bridge or stream. Due to exposed conduits under bridges being damaged by vandalism, boring underneath stream crossings or arterials should be designed whenever possible to protect the fiber optic cable and conduit, and bridge-attached conduit should be designed as a last resort. If conduit must be attached to the bridge, it is preferred to bore around the approach slab and end wall. The bore should be terminated in a pull box that is placed in the slope paving. Fiberglass conduits are then run from the pull box up the end wall and then across the bridge according to the detail provided by the Bridge Office.

For each ITS project requiring conduit attachment to bridges, designers must send a letter to the GDOT Bridge Office with the following information:

- Each bridge within the project limits to which conduit attachment is proposed
- Proposed location of conduit on each bridge
- Request for the Bridge Office to furnish both an attachment detail and bridge plans.

In return, the GDOT Bridge Office will

- Advise if conduit can be attached to the listed bridges
- Supply a conduit hanging/attachment detail
- Supply bridge plans for each bridge to which conduit can be attached.

3.2.1.2 Urban Arterial Streets and Highways
When cable is installed aerially on utility poles, it shall be in accordance with the pole owner requirements and the National Electric Code (NEC). The utility companies are responsible for the design and point of attachment information. ITS plans need to show the routing of the cable, and designers need...
to make sure that the GDOT Utilities Office is coordinating with the utility companies to prepare the design.

When cable is installed in conduit, the designer shall determine the number and size of conduits. The designer should provide a separate conduit for each fiber optic cable and two spare conduits. A conduit detection wire shall be installed in the trench as shown in the installation details and as outlined in Section 3.2.1.1.

The requirements for conduit installation under travel lanes or ramps and for bridge installations, shall be as outlined in Section 3.2.1.1.

### 3.2.1.3 Rural

When cable is installed aerially on utility poles, it shall be in accordance with the pole owner requirements and the National Electric Code (NEC). The utility companies are responsible for the design and point of attachment information. ITS plans need to show the routing of the cable, and designers need to make sure that the GDOT Utilities Office is coordinating with the utility companies to prepare the design.

The conduit shall be installed by open trenching at a minimum depth of 18” and backfilled with Class B concrete up to 12” below the existing grade. The remaining trench shall be backfilled with excavated material and area restored to match the surrounding area.

Designers determine the number of conduits, providing a separate conduit for each fiber optic cable and two spare conduits. A conduit detection wire shall be installed in the trench as shown in the installation details and as outlined in Section 3.2.1.1.

The requirements for conduit installation under travel lanes or ramps and for bridge installations, shall be as outlined in Section 3.2.1.1.

### 3.2.2 Pull Boxes and ECBs

The electrical communications boxes (ECBs) and pull boxes (PBs) used on GDOT ITS projects are designed to be large enough to accommodate a splice enclosure and the coil of the specified amount of slack fiber optic cable without violating the manufacturer’s specified bending radius of the cable.

A PB should also be located at each end of a directional bore. Additionally, a PB or ECB is required immediately before and after a bridge or any other situation where there is a conduit transition, for example at a device location or a FO trunk cables junction point.

For freeway or arterial installations, the Type 7 PB is commonly used when several conduits and large fiber optic cables are required or along the FO trunk cable for maintenance slack, device drops, or reel to reel splices. A Type 4S PB is used at the base of ITS device poles. A drop cable, typically 12 fiber, connects the Type 4S PB back to the Type 7 PB along the FO trunk cable.

An ECB is necessary if a box needs to be installed in the shoulder or other paved area. ECBs should not be installed in an active travel lane. The most commonly used ECB is a Type 5 ECB, which is a precast structure with a manhole lid rating for bearing traffic. ECB rehabilitation is required when a new conduit needs to enter an existing ECB. Designers should verify the ECB is in good condition and can accommodate the number of desired conduits.

Conduit installation on top of a reinforced earth (RE) wall should be avoided. Where it is necessary, care is needed to avoid the reinforcing straps. Because of this, two exceptions to typical placement occur. First, the conduit is installed at a shallower depth (typically 12”). Second, a Type 4S or 5S pull box is used instead of an ECB, because an ECB would conflict with the RE wall straps.
3.3 Options

3.3.1 Cable
Fiber-optic cable sizing depends on the project communications requirements. The options to consider are cable type, cable construction, fiber mode, and fiber count. This is generally agency driven and options should be discussed early in the design process.

3.3.1.1 Cable Type
The type of fiber optic cable selected depends on whether it is intended for outside installation (outside plant cable or OSP) or inside installation (inside plant cable or ISP). Most cable used on GDOT ITS projects will be OSP. Upon entrance to a building, OSP FO cable must terminate and transition to ISP cable within 50’ of OSP cable exposure (if it is not in rigid steel conduit) in a building. Designers are responsible for designing ISP in conformance with building and fire codes. Other details associated with the structure of the fiber are as described in the specifications.

3.3.1.2 Cable Construction
Outside plant cable for GDOT trunk cables is exclusively loose tube construction. Outside plant cable for GDOT drop cables (used between the trunk cable and individual device cabinets) can be either pre-terminated drop cable assemblies or loose tube cables that are spliced to a pigtail. Typically, each field device will require a 4 to 12 fiber pre-terminated drop cable assembly. The contractor uses the drop cable distance provided in the project plans to order the correct drop cable length, since pre-terminated drop cables must be made to order. If for a special situation a drop cable greater than 12 fibers is required, then a pigtail is used. The contractor will splice the pigtail, a short section of pre-connectorized loose tube cable, to the drop cable. The pre-connectorized end may include a Fiber Distribution Center (FDC) for use in a field cabinet. The non-connectorized end is then field spliced to the drop cable by the Contractor. Designers should note that the pigtail and the fusion splices required to connect the pigtail to the drop cable are not paid for separately but are included in the cost of the drop cable.

3.3.1.3 Fiber Mode
The majority of fiber optic cable on existing GDOT freeway ITS projects is single mode, but some multi mode remains. Only single mode fiber optic cables are specified for future NaviGAtor projects.

3.3.1.4 Fiber Count
At this time, the typical drop cable required for freeway projects is 12 fibers, with all twelve fibers from the drop cable spliced at each device cabinet, including several spare fibers. Drop cables along freeways and arterials can contain 4, 6, or 12 fibers.

The number of fibers needed in the trunk cable is a combination of the number needed to support the devices, plus the number of spares, rounding up to a standard cable size. First, determine the number of fibers required to provide communications for every device chain, as discussed later in this section. Next, assume 25 to 50% spares. Finally, round up or down to the nearest standard cable size (see the standard sizes in Pay Item Selection at the end of this section).

3.3.1.5 Reel To Reel Splicing
Fiber optic cable is available in reels of up to 20,000 feet of cable. Depending on the number of fibers, reel to reel splices should be anticipated and planned for at convenient locations. Designers should note that fusion splices must be paid for at reel to reel splices. For example, if a 72-fiber cable is used, then 72 fusion splices will be required at every reel to reel splice point.
Designers should add the reel to reel splices to the plans just prior to finalizing the plans for PFPR submittal. For freeway installations, reel to reel splices should be placed in intermediate ECBs or pull boxes where no other splices exist. On arterials, it is typically most practical to perform reel to reel splices at other splice locations, such as at device drops. Reel to reel splicing for both aerial and underground arterial applications should be planned every 3,000 to 5,000 feet of cable. Reel to reel splicing for freeway applications should be planned approximately every 10,000 feet of roadway. When determining reel to reel splicing locations, remember to account for the slack cable coiled in pull boxes and ECBs. Cable storages for pull box and ECB are specified in Section 935 of the Special Provisions.

3.3.2 Conduit
Three different conduit types are used in ITS projects: continuous flexible conduit (HDPE non-metal Type 3), Schedule 40 (Sch 40) PVC conduit (non-metal Type 2), and fiberglass conduit.

For typical FO trunk cable applications, HDPE is the preferred conduit choice. The typical HDPE installation will have a conduit quantity and size configuration that is installed on both sides of the road. Conduit duct bank configuration Type 3 is defined as follows and is included in Section 682 of the Special Provisions:

- **Type 3**: four (4) 2” HDPE ducts

Pre-formed PVC conduit bends and sweeps are also used, because HDPE conduit bends and sweeps are not available. HDPE conduit transition to a PVC bend or sweep is shown in the installation details. PVC conduit should be used between the trunk pull box and device pull box if the distance between the two is less than 20 feet.

Fiberglass conduit is used in two situations: attachment to bridge structures and when exposed (such as hub building or device entrances). Transitioning between conduit types requires a transition in an ECB or pull box.

3.4 Fiber Allocation

3.4.1 Communications Path
The typical communications path from a field device to the hub or control center is as follows:

Field Device → Drop Cable → Trunk Cable → Hub/Control Center

Each field device is connected by a drop cable. The drop cable is spliced to a trunk cable. When a device communicates as part of a string with other devices, as discussed later, the other side of the trunk cable fiber is used to communicate with the next device. The final destination for FO trunk cables is a termination at a hub or control center.

3.4.2 Communications Strategies
There are three communications scenarios used in GDOT ITS Design projects.

- **New Fiber Optic Trunk Cable with New ITS Devices and Ramp Meters**: New ITS devices follow Ethernet communication architecture. A field switch is installed at each device location, and devices on the same side of the freeway are daisy chained. The daisy chain utilizes a pair of trunk fibers which are terminated at designated hubs. Each daisy chain reserves two pairs of trunk fiber for daisy chain spares. The length of the daisy chain is limited to either eight (8) field switches or six (6) CCTV cameras, whichever is reached first. A 12 fiber drop cable is installed at each location with up to 12 splices at each location. To connect a ramp meter cabinet, use a field switch with 1 or more ports to communicate over a pair of fibers to a field switch at an ITS device location containing a 3 port switch. In the event that only one hub is present and the daisy chain needs to be completed with
both ends terminating in the same hub, the last Field Switch on one side of the freeway will be connected to a pair of trunk fibers connecting back to the hub, preferably on the other side of the freeway via a crossover.

- **Existing Fiber Optic Trunk Cable with New ITS Devices and Ramp Meters**: If single-mode FO trunk cable is existing, ITS devices are daisy chained with a pair of trunk fibers, and 2 spare daisy chain pairs, as described above. Each ramp meter connects to a designated ITS device location as described above. In the event that only multi-mode fibers are available and there are suitable existing conduits for installing new fiber, a new single-mode FO trunk cable may be installed with GDOT approval.

- **Existing Fiber Optic Trunk Cable and ITS Devices with New Ramp Meters**: If there are single-mode trunk fibers available, the ramp meters will communicate with the hubs through a pair of trunk fibers, as described above. A four (4) fiber drop cable as well as a Type C, D, or E field switch is installed at each ramp meter location, and ramp meters on the same side of the freeway are daisy chained, with the chain end terminating at designated hubs.

### 3.4.3 Daisy-Chaining Devices

The following schematics illustrate how devices are daisy-chained given a one or two hub layout. For most new ITS projects, a one hub layout will commonly be used. Three pairs of fibers are used for each daisy chain of up to eight devices, as described above. Two fibers are used for Transmit/Receive while the remaining four are spares. Three pairs of fibers are used to complete the communications loop on the opposite side of the road, unless there is hub-to-hub communications between the two hubs adjacent to the daisy-chained devices.
3.4.4 Field Switch Selection

There are currently five (5) field switch types that may be used on GDOT ITS projects. To determine the type of field switch needed, designers must determine the upstream and downstream distance to the next device in the daisy chain or hub.

<table>
<thead>
<tr>
<th>Field Switch Type</th>
<th>GBIC Configuration</th>
<th>Distance to Upstream Location</th>
<th>Distance to Downstream Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>2 LX, 1 spare LX</td>
<td>&lt; 6 miles</td>
<td>&lt; 6 miles</td>
</tr>
<tr>
<td>Type B</td>
<td>1 LX, 1 XD, 1 spare XD</td>
<td>&gt; 6 miles</td>
<td>&gt; 6 miles</td>
</tr>
<tr>
<td>Type C</td>
<td>2 LX</td>
<td>&lt; 6 miles</td>
<td>&lt; 6 miles</td>
</tr>
<tr>
<td>Type D</td>
<td>1 LX, 1 XD</td>
<td>&gt; 6 miles</td>
<td>&lt; 6 miles</td>
</tr>
<tr>
<td>Type E</td>
<td>2 XD</td>
<td>&gt; 6 miles</td>
<td>&gt; 6 miles</td>
</tr>
</tbody>
</table>

Note that Type A and B field switches are used for freeway mainline ITS locations and Type C, D, and E field switches are used for ramp meter locations.

3.4.5 Device Allocation Table

The Device Allocation Table is a splicing and allocation table provided in Special Provision 940. An example is included in the Appendix. The table shows the drop cable and trunk cable(s) each device uses to communicate, as well as the device’s associated communications equipment in the hub and in the field.

Device Location Station: The roadway station of the device as shown on the design plans.

Device Location Structure Number: The identification number assigned to the device pole as shown on the design plans. The ID number is entered as “NAVX YY_YY, and is explained in detail in Section 2.2.
**VDS Device ID**: The identification number assigned to the VDS field device. Each field is entered as “AXCYYY”, where “A” is N, S, E or W for one of the cardinal directions, “X” is a single digit number, “C” is always C and “YYY” is the three numeric digits of the applicable CCTV ID. For example, “N7C034” would be the 7th VDS north of CCTV camera “CAM034”. VDS ID is assigned by the TMC Configuration Management Section (see Section 2.4).

**CMS Device ID**: The identification number assigned to the CMS field device. The ID is a four digit number assigned by the TMC Configuration Management Section (see Section 2.4).

**CCTV Device ID**: The identification number assigned to the CCTV field device. Each field is entered as “CAMYYY”, where “YYY” is the three digit number assigned to the CCTV. CCTV ID is assigned by the TMC Configuration Management Section (see Section 2.4).

**Ramp Meter Device ID**: The identification number is assigned to the ramp meter. Ramp Meter ID is assigned by the TMC Configuration Management Section (see Section 2.4).

**Trunk Cable Fiber Number or Drop Cable Fiber Number**: The identification number assigned to the interstate trunk cable. ID number is entered as “NAV05-YYYY.Z.” “YYYY” is the unique trunk cable ID and “Z” is the fiber number of the trunk cable. The trunk cable ID is assigned by the TMC Configuration Manager (see Section 2.4).

**Drop Cable ID**: The identification number assigned to the drop cable. Drop cable ID is entered as NAV05-YYYY-0XX, where “YYYY” is the ID of the trunk cable used in communications routing and “0XX” is the three-digit number assigned to that drop cable for the given trunk cable. The drop cables are numbered for each trunk cable, starting with 001.

**Fiber Number**: Fiber number used. For example, “S2” would be the second fiber of a single mode drop cable.

**Destination or FDC Port (Hub/Center, FDC or Device)**: The next sequential destination of the device’s communications, given as another device, a hub building, or specific FDC port. FDC ports are labeled as “HUBXXFODISTRAABBCCDD”, where “XX” is the hub’s letter designation, “AA” is the rack number within the hub/control center, “BB” is the FDC position in the rack, “CC” is the column within the FDC and “DD” is the row within the FDC.

**Function**: Specifies whether the fiber is transmitting or receiving, or whether it is a spare for a daisy chain or a hub home run.

**Field Switch GBIC Port**: Either “LX” or “XD” depending on the transmit distance to the hub. “LX” GBICs are used for distances under 6 miles, while “XD” GBICs are used for distances over 6 miles or for the last device in a daisy chain.

Note: Fiber optic cables follow the TIA/EIA 598-A Color Code standard shown below.

<table>
<thead>
<tr>
<th>TIA/EIA 598-A Color Code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
</tr>
<tr>
<td>1</td>
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<td>8</td>
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</tbody>
</table>
3.5 **Pay Item Selection**

The pay item numbers and descriptions below are examples that may be appropriate for ITS communications design. Always check the Department’s most current list of pay items.

Identify the outside plant cable type (typically, loose tube or drop) and fiber count (as required), per linear foot, as well as the quantity of fiber splicing and termination components:

- 935-111X = Outside Plant FO Cable, SM
- 935-15XX = Outside Plant FO Cable, Drop, SM
- 935-31XX = FO Closure, Underground
- 935-32XX = FO Closure, Aerial
- 935-34XX = FO Closure, Rack-Mounted
- 935-35XX = FO Closure, Wall-Mounted
- 935-36XX = Outside Plant FO Pre-terminated Drop Cable
- 935-4010 = FO Splice, Fusion
- 935-1XXX = Outside Plant FO Cable

Identify the linear foot quantity of conduit, power service conduit and wire, and the quantity of pull boxes, ECBs:

- 647-2141 = Pull Box, PB-4S
- 647-2151 = Pull Box, PB-5S
- 647-2160 = Pull Box, PB-6
- 647-2170 = Pull Box, PB-7
- 682-6219 = Conduit, nonmetal, Tp 2, 1 in.
- 682-6222 = Conduit, nonmetal, Tp 2, 2 in.
- 682-6228 = Conduit, nonmetal, Tp 2 – Power Service, 2 in. (see Sec 2.5)
- 682-6231 = Conduit, nonmetal, Tp 3, 1 ¼ in.
- 682-6233 = Conduit, nonmetal, Tp 3, 2 in.
- 682-6520 = Conduit, fiberglass, 2 in.
- 682-7060 = Conduit duct bank, Type 1
- 682-7061 = Conduit duct bank, Type 2
- 682-7062 = Conduit duct bank, Type 3
- 682-9028 = Electrical communication box, Tp 5
- 682-9029 = Electrical communication box rehabilitation
4. CHANGEABLE MESSAGE SIGN DESIGN

**Goal/Concept:** Changeable Message Signs (CMS) allow NaviGAtor system operators to display incident or travel time information to the motorists on the freeways. Incident information can be related to accidents, stalls, roadwork or debris. Additionally, information concerning the general condition of downstream traffic, often expressed in travel times, may be shown on the signs when no other incidents are occurring. Messages may also include Amber alerts, evacuation information, or other traffic related information. Messages on the signs may be either operator-generated, or automatically created by the NaviGAtor system. A series of database tables allows the instant creation of response plan messages based upon incident data entered by the operators. Message sign placement is very important.

Changeable message signs are specified in the Section 631 Special Provisions. Plans details used with CMS installations include Electrical Service Installation Typical Details and Clearance Diagrams (site specific).

4.1 Placement Guidelines

### 4.1.1 Urban Freeways

The standard spacing between successive CMS is generally 5 to 6 miles, though CMS should be located in advance of major decision points and potential diversion routes. As applicable, consider location of existing CMS and roadway geometrics when locating new CMS.

CMS should be placed in advance of major decision points and potential diversion routes, so that motorists have sufficient opportunity to:

- Recognize the sign
- Read the message on the sign
- Determine their response to the message on the sign, and
- Make adjustments (turn signals, lane changes) in response to the message on the sign

Consequently, CMS should be:

- Located at a minimum of 2/3 mile in advance of an interchange exit
- Located a maximum of 2 miles before decision points or diversion routes, including freeway to freeway interchanges.
- Motorists should be able to read the CMS’s message 900 ft. upstream of their location. The placement of the CMS should facilitate the display of message to the maximum extent possible.

Please see Section 2.1 for additional placement guidelines.

### 4.1.2 Urban Arterial Streets and Highways

The use of CMS on urban arterial streets and highways is usually associated with special event location, diversion route for hurricane evacuations, or similar special conditions. Designers should coordinate the location of CMS with the local agency responsible for traffic operations on the roadway. The visibility requirements listed in Section 4.1.1 are not appropriate for arterial streets. The requirements contained in section 2C.05 of the MUTCD should be used as a guideline for sign placement.

### 4.1.3 Rural

Currently, there are not specific criteria to determine whether a CMS is needed on a rural roadway. As such, designers should seek input from GDOT/Client stakeholders, apply their own judgment and then
gain approval from the ITS Design Manager and the GDOT district traffic operations personnel. Generally, a rural CMS is warranted if it is intended to be used for a specific purpose, such as special event traffic control or a hurricane evacuation route. The designer should make sure the CMS is part of an operational plan by the District and GDOT TMC. The availability of electrical power and communications, typically telephone, are the controlling factors in placing rural devices. The specific requirements listed in Section 4.1.1 should also be considered in location selection. As with freeway CMS, rural CMS should be placed in advance of major decision points and potential diversion routes, so that motorists have sufficient opportunity to recognize, read, respond, and make adjustments as necessary.

### 4.2 Field Location Considerations

There are many considerations designers should address through CMS design. Care should be taken to avoid locating CMS:

- Within merging/weaving sections
- Near entrance and exit ramps
- Within 800 feet (upstream or downstream) of existing or known proposed static sign structures (except for post-mounted signs and median mounted sequential guide signage).

Two types of CMS are predominantly used for limited access-roadway applications:

- 3 x 15 signs (3 lines of text with 15 characters per line, 18” character height) are typically mounted on a butterfly structure outside of the clear zone on the right side of the roadway.
- 3 x 21 signs (3 lines of text with 21 characters per line, 18” character height) are used for limited access general signage. This type CMS will be centered over the lanes for which the message is intended, using a full-span structure.

Provide sufficient clearance around structural base to allow for

- Personnel to access the sign face and overhead structure
- Installation of the structural support-mount cabinet (when used)
- Access to both the front and back doors of the structural support-mount CMS cabinet
- Opening of the cabinet interior from either front or back doors
- Safe location of a maintenance bucket truck (on a lane closure for maintenance)

If a VDS or CCTV will be mounted on a tubular extension attached to a CMS structure, the VDS or CCTV cabinet shall be mounted on the structural support while the CMS cabinet shall be base-mounted upstream of the CMS. Radar detection units (RDS) should not be mounted on CMS structures due to the interference the radar units will receive from the CMS.

For base mounted CMS cabinets:

- Locate the cabinet approximately 100 feet from the CMS in a flat, protected area
- Provide personnel easy access to the cabinet interior using the front and back doors
- Place the cabinet such that the doors will open to at least 90°
- Locate the cabinet within the right of way

The CMS cabinet is generally mounted in advance of the sign to facilitate a technician’s view of the CMS face from the cabinet during maintenance or troubleshooting.

If an existing median barrier wall exists, call for a total of 60’ of the wall to be removed and replaced with *Concrete Barrier, Special Design, Type 26 (30’ upstream and downstream of the structural support).*
For traffic control, include 350’ of Precast Concrete Median Barrier, Method 1 or 2, for every CMS site that requires removing and replacing median barrier wall. Method 1 shall be used when the roadway is at grade, Method 2 shall be used on approach slabs and bridges.

The location of the power source and the communications service point (if applicable) should be considered during preliminary design. Careful location of a CMS can significantly simplify getting both power and communications service to the sign. Proximity of the CMS cabinet to retaining walls or other intervening obstacles between the CMS and the AC power source should be considered. The designer should coordinate with the local service providers to establish the power service points shown on the plans. If fiber optic communications are not shown in the plans, then the contractor will determine the final communications source. District Utilities should be kept aware and invited to all meetings between the designer and electrical service and communications providers. The Contractor will coordinate final power and communications locations with the local service providers, but, nonetheless, reasonable power service and communications points need to be established on the plans.

Guardrail should be installed as dictated by GDOT installation standards and the Roadside Design Manual. The placement of the CMS cabinet should be such that it will be adequately protected by either existing guardrail or new guardrail protecting the structure support.

As part of the design effort, CMS Clearance Diagrams must be developed for new CMS structural supports. This diagram will include sign placement over the travel lanes and clearance above the roadway. The GDOT Bridge Office shall review all existing CMS structures for structural sufficiency. The GDOT Office of Materials and Research shall inspect any existing structures that are to be reused to evaluate their condition. A sample clearance diagram is included in the Appendix.

4.3 CMS Options
There are five options in a CMS installation design: character height, display matrix, housing type, display technology, and communications medium.

Permanent, freeway signs always use 18” high characters. Non-freeway or portable signs may use smaller characters if appropriate visibility and perception/reaction time is maintained.

The display matrix describes the size of the sign in number of rows high and characters wide. As mentioned above, signs will be 3 rows high and 15-21 characters wide.

Sign housing may be either walk-in or non-walk-in. 3x21 signs are typically walk-in, whereas 3x15 signs are typically non walk-in.

All signs use LED pixel display technology. NaviGAtor communication is typically over fiber-optic cable; however, CMS can also communicate using other technologies. If fiber-optic-based communications are not available, private/leased communications, such as a digital subscriber line can be used. Signs may be upgraded to fiber-optic communications in future phases of NaviGAtor expansion.

A sample plan sheet showing a CMS installation is included in the Appendix.

4.4 Pay Item Selection
A detailed ITS pay item list is included in the Appendix.

- Power source
  The only selection to be made concerning power source is whether the service point is aerial (939-5010) or underground (939-5020).
- Drop cable
Two sets of decisions are required when calling out the pay item for a drop cable: type of fiber (single mode, typically), and the fiber count (12 typically, 6 or 12 for arterials). For instance, a six-count single mode drop cable would have a pay item of 935-1511.

- Splice requirements (type and number)

Only fusion splices, (935-4010) shall be used on GDOT ITS projects. Note that the splice pay item is per each splice. Designers should note that fusion splices must be called out and paid for individually where the drop cable is spliced to the trunk cable (typically occurring in a PB or ECB). However, fusion splices are not paid for separately where the drop cable ties into the cabinet. This end of the cable is either pre-connectorized or the contractor must splice on a pigtail, either of which are included in the price of the drop cable.

Splice closures can be located in one of three locations: underground, aerial, or in a cabinet. The capacity of the splice closure should match the drop cable size. Therefore, an underground six-fiber fiber splice closure would have a pay item number of 935-3101.

- Communication type and associated hardware

For device communications transmitters, the choices to be reflected in the pay item include the communications medium, either fiber optic communications or public network.
- 939-1355 = DSL modem
- 939-1375 = Public network dial-up modem
- 939-23xx = Field switch, type x (choose appropriate field switch strength and # of communication channels)

- Display technology, housing type, matrix size, and character height

The display technology, housing type, matrix size, and character height are all defined in the pay item number. For a 3x21 CMS with 18” characters and a walk-in housing, the pay item number would be 631-1163. Because the cabinet and internal processor equipment are unique to the CMS and other devices electronics will not be located in the same cabinet, there is no specific callout for a controller (processor) and cabinet assembly; they are included in the pay item for the CMS sign assembly. The only items paid for separately in a CMS cabinet are FDCs and communications equipment.
5. CLOSED CIRCUIT TELEVISION SYSTEM (CCTV) DESIGN

From TMC Planning Section’s Design Criteria document: \textit{Goal/Concept: CCTV dome cameras are used by NaviGAtor operators for incident verification and general transportation system surveillance. These color cameras can pan, tilt and zoom by using the NaviGAtor Graphical User Interface (GUI). Cameras are typically located on strain poles at a substantial height to provide the most commanding view of the adjacent area. As close to 100% coverage as is possible is desired for the CCTV camera system. This means that blind spots due to bridges, overpasses, signs, billboards, trees, etc. should be minimized if not altogether eliminated.}

CCTV systems are specified in Section 936 Special Provisions. Additional plans details used with CCTV installations include VDS Installation Typical Details, CCTV/Microwave Radar Detection Installation Typical Detail, Electrical Service Installation Typical Details, and Grounding Assembly Typical Erection Details.

5.1 \textbf{Placement Guidelines}

5.1.1 \textbf{Urban Freeways}

CCTV sites are located after the CMS sites are determined. The designer should start by locating poles with CCTV cameras (used for general traffic surveillance) at all interchanges within the project limits. Place the CCTV sites in the quadrant of interchange that provides the best freeways views (primary) and the best arterial views (secondary). CCTV cameras at interchanges should be able to monitor the operations of each of the ramp/arterial intersections as well the queue discharge area of any ramp meters. If a single camera does not have a clear view of all of these locations, then separate CCTV cameras will need to be placed for optimal coverage.

Locate CCTV sites between interchanges after you have placed VDS cameras (see Chapter 6, Video Detection System (VDS) Design). The goal of CCTV camera placement is to achieve 100% coverage of the roadway with some overlap in coverage areas of adjacent cameras. If complete coverage cannot be achieved by using proposed VDS poles, then additional poles will need to be added exclusively for the CCTV cameras. CCTV coverage should not be sacrificed to co-locate CCTV and VDS on the same poles. However, when a conveniently located pole or structure exists, it may be less costly to use two co-located CCTVs instead of one CCTV on a separate pole by itself.

The CCTV cameras currently used by the Department have a straight line, maximum zoom viewing range of about 2/3 mile. Spacing between CCTV cameras is 1 mile.

As a first pass, place CCTV cameras at 1 mile intervals, preferably on the same poles used for VDS cameras, and all on the same side of the road (it’s easier for operators this way). To refine the locations, consider the following issues, and move the cameras or place them on poles separate from the VDS if necessary:

- A CCTV camera on a curve should be on the outside of the curve to maximize viewing distance in each direction.
- A CCTV camera view should not be obstructed by bridges, overhead sign structures, tunnels, vegetation, vertical curves, etc. Pay particular attention to the camera view in sag vertical curves. Dome cameras can only pan vertically approximately 2% above the horizon.
- Make sure that camera coverage includes the freeway under cross-road overpasses, except where the view of the cross-road is deemed a higher priority.
- The face of each CMS should be readable using a CCTV camera. The CCTV camera shall be placed 600 to 2000 ft from the face of the CMS structure.
Visit each CCTV site in the field to confirm and finalize camera locations. Consider implications of nearby airports when selecting pole locations. Restricted glide paths for approaching aircraft are sometimes distant from the airport itself. Consequently, pole locations and heights should be approved by the FAA in projects passing near airports. Contact the appropriate airport manager if there is a concern that a pole may be in a runway glide path.

Please see Section 2.1 for additional placement guidelines.

5.1.2 Urban Arterial Streets and Highways
Location of CCTV sites on arterial streets and highways will normally be near signalized intersections to provide coverage of both arterial and intersecting streets. Power and communications are usually available at these locations. Designers should coordinate with the agency responsible for traffic operations on the roadway.

If a pole is not available for mounting, try to locate the pole outside of clear zone, but within the right of way, to eliminate the need for guardrail. In addition to the clear zone requirements, overhead utilities may be located in the area of proposed poles. Designers should locate poles to provide a minimum of 10 ft clearance (vertical and horizontal) of power service lines.

5.1.3 Rural
Currently, there is no specific criterion to determine whether a CCTV is needed on a rural roadway. As such, designers should use their own judgment and then gain approval from the ITS Design Manager and the GDOT district traffic operations personnel. Generally, a rural CCTV is warranted if it is intended to be used for a specific purpose, such as special event traffic control or monitoring hurricane evacuation routes. The designer should make sure the CCTV is part of an operational plan by the District and GDOT TMC.

Location of CCTV sites on rural roadways will depend on availability of suitable power and communications. These sources are normally available at interchanges and cross roads, so this will be the starting point for CCTV locations.

The provisions of Section 5.1.1 should be followed to locate any additional CCTV sites.

5.2 Field Location Considerations
Use overhead sign structures for the mounting of CCTVs where possible, using a 35’ tubular extension, but do not mount cameras on Type 2 (cantilever) sign structures. You can often compensate for blind spots caused by sign structures by placing a CCTV camera on the structure.

Provide sufficient clearance around the pole base to allow for

- Installation of the side-mount cabinet (Type D)
- Access to both the front and back doors of the side-mount CCTV cabinet
- Opening of the cabinet doors to at least 90°
- Personnel to access the cabinet interior from either front or back doors
- Safe location of a maintenance bucket truck (on shoulder or off pavement so as to not require a lane closure for maintenance)

If cabinet will be base mounted, then

- Locate the cabinet no more than 100 feet from the pole in a flat, protected area
- Provide personnel easy access to the cabinet interior using the front and back doors
• Place the cabinet such that the doors will open to at least 90°
• Locate the cabinet within the right of way

A CCTV shall be placed 600 to 2000 ft from the face of each CMS to view the messages being displayed on the CMS.

Although a camera is placed at a certain location to accomplish a transportation management function, a related issue concerns the location of the AC power sources. Consider the proximity of AC power sources during preliminary design. Careful location of a camera pole can significantly simplify the provision of AC power to the camera(s). Consider, also retaining walls, guardrails, or other intervening obstacles between the camera pole and the AC power source. The designer should coordinate with the local service providers to establish the power service points shown on the plans. District Utilities should be kept aware and invited to all meetings between the designer and electrical service providers.

Ideally, CCTV poles should be placed outside the clear zone, which is determined by the design speed of the roadway. If this is not possible, protect CCTV poles with guardrail per GDOT’s standards. If existing guardrail is not present at a proposed pole location, specify the installation of new guardrail per Department standards. Locate poles 6 feet behind the guardrail.

The poles are specified in Section 639.03.1 Special Provisions, as “poles for supporting CCTV and VDS devices....” The length of the pole is not explicitly called out on the plans, though the desirable CCTV mounting height above the pavement surface is called out (55 to 70 ft on urban/rural freeways and 45 to 55 ft on arterial streets and highways). It is up to the contractor to determine the actual length of the pole itself to both achieve the specified mounting height for each device and to have adequate pole depth below the surface. To simplify their work, contractors will often choose one pole length to meet all height requirements rather than buying different length poles.

### 5.3 CCTV Options

NaviGAtor communication is typically over fiber-optic cable; however, CCTV cameras can also communicate (both video from the camera and data to and from the camera) using other technologies. If fiber-optic-based communications are not feasible, alternative communications, such as DSL, can be used. Existing cameras utilizing older dial-up technology may be upgraded to fiber-optic communications in future phases of NaviGAtor expansion. Designers must coordinate with the Utility Companies prior to letting to make sure that the required communications are available; however, it is the contractor’s responsibility to coordinate the installation.

Typically, one Type D cabinet is used for each freeway CCTV installation. If placing a pole with cabinet on a steep slope, then provide a platform to enable cabinet access for a technician. Sample plan sheets showing CCTV installations are included in the Appendix.

Each CCTV location will require a Video Encoder to digitize the analog video signal and send it over the network. Video Decoders convert the digital video back to analog video signals so the images can be viewed on an analog monitor, such as at a TCC. Video Decoders should only be included when requested by the agency overseeing the project.

### 5.4 Pay Item Selection

A detailed ITS pay item list is included in the Appendix.

• Power source

  The only selection to be made concerning power source is whether the service point is aerial (939-5010) or underground (939-5020).

• Cabinet type
Closed Circuit Television System (CCTV) Design

- 939-4040 = Type D Cabinet (cabinet only, with light, AC power service assembly, and fan. Internal equipment and wiring is specified with the field devices)

- Drop cable

  Single mode pre-terminated drop cables are preferred on GDOT ITS projects, however designers must determine the appropriate the fiber count (12 typically, 6 or 12 for arterials). When using a pre-terminated drop cable, designers must call out both the pre-terminated FDC as well as the length of drop cable. For example, a twelve-fiber pre-terminated single mode drop cable would include the following pay items:

  - 935-1512 = OSP Fiber Optic Cable, Drop, Single Mode, 12 Fiber
  - 935-3603 = Fiber Optic Closure, FDC (Pre-Terminated), Type A, 12 Fiber

- Splice requirements (type and number)

  Only fusion splices, (935-4010) shall be used on GDOT ITS projects. Note that the splice pay item is per each splice. Designers should note that fusion splices must be called out and paid for individually where the drop cable is spliced to the trunk cable (typically occurring in a PB or ECB). However, fusion splices are not paid for separately where the drop cable ties into the cabinet. This end of the cable is either pre-connectorized or the contractor must splice on a pigtail, either of which are included in the price of the drop cable.

  Splice closures can be located in one of three locations: underground, aerial, or in a cabinet. The capacity of the splice closure should match the drop cable size. So, an underground six-fiber fiber splice closure would have a pay item number of 935-3101.

- Communication type and associated hardware

  For device communications transmitters, the choices to be reflected in the pay item include the communications medium, either fiber optic communications or public network.

  - 939-1355 = DSL modem
  - 939-1375 = Public network dial-up modem
  - 939-23xx = Field switch, type x (choose appropriate field switch strength and # of communication channels)

- CCTV equipment

  - 936-1001 = CCTV system, Type B
  - 939-8000 = Testing
  - 939-8500 = Training
  - 939-1190 = Video Encoder, Type A
  - 939-1195 = Video Decoder, Type A
6. VIDEO DETECTION SYSTEM (VDS) DESIGN

Video Detection Systems (VDS) are only used for Urban Freeways. From TMC Planning Section’s Design Criteria document: Goal/Concept: Video Detection System cameras are used by the NaviGAtor system for automated traffic detection. Types of traffic detection include measurement of speed of vehicles, counting of vehicles and measurement of other significant traffic parameters. The data obtained by the video detection system is fed into NaviGAtor. For adequate algorithm functionality, a VDS camera spacing distance of 1/2 mile has been determined. This refers to the spacing between adjacent mainline VDS cameras in one direction of travel. Cameras aimed at entrance and exit ramps are also necessary for count data collection and detection of wrong way movements.

Video detection systems are specified in the Section 937 Special Provisions, which includes details for equipment included in the cabinet. Additional plan details used with VDS installations include CCTV/VDS/IVDS Assembly and Typical Erection Details, Electrical Service Installation Typical Details, and Grounding Assembly Typical Erection Details.

6.1 Placement Guidelines

6.1.1 Urban Freeways

After you have located poles for CCTV cameras at all interchanges (See Chapter 5, Closed Circuit Television System (CCTV) Design), you can begin VDS camera placement.

Begin placing VDS cameras using the following process:

1. Familiarize yourself with the following VDS camera spacing criteria (for VDSs along one side of the freeway):
   - 2640 feet preferred spacing
   - 1760 feet desirable minimum spacing
   - 1500 feet absolute minimum spacing
   - 2800 feet desirable maximum spacing
   - 3000 feet absolute maximum spacing

   The absolute minimum and maximum of 1500 feet and 3000 feet should only be used in extreme cases where placement of VDS poles/cameras is impossible within the normal design ranges due to obstructions or steep slopes in the field. Meeting the spacing criteria will ensure that NaviGAtor obtains accurate data, and designing as many tubular extensions on existing structures and sharing poles for VDS and CCTV cameras will reduce construction costs.

2. Pick one direction (NB/EB or SB/WB) to work on at a time.

3. Identify elements that may control the location of VDS sites.
   a) If the new project is adjacent to an existing NaviGAtor coverage area, then first note the location of the last existing VDS camera or radar detector.
   b) Second note the locations of CCTV poles that you consider fixed at this point, such as CCTV cameras located within interchanges or at key cross streets.
   c) Third, note the location of CMSs and mark an area 600 to 2000 ft in front of the CMS where you need to locate a CCTV. You want to co-locate VDS cameras on these CCTV poles if possible.
   d) Fourth, note full-span truss type sign structures. Constructing a tubular extension to mount a VDS camera on an existing sign structure costs much less than using a new pole.

4. Locate ramp/mainline VDS cameras first.
It is desirable to have detection on each ramp at an interchange and typically these poles become key control points in your layout, so locate them first. These VDS poles should have VDS cameras for both the mainline and the ramp, as separate poles for ramp coverage only are generally not installed.

VDS cameras on ramps should be oriented towards free-flowing traffic segments of a ramp. For an exit ramp, the VDS camera coverage area should be as close to the gore as possible and not less than 400 feet from the stop bar at the end of the ramp. For an entrance ramp, the VDS camera coverage area should be not less than 300 feet from the “top,” or arterial intersection, of the ramp, and not less than 400 feet from the gore.

5. Next, fill in VDS cameras between the VDS cameras located at the interchanges. It is desirable to have at least one VDS camera in each direction of travel between interchanges. Accomplish this by following the VDS spacing criteria presented in Step 1 and then adjust the VDS cameras to take advantage of any existing CCTV poles or sign structures that you identified in Step 2. Make sure the VDS spacing criteria is met.

6. Other considerations:

Freeway-to-freeway interchanges place additional restrictions on VDS camera locations, because the vicinities of merge and diverge points are often locations where traffic is not free-flowing. Consequently, VDS cameras should not be located less than 700 feet upstream of a diverge location or downstream of a merge location.

Place no more than 4 VDS cameras and one CCTV camera on a single pole.

The VDS specification (937.2.E.2 – Video Detection System), states “The maximum number of lanes to be monitored is 7 plus 2 shoulder/emergency lanes.” VDS coverage of all interchange ramps is desired, which can be accomplished using the same VDS camera that monitors the mainline depending on the VDS camera mounting location and orientation. Do not design for coverage of more lanes with a single camera than the specification requires.

VDS cameras should normally be placed off the right shoulder of the highway for detection of travel lanes nearest to the pole. VDS cameras should not be placed to detect travel lanes across the median/barrier wall (i.e., in the opposite direction of travel), because shadowing by the median wall, its shadow, tall vehicles, and parallax distortion will degrade the quality of detection. Instead, use a separate pole on the opposite side of the road. NOTE: On some narrow-median roadway configurations, such as two lanes in each direction separated by a median barrier wall, it may be possible to detect traffic across a median wall). VDS cameras should be oriented to detect traffic approaching the camera.

Please see Section 2.1 for additional placement guidelines.

### 6.2 Field Location Considerations

Use overhead sign structures for mounting of VDS cameras where possible, using a 35’ tubular extension, but do not mount cameras on Type 2 (cantilever) sign structures. You can use two tubular extensions on a sign structure that bridges the roadway (i.e., one on the left edge of the structure and one on the right). There is a construction detail for tubular extension mounts available in the standard GDOT ITS details. A sketch of the various extensions, VDS cameras, and CCTV cameras on a sign structure should be drawn during the preliminary device location stage.

Provide sufficient clearance around the pole base to allow for

- Installation of the side-mount cabinet (Type D)
- Access to both the front and back doors of the side-mount VDS cabinet
- Opening of the cabinet doors to at least 90°
• Personnel to access the cabinet interior from either front or back doors
• Safe location of a maintenance bucket truck (on shoulder or off pavement so as to not require a lane closure for maintenance)

In the event that a VDS will be mounted on a tubular extension attached to a CMS structure, the VDS cabinet shall be mounted on the structural support and the CMS cabinet shall be base-mounted.

If a VDS cabinet will be base mounted, then

• Locate the cabinet no more than 100 feet from the pole in a flat, protected area
• Provide personnel easy access to the cabinet interior using the front and back doors
• Place the cabinet such that the doors will open to at least 90°
• Locate the cabinet within the right of way

Although a VDS camera placed at a certain location will accomplish a transportation management function, a related issue concerns the location of the AC power sources. Consider the proximity of AC power sources during preliminary design. Careful location of a VDS pole can significantly simplify the provision of AC power to the device(s). Consider, also retaining walls, guardrails, or other intervening obstacles between the VDS pole and the AC power source. The Contractor will coordinate final power and telephone source locations with the local service providers, but, nonetheless, reasonable power service points need to be established on the plans.

All VDS poles inside the clear zone need to be protected with guardrail. If guardrail is not existing at a proposed pole location, specify the installation of new guardrail per GDOT standards. Poles shall be located 6 feet behind guardrail.

Poles for VDS are specified in Section 639.03.1 Special Provisions, as “poles for supporting CCTV and VDS devices….” The length of the pole is not explicitly called out on the plans, though the desirable VDS camera mounting height above the pavement surface is called out (65’ +/-5’ on urban/rural freeways). It is up to the contractor to determine the actual length of the pole both to achieve the specified mounting height for each device and to have adequate pole depth below the surface. To simplify their work, contractors will often choose one pole length to meet all height requirements rather than buying different length poles.

NaviGAtor communication is typically over fiber-optic cable. Consequently, VDS cameras cannot be considered for implementation without the presence of fiber-optic-cable communications.

### 6.3 VDS Options

After the VDS locations are determined, the designer needs to specify the type of processor used. A Type A processor is used when there are one or two VDS cameras sharing a single cabinet. A Type B processor is used when there are three or four VDS cameras sharing a single cabinet.

### 6.4 Pay Item Selection

A detailed ITS pay item list is included in the Appendix.

• Power source
  The only selection to be made concerning power source is whether the service point is aerial (939-5010) or underground (939-5020).

• Cabinet type
  - 939-4040 = Type D Cabinet (cabinet only, with light, AC power service assembly, and fan. Internal equipment and wiring is specified with the field devices)
- **Drop cable**

  Single mode pre-terminated drop cables are preferred on GDOT ITS projects, however, designers must determine the appropriate the fiber count (12 typically, 6 or 12 for arterials). When using a pre-terminated drop cable, designers must call out both the pre-terminated FDC as well as the length of drop cable. For example, a twelve-fiber pre-terminated single mode drop cable would include the following pay items:
  - 935-1512 = OSP Fiber Optic Cable, Drop, Single Mode, 12 Fiber
  - 935-3603 = Fiber Optic Closure, FDC (Pre-Terminated), Type A, 12 Fiber

- **Splice requirements (type and number)**

  Only fusion splices, (935-4010) shall be used on GDOT ITS projects. Note that the splice pay item is per each splice. Designers should note that fusion splices must be called out and paid for individually where the drop cable is spliced to the trunk cable (typically occurring in a PB or ECB). However, fusion splices are not paid for separately where the drop cable ties into the cabinet. This end of the cable is either pre-connectorized or the contractor must splice on a pigtail, either of which are included in the price of the drop cable.

  Splice closures can be located in one of three locations: underground, aerial, or in a cabinet. The capacity of the splice closure should match the drop cable size. So, an underground six-fiber fiber splice closure would have a pay item number of 935-3101.

- **VDS equipment**

  - 937-1000 = Video camera sensor assembly
  - 937-3010 = Video detection system processor, Type A
  - 937-3011 = Video detection system processor, Type B
  - 937-8000 = Testing
  - 937-8500 = Training
7. MICROWAVE RADAR DETECTION SYSTEM DESIGN

Microwave radar detection systems are specified in Section 938 Special Provisions, which include details for equipment included in the cabinet. Additional plans details used with microwave radar detection installations include CCTV/Microwave Radar Detection Assembly, Typical Erection Details and Electrical Service Installation Typical Details, and Radar Assembly for Overhead Sign Structures Details.

The purpose of microwave radar detection is to provide presence detection, vehicle count, occupancy, and speed information to the Department’s NaviGAtor advanced transportation management system. Microwave radar detection may be used in place of VDS technology for NaviGAtor projects, if video images are not required at the detection stations. An average spacing of ½ mile is recommended for NaviGAtor microwave radar detection.

The Microwave Radar Detection System specification (938.2.C.1 – Microwave Radar Detection), states “[The detector shall] provide presence, vehicle count, lane occupancy and time mean speed data on a minimum of six detection zones in a user-definable reporting period from 20 to 600 seconds.”

7.1 Placement Guidelines

7.1.1 Urban Freeways

After CCTV poles have been located at all interchanges (See Chapter 5, Closed Circuit Television System (CCTV) Design), the microwave radar detection placement can begin.

Begin placing Microwave radar detection units using the following process:

1. Familiarize yourself with the following microwave radar detection spacing criteria (for microwave radar detection along one side of the freeway):
   - 2640 feet preferred spacing
   - 1760 feet desirable minimum spacing
   - 1500 feet absolute minimum spacing
   - 2800 feet desirable maximum spacing
   - 3000 feet absolute maximum spacing

   The absolute minimum and maximum of 1500 feet and 3000 feet should only be used in extreme cases where placement of microwave radar detection units/poles is impossible within the normal design ranges due to obstructions or steep slopes in the field. Meeting the spacing criteria will ensure that NaviGAtor obtains accurate data, while designing as many tubular extensions on existing structures and sharing poles for microwave radar detection and CCTV will reduce construction costs.

2. Pick one direction (NB/EB or SB/WB) to work on at a time.

3. Identify elements that may control the location of microwave radar detection sites.
   a) If the new project is adjacent to an existing NaviGAtor coverage area, then determine the location of the last existing microwave radar detection unit. This will allow the designer to maintain optimal spacing when transitioning from existing to proposed devices.
   b) Secondly, determine the locations of CCTV poles that you consider fixed at this point, such as CCTV cameras located within interchanges or at key cross streets.
   c) Third, determine the location of CMSs and mark an area 600 to 2000 ft in front of the CMS where you need to locate a CCTV. You want to co-locate microwave radar detection units on these CCTV poles if possible.
d) Fourth, note full-span truss type sign structures. These structures may be used for forward mounting radar or for side fire mounting. Do not mount a microwave radar detection unit on a CMS sign structure, as the interference caused by the large amount of metal in the structure assembly often reduces the accuracy of the microwave radar detection unit. When mounting the radar on an overhead structure, the unit will work best in forward-looking mode. Since the units rely on a signal being reflected back at them, they do not work well at angles and should not be aimed as such. Microwave radar units mounted on overhead structures should not be mounted at more than 22 feet so that their detection zone is limited to a single lane.

The GDOT Office of Transportation Data may request that a highway station be equipped with forward-mounting radar units for each highway lane.

4. Locate ramp/mainline microwave radar detection units first.

It is desirable to have detection on each ramp at an interchange and typically these poles become key control points in your layout, so locate them first. These microwave radar detection poles should have microwave radar detection for both the mainline and the ramp.

Next, place microwave radar detection units along the mainline between the microwave radar detection units located at the interchanges. This is accomplished by following the microwave radar detection spacing criteria presented in Step 1 and then adjusting the microwave radar detection units to take advantage of any existing CCTV poles or sign structures that were identified in Step 2. Ensure that the microwave radar detection spacing criteria is met.

5. Other considerations:

The microwave radar detection specification (938) allows for a maximum of 6 lanes of detection per unit. Coverage of all interchange ramps, with one microwave radar detection unit per ramp, is desired.

Freeway-to-freeway interchanges place additional restrictions on microwave radar detection locations, because the vicinities of merge and diverge points are often locations where traffic is not free-flowing. Consequently, microwave radar detection should not be located less than 700 feet upstream of a diverge location or downstream of a merge location.

Microwave radar detection units are commonly mounted in side-fire mode, since multi-lane detection with a single unit provides acceptable accuracy, and is more economical than installing a forward-mounting radar for each highway lane. The mounting height of the unit is 17 feet above the roadway and is generally offset 20 feet from the first lane being detected. If the microwave radar detection unit for mainline lanes is to be installed on a pole along the median barrier, and the corresponding shoulder is less than 10 feet wide, then it will be necessary to install two units for each roadway alignment. The first unit is positioned in a forward mounting and aimed at the inside lane while the second unit is positioned in side-fire mounting to detect the remaining lanes.

Optimally, a microwave radar detection unit should be mounted on a breakaway pole, but it may be mounted on a strain pole if guardrail is also installed. Place no more than 4 microwave radar detection units and one CCTV camera on a single pole.

Microwave radar detection units should normally be placed off the shoulder of the highway for detection of travel lanes nearest to the pole. Microwave radar detection units should not be placed to detect travel lanes across the median/barrier wall (i.e., in the opposite direction of travel), because shadowing by the median wall, tall vehicles, and parallax distortion will degrade the quality of detection. Instead, use a separate pole on the opposite side of the road. NOTE: On some narrow-median roadway configurations, such as two lanes in each direction separated by a median barrier wall, it may be possible to detect traffic across a median wall). Microwave radar detection should be oriented within 5 degrees perpendicular to the lanes detected.
7.1.2 Urban Arterial Streets and Highways
The preferred location for microwave radar detection is where free-flowing traffic is common and where traffic flow breakdowns are less likely to occur. Typical spacing for microwave radar detection installations is approximately ½ to 1 mile. Designers should coordinate with the local agency (typically the County/ City DOT) responsible for traffic operations on the roadway.

7.1.3 Rural
When rural speed detection is needed, microwave radar detection should be used. The preferred location for microwave radar detection is where free-flowing traffic is common and where traffic flow breakdowns are less likely to occur. Spacing for microwave radar detection installations depends on the application. Additional placement guidelines are outlined in Section 2.1 of this manual.

7.2 Field Location Considerations
Likely locations for radar detection are mid-way between traffic signals or within the bounds of an interchange, such as between a ramp, the freeway lanes, and a cross street. Such locations often provide reasonably free-flowing traffic, good proximity to both AC power and telephone service if required, and protection from uncontrolled land disturbance activities which could damage the installation.

Designers should first determine the approximate location of detection units. Next, the designer shall conduct a site visit to determine the exact location, number of units required, and mounting height of each unit, according to the current criteria in the 938 Special Provisions. Microwave radar detection is typically mounted on poles in a side-fire position, perpendicular to the detected lanes, at the side of the road. Exhibit 1 shows a sample of a vendor’s sidefire design criteria.
Microwave radar detection can also be mounted on a bridge directly over the lane in forward-looking position if highly precise speed data is required. The side-fire position is typically the preferred position because one unit can detect six lanes, where a forward-looking position only covers one lane. When locating the units, designers must avoid metal signs and tree leaves within the detection zone, and should place the poles outside of the clear zone whenever possible. When trying to detect both directions on a roadway and barrier walls or major elevation differences between the lanes exists, designers must determine if a separate unit is needed for each direction. To reduce cost, designers should try to mount microwave radar detection on utility poles (must coordinate with utility pole owners and the local agencies).

Provide sufficient clearance around the pole base to allow for

- Installation of the side-mount cabinet (Type D)
- Access to both the front and back doors of the side-mount microwave radar detection cabinet
- Opening of the cabinet doors to at least 90°
- Personnel to access the cabinet interior from either front or back doors
- Safe location of a maintenance bucket truck if the device mounting height requires bucket truck access (on shoulder or off pavement so as to not require a lane closure for maintenance)

When mounting RDS, the designer’s first choice should be a 20’ breakaway pole.
Type D cabinets are typically used for microwave radar detection system installations. In the event that microwave radar detection is to be mounted on the vertical support for an overhead sign, the microwave radar detection cabinet can be mounted on the sign structural support.

Where needed, protect poles with guardrail. When guardrail is present, the pole should be located at a minimum of 6 feet behind guardrail.

The actual length of poles used on limited access roadways shall be determined by the Contractor and shall be chosen to achieve the designed height of the camera and radar unit above the roadway surface.

### 7.3 Radar Detection System Options

Currently, NaviGAtor software has only been developed to communicate with microwave radar detection systems on fiber optic cable.

A sample plan sheet showing a microwave radar detection system installation is included in Appendix 14.

### 7.4 Pay Item Selection

A detailed ITS pay item list is included in the Appendix.

- **Power source**
  
  The only selection to be made concerning power source is whether the service point is aerial (939-5010) or underground (939-5020).

- **Cabinet type**
  
  - 939-4040 = Type D Cabinets (cabinet only, with light, AC power service assembly, and fan.  
    Internal equipment and wiring is specified with the field devices)

- **Splice requirements (type and number)**

  Fiber optic splices will be fusion (935-4010). Note that the splice pay item is per each splice. Designers should note that fusion splices must be called out and paid for individually where the drop cable is spliced to the trunk cable (typically occurring in an ECB or PB). However, fusion splices are not paid for separately where the drop cable ties into the cabinet. This end of the cable is either pre-connectorized or the contractor must splice on a pigtail, either of which are included in the price of the drop cable.

- **Communication type and associated hardware (microwave radar detection assembly)**

  For device communications transmitters, the choices to be reflected in the pay item include the communications medium, either fiber optic communications or public network.

  - 939-1375 = Public network dial-up modem
  - 939-23xx = Field switch, type x (choose appropriate field switch strength and # of communication channels)

- **Radar detection system**

  - 938-0503 = Microwave radar detection assembly
  - 938-8000 = Testing
  - 938-8500 = Training
8. WEATHER MONITORING AND REPORTING SYSTEM DESIGN

Weather Monitoring and Reporting Systems (WMRS) are specified in Section 694 Special Provisions, which includes two major subsystems. These are the field elements, referred to as the Weather Monitoring Station (WMS) and the Central System (CS). The Field elements of a WMRS consist of the Weather Station with sensors and a CCTV camera connected to slow scan dial up transceiver. The Central System processes the data collected and received from the WMS.

The present WMRS requirements specify standard GDOT Type A cabinets and Type C equipment. The WMRS and the CCTV systems are not interconnected in any way and are co-located only. The CCTV portion of the WMRS is specified in Special Provisions Sections 936. Additional equipment in the form of a WMRS server and Slow Scan transceivers are located in the TMC and are required to collect the data recorded in the field.

8.1 Placement Guidelines

WMRS sites are located to provide Traffic Operations (NaviGAtor), DOT Maintenance and the public access to present and historical weather information. The sites will measure and report weather conditions that may affect traffic movement and roadway safety. These sites require two dial up telephone lines and 120VAC power. Therefore, the availability of these services is a prerequisite for site location. The primary mission of the WMRS is to collect atmospheric data such as temperature, humidity, wind speed, precipitation and roadway data or pavement data. Pavement data includes the pavement temperature, subsurface temperature and the presence of ice, water and de-icing chemical concentrations. The placement of WMRS sensors on bridge decks is especially useful in monitoring the formation of ice on the bridge. The CCTV section of the project is utilized to confirm weather conditions and observe the effect of weather conditions on the roadway and traffic movement. Traffic surveillance is a secondary task of the WMRS and should not dictate the location of a WMRS.

8.2 Field Location Considerations

8.2.1 Central Site Equipment

The Central site equipment includes one or more rack-mounted servers, slow scan video transceivers and access to telephone lines, modems and the NaviGAtor system. Any prospective WMRS project must coordinate with TMC personnel prior to designing a WMRS system. The WMRS system must be integrated with existing TMC equipment and the NaviGAtor software and will utilize limited equipment room space and network resources. Coordination with the TMC at all phases of the project from site selection through out design and also through installation will ensure a successful project.

8.2.2 Field Equipment

The designer must visit all prospective WMRS sites in order to verify that the site will be located correctly. Remember, the primary mission of the WMRS is to gather atmospheric data and to observe the effects of weather on roadway conditions. The engineer should have a basic understanding of weather phenomena and the end users requirements before locating a WMRS site.

The requirements of the WMRS project should be clearly stated in the specification and understood by the designer prior to locating the WMRS stations. For example, will the site be used to assist maintenance in cold weather operations such as salting and sanding or will the site be used to support a coastal hurricane evacuation? Each project requires that the site be placed so as to support the stated requirement. Excellent site location information can be obtained by interviewing local DOT district personnel about the best place to locate a WMRS site.
The WMRS field station is primarily a CCTV site with the Weather Station sensors and equipment cabinet attached to the pole. The CCTV section of the Design Manual contains field location information and should be utilized when designing a WMRS station. In addition to the basic CCTV field location considerations, the followings items should be observed:

- Position the site in an open or clear area away from trees or other obstructions that might cause erroneous sensor readings. A prime location would be on a slight rise in an open field.
- Provide unimpeded access to equipment located at ground level. Do not locate poles in a depression or on an uneven slope.
- Allow for access to the site by a bucket truck.
- Minimize lane closures by providing bucket truck parking on a level surface near the site and preferably off the shoulder and travel lane.
- Attempt to locate the site near existing power and telephone access points.
- Optimize the location of the camera on the pole for maximum visibility and minimum dead spots.

### 8.3 WMRS Options

A sample plan sheet showing a WMRS installation is included in the Appendix.

### 8.4 Pay Item Selection

A detailed ITS pay item list is included in the Appendix.

*NOTE: CCTV is paid for as part of the Weather Monitoring Station. Therefore, designers must delete the measurement and payment sections of Section 936.*

- **Power source**
  - The only selection to be made concerning power source is whether the service point is aerial (939-5010) or underground (939-5020).

- **Cabinet type**
  - 939-4AAA = Cabinets (cabinet only, with light, AC power service assembly, and fan. Internal equipment and wiring is specified with the field devices)
    - 010 = Type A (336S)
    - 020 = Type B (337)
    - 030 = Type C (332)
    - 040 = Type D (303)

- **Communication type and associated hardware**
  - 939-1375 = Public network dial-up modem

- **Weather Monitoring and Reporting Station**
  - 694-1000 = Weather Monitoring Station
  - 694-1010 = WMRS Central System
  - 694-1020 = WMRS Training
  - 694-1030 = WMRS Warranty and Maintenance
9. RAMP METER DESIGN

In Georgia, ramp meters are installed and operated to manage safe and smooth traffic flow on mainline freeway lanes. In order to manage safe and smooth flow, it is necessary to break up platoons (clusters) of vehicles as they enter the freeway traffic stream. It has been shown that ramp meter installation results in approximately a 26% reduction in weaving crashes. It may also be necessary to restrict the total flow of vehicles at specific entrance ramps during peak hours or in response to freeway incidents. Ramp meters provide GDOT staff with the ability to control traffic flow on freeway entrance ramps, and thereby manage congestion on the freeway mainline lanes.

9.1 Placement Guidelines

As a general policy, all freeway and interstate highway entrance ramps will be metered within the metro Atlanta area. There are two exceptions:

1. Freeway-to-Freeway ramps will not be metered. Travel speeds on these roadway segments will be high. Placement of signals that require vehicles to stop completely will violate driver expectancy.

2. Entrance ramps that enter a Collector-Distributor roadway system (C-D roads) will not be metered. Ramp meters on these entrance ramps will have no effect on mainline lanes, since the C-D roads absorb all the interruption of flow. Where the C-D roads enter the mainline will not be metered. Travel speeds on these roadways should be high, and traffic signals at the end of the C-D road system would also violate driver expectancy.

[At present, there are no Georgia Department of Transportation ramp meter warrants. GDOT staff has indicated which ramps will metered. The table below is provided as interim guidance when considering ramp meter installation.]

### Ramp Meter Warrant Criteria

<table>
<thead>
<tr>
<th>Congestion</th>
<th>Collision Rate</th>
<th>Peak Hour Volume</th>
<th>Install Meter?</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/C &gt; 0.88?</td>
<td>&gt;2.0 per million vehicles</td>
<td>&gt;240 vehicles</td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td>any value</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>YES</td>
<td>any value</td>
<td>NO</td>
<td>NO *</td>
</tr>
<tr>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
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<td>YES</td>
<td>NO</td>
<td>NO *</td>
</tr>
<tr>
<td>NO</td>
<td>NO</td>
<td>any value</td>
<td>NO *</td>
</tr>
</tbody>
</table>

* Ramp meter is not essential, but may be installed for reasons other than those listed above.

Source: NET Corporation, June 2005

The proper placement of ramp meter devices is vital to safe and efficient ramp meter operation. Driver safety is the paramount concern when designing all roadway features, and ramp meters should be designed with the same attention to driver safety. The designer should be familiar with the latest edition of AASHTO’s *Roadside Design Guide* and GDOT policies in order to verify and follow clear zone requirements in effect at the time of design.

Please refer to the latest version of ramp meter typical details and example design plans to understand the concepts presented in this section. This manual assumes that the designer has some experience with...
traffic signal equipment and Georgia DOT traffic signal operations, and is familiar with the Georgia DOT Plan Development Process. Another useful reference for ramp meter design and operation is FHWA’s Freeway Management and Control Handbook.

9.1.1 Stop Bar Placement

The first step in designing a ramp meter is correctly locating the stop bar. There are three criteria that determine stop bar location:

1. Providing a safe acceleration distance between the stop bar and the point where vehicles will be required to merge with mainline traffic,

2. Placing the stop bar upstream of the physical gore to discourage drivers from leaving the ramp meter queue and entering mainline traffic, and

3. Preserving the longest possible storage length on the ramp.

Acceleration distances are taken from AASHTO Exhibit 10-70, Minimum Acceleration Lengths for Entrance Terminals with Flat Grades of Two Percent or Less. Note that the table provides distances for flat-grade ramps; “downhill” ramps may be designed with shorter acceleration distances if documented and approved by GDOT. An excerpt from that exhibit is shown below. Acceleration lengths for each ramp should be based on the mainline freeway posted speed. Ramps on the I-75/I-85 downtown connector should be designed using the 55 mph design speed.

<table>
<thead>
<tr>
<th>Design Speed</th>
<th>Speed Reached</th>
<th>Distance required from STOP condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mph</td>
<td>39 mph</td>
<td>720 feet</td>
</tr>
<tr>
<td>55 mph</td>
<td>43 mph</td>
<td>960 feet</td>
</tr>
<tr>
<td>60 mph</td>
<td>47 mph</td>
<td>1,200 feet</td>
</tr>
<tr>
<td>65 mph</td>
<td>50 mph</td>
<td>1,410 feet</td>
</tr>
<tr>
<td>70 mph</td>
<td>53 mph</td>
<td>1,620 feet</td>
</tr>
</tbody>
</table>


The minimum acceleration distance is measured from the farthest point a merging vehicle can travel down the entrance ramp and acceleration lane before it must merge with mainline vehicles. For practical purposes, the final merge point is where the width of the acceleration lane drops below 12 feet. At this point, vehicles entering the freeway no longer have a separate lane and must begin merging with mainline vehicles. For entrance ramps with “add lanes,” some other point (a downstream exit gore, for example) must be selected as the basis for measuring the acceleration distance.

It is important that vehicles on a metered entrance ramp are actually controlled by the ramp meter signals. This is why the stop bar should be placed upstream of the physical gore. Guardrail, barrier walls, retaining walls, a concrete-lined ditch, or even a grassed area will discourage impatient drivers from leaving the ramp meter queue and merging directly into mainline traffic. This illegal behavior would significantly reduce the effectiveness of the ramp meter, undermining its ability to help manage mainline congestion.

9.2 Field Location Considerations

Ramps should be striped to increase vehicle storage lengths, since storage capacity will have a direct effect on the length of time each ramp meter will be able to operate. Consideration should be given to
minor ramp widening if that effort will result in significant additional storage. However, it is extremely important to preserve a 10 foot outside shoulder and 4 foot inside shoulder for disabled vehicles. It is equally important to provide a 4 foot shoulder where guardrail or barrier wall is present. In locations which experience a high volume of truck parking on the shoulders, No Parking Signs should be added to the plans to discourage truck parking. Eliminating illegal parking on ramp shoulders will help improve the safety of the metered ramps.

9.2.1 Signals for Single-Lane Entrance Ramps
If the ramp is less than 24 feet wide, it must either be widened to accommodate two approach lanes or function as a single-lane ramp meter.

Single-lane ramp meters will have pedestal-mounted signals as shown in the accompanying typical detail: one 12-inch display facing upstream, and one 8-inch display facing the waiting vehicle. An enforcement display will be provided for the upper, 12-inch signal head. The pedestal should be located on the left side of the ramp, about 6 feet downstream of the stop bar and 8 feet from the travel lane, to provide drivers with a clear view of the 8-inch display. Pedestals will be mounted on breakaway bases. A “ONE CAR PER GREEN (ball)” sign will also be installed on the pole such that it is clearly visible to drivers. Cabinets for single-lane ramp meters should be placed outside the clear zone or behind guardrail.

9.2.2 Signals for Multi-Lane Entrance Ramps
If the ramp is 24 feet wide, and contains a 10’ paved outside shoulder and a 4’ paved inside shoulder (or wider) it should be striped as a two-lane approach at the ramp meter stop bar. Skip striping (5-inches wide, 10-foot stripe with 30-foot skip) will be used to separate the two lanes.

Multi-lane ramp meters will have two 3-section signals per lane mounted on a mast arm. One signal per lane will have an accompanying enforcement indicator for downstream visibility. "LEFT LANE SIGNAL", "RIGHT LANE SIGNAL", and “ONE CAR PER GREEN (ball)” signs will be mounted on the mast arm as shown in the typical detail. The mast arm should be located about 60 feet downstream of the stop bar to allow good visibility from stopped vehicles. Minimum vertical clearance to the bottom of the signal heads should be between 17 and 19 feet. The mast arm pole can be mounted to either side of the ramp in order to minimize the need for directional boring or construction of new guardrail. If possible, the cabinet for multi-lane ramps should be placed behind the same section of guardrail as the mast arm pole. All guardrail should meet GDOT and AASHTO design standards.

9.3 Ramp Meter Equipment
Ramp meter components are primarily traffic signal and ITS devices. Typical devices include traffic signal heads, a controller and cabinet, inductive loop detectors, IVDS detector units, conduits, electrical cabling, fiber optic cabling, Ethernet switches, and pullboxes. Special signs, shown on ramp meter typical detail sheets, are also required to provide information to drivers. In some cases, additional striping may be needed to clearly delineate queuing lanes. Communication equipment and mainline video detection devices are necessary for local traffic responsive operation, wide-area coordinated operation, or other sophisticated method of operation.

9.3.1 Ramp Detection, Advance Signing, and CCTV Cameras
Presence and passage loops will be placed 4 feet from the stop bar (see typical layout in Appendix).

Queue loops will be placed upstream of the stop bar, at 80% of the distance between the stop bar and the cross street. For example, if the distance from the cross street to the ramp meter stop bar is 1,400 feet, the queue loop(s) should be placed 1,120 feet from the stop bar. An advance warning sign with flashers will be placed adjacent to the queue loops, or where visible to vehicles entering the ramp. Two advance warning flashers (commonly referred to as wig-wag) signs shall be installed for multi-lane ramps to
minimize occlusion by other vehicles. These signs will require electricity (for the wig-wag signal flashers) from the ramp meter controller, so appropriate conduits and pullboxes must be provided to the cabinet. A merge sign (W4-2) shall be installed 150 feet downstream of the advance warning signs on all ramps with two or more lanes. Unless physical conditions dictate otherwise, a W4-2R sign shall be used on the right side of the ramp.

An IVDS unit should be placed to detect mainline traffic conditions within 50 to 500 feet upstream of the ramp gore where meters are proposed. These IVDS units are necessary for ramp metering algorithms that require mainline speed and volume information at the ramp. The IVDS unit should monitor up to four outermost travel lanes, with two detection zones in each lane forming a “speed trap” to determine vehicle speed. If there are more than two travel lanes to be monitored, then an Output Expansion Module is necessary.

A Type B CCTV camera is required to view as much of the entrance ramp as possible, but it is vital to monitor the ramp meter stop bar and discharge area. Wherever possible, these cameras should be mounted on the same pole as the IVDS units. See Chapter 5 for CCTV installation guidelines. For ITS projects, the designer should be able to adjust mainline VDS locations to provide a pole to meet the requirement for ramp meter cameras. For ramp meters along freeway corridors with existing ITS devices, it may be necessary to install a new pole with the IVDS and CCTV cameras required for ramp meter operation.

9.3.2 Ramp Meter Cabinet Equipment

Each ramp meter cabinet will contain a 2070L traffic signal controller capable of ramp meter operations, housed in a 334 controller cabinet. Also included in the cabinet is a Type C, D, or E field switch (Ethernet) for fiber optic networks with IP addressing, and equipment necessary to operate detector loops, traffic signal displays, wig-wag flashers on the advance warning signs, and other standard traffic signal equipment.

The ramp meter cabinet should be placed outside the clear zone or behind guardrail, and where signal electricians can simultaneously view the cabinet electronics and the signal displays. Good design will also place cabinets for easy vehicular access and parking, allowing safe movement of the field technician around the cabinet, poles, and pullboxes.

Each cabinet must connect to the existing NaviGAtor fiber network. For ramp meters within existing ITS freeway sections, the existing fiber ECBs or pull boxes must be field located and checked for available space for new drop cables. Precise and accurate fiber allocations must be coordinated with GDOT staff, and NaviGAtor System Change Requests (SCRs) must be submitted promptly. Ramp meters that will be installed with a new ITS system should be included in the designer’s fiber count and cable routing plans.

Georgia DOT will use a pre-terminated FDC, Type A, for all ramp meter drop cables. This component is factory-assembled, and consists of a 4, 6, or 12-fiber cable with a block on one end. Each individual fiber is led through the block to a connector. By using pre-terminated FDCs, no fiber splices will be necessary inside the cabinet. All connections within the cabinet will be via jumper fibers with connectors on one end.

Conduit and cabling between the ramp meter devices are identical to those used in traffic signal applications. Fiber optic connections are identical to those used in other GDOT NaviGAtor projects. Ramp meters installed within an existing ITS system will connect to existing fiber optic cables.

9.3.3 Utility Coordination and Electric Power Service

Ramp meter devices will need a connection to the electric power grid. Utility submittals (full-size sheets) should be made as early in the project as practical, and a separate submittal should be made to the GDOT Utility Office for coordination with the local power company for service point identification. The electric
power submittal can be made on half-size or 11 x 17 paper. The Designer shall be responsible for coordinating service points with the local utility companies directly, while keeping District Utilities informed of the progress.

### 9.3.4 Loop Detectors

Inductive loops and detectors are generally used to collect ramp traffic data, since these can be installed under traffic on most ramps. Three separate loops are required for each approach lane: 6 x 6 queue loops at the “head” of the ramp, 6 x 40 presence loops just upstream of the stop bar, and 6 x 6 passage loops just downstream of the stop bar. (Single lanes wider than 16 feet require two side-by-side sets of presence and passage loops to ensure proper vehicle detection.) Presence and passage loops work together to inform the controller when vehicles are present (to call the green indication) and when they have passed through the discharge area (to terminate the green indication.) Queue loops indicate when stopped traffic may begin affecting intersection operations at the upstream end of the ramp, and are used to increase the metering rate or turn off metering altogether. Advance warning flashers, designed to warn drivers approaching the ramp meter signals, should be placed adjacent to queue loops.

Refer to the illustrations of typical ramp meters found in the Appendix of this document. The actual type and location of ramp meter components will depend on ramp length, number of queuing lanes, horizontal and vertical curvature, side slopes, existing guardrail and/or barrier wall, overhead obstructions, underground utilities, and other characteristics of the ramp itself. Field work is essential to verify the physical conditions of the ramp and its surroundings, and to ensure that proposed equipment is appropriate for the desired operation.

Details for special devices, or special modifications to traffic signal devices, are shown in accompanying illustrations. A ramp meter specification does not currently exist. Individual component devices use to create ramp meters are described under existing Georgia DOT traffic signal specifications.

### 9.4 Pay Item Selection

Many of the items included in a ramp meter installation are paid for as part of the Traffic Signal Installation lump sum pay item (647-1000). These items include cabinet/controller assemblies, signal and loop cables, signal heads, pedestal poles, advance warning flashers, ramp meter signage, and enforcement heads. A detailed list of materials is included in the Appendix.

- **Power source**
  
The only selection to be made concerning power source is whether the service point is aerial (939-5010) or underground (939-5020).

- **Cabinet type**

  334 Cabinets with a 2070L Controller are used at ramp meter locations (cabinet only, with light, AC power service assembly, and fan. The cabinet, controller, and associated hardware are included in the Traffic Signal Installation lump sum pay item.

- **Drop cable**

  Typically a 4, 6, or 12 fiber pre-terminated FDC is used at ramp meter location. Their pay items are 935-360X and they are paid for per each. The length of drop cable needed shall be called out in the “cabinet to closure” total. This length is paid for separate from the FDC.

- **Splice requirements (type and number)**

  Only fusion splices, (935-4010) shall be used on GDOT ITS projects. Note that the splice pay item is per each splice. Typically four fusion splices are needed at each ramp meter cabinet, however, the quantity depends on the drop cable and the number of fibers used.
Splice closures are generally underground and are located in a nearby pull box or ECB along the trunk line. A 6 or 12 fiber closure is generally used. A larger splice closure may be used when there is also an ITS device (CCTV, VDS, RDS) present at the trunk pull box where the ramp meter drop cable is spliced. Ramp meters that are not connected to an ITS cabinet will have 12 fiber closures and be spliced so that the ramp meter is another device in the daisy chain.

- **Conduit**
  Type 2 and Type 3 Conduit is generally used on ramp meter installations. Typical pay items associated with conduit and conduit installation are listed below:

  - 615-1200 = Directional Bore, ‘x’ inch
  - 682-6222 = Conduit, Nonmetl, Tp 2, 2 in
  - 682-6228 = Conduit, Nonmetl, Tp 2 – Power Service, 2 in
  - 682-6233 = Conduit, Nonmetl, Tp 3, 2 in

- **Pull boxes**
  Type 4S pull boxes (647-2141) are used wherever there is fiber optic drop cable present and at the base of the ramp meter cabinet. A Type 7 pull box (647-2170) or Type 5 ECB is used where the drop cable splices into the trunk cable. For loop lead-ins and advance warning flasher signal cable, Type 2 Pull boxes can be used. Type 2 pull boxes are not paid for separately, rather they are included in the Traffic Signal Installation lump sum pay item.

- **Mast Arms**
  For two lane approaches, a strain pole with mast arm is used. The pay item is Steel Strain Pole, Type IV, with XX ft. Mast Arm (639-3004). “XX” is the length of mast arm required. The pay item is the same regardless of mast arm length.

- **Intersection Video Detection**
  Intersection Video Detection cameras are used to monitor traffic in the four outermost travel lanes. If more than 2 lanes are monitored, then an Output Expansion Module is necessary. Pay items are listed below:

  - 938-1100 = Intersection Video Detection System Assembly, Type A
  - 938-1210 = Output Expansion Module, Type A
  - 938-8000 = Testing
  - 938-8500 = Training
10. HUB BUILDING DESIGN

Hub buildings are specified in Section 797 Special Provisions. Plans details used with hub building installations include Hub Layout Details, Hub Equipment Frame (Rack) Details, and Hub Block Diagram Details.

Hubs in the NaviGAtor system serve as a location to

- Act as nodes in the NaviGAtor network
- Collect field device communications
- House equipment racks or frames for fiber distribution centers, a network layer-3 switch, and supporting equipment.

10.1 Placement Guidelines

Locate hubs where there is reasonable electrical service access, fiber trunk line connectivity, and accessibility by installation and maintenance personnel, including space for parking for maintenance vehicles. Hubs typically are located at major junctions of two limited access facilities or at the interchange between a limited access facility and a major arterial. Before establishing a location as a hub site, it is important to research through the Planning Office, Urban Design Office, Road Design Office, and Maintenance Office whether the likely site is proposed for any roadway expansion or reconstruction. If this is the case, the hub location must be chosen to avoid the anticipated construction. If the construction work is not fully conceptualized, a shift of the hub away from the preferred interchange may be required.

The hub will also have a fixed CCTV security camera installed inside the building. This camera will be mounted on an inside wall of the building, located and aimed for maximum viewing. A video encoder will be used to convert the camera to digital format, and the video encoder output will be connected to a network port on the hub network layer-3 switch.

Please see Section 2.1 for additional placement guidelines.

10.2 Hub Building Options

Options for hub buildings include size and outfitting. A 16’ x 24’ hub will accommodate two rows of nine equipment racks or frames in each row. The number of racks installed in the initial hub installation will depend on the amount of hub equipment required from the network electronics design.

A fully outfitted hub is standard for NaviGAtor, and this includes HVAC, power distribution, lighting, security, cable runways, etc. Although a pay item is available for a hub with no interior outfitting, it is rarely used. Future hubs should consider installing a VOIP telephone, including equipment needed to communicate via the NaviGAtor network to allow a phone connection.

10.3 Pay Item Selection

A detailed ITS pay item list is included in the Appendix.

- Power source
  The only selection to be made concerning power source is whether the service point is aerial (939-5010) or underground (939-5020).
- Hub building type and size
  Identify the hub size and outfitting requirements (typically, 16’x24’, fully outfitted)
- Mini-hub pay item under development.
11. HUB EQUIPMENT DESIGN

Hub equipment is specified in Section 939 Special Provisions.

11.1 Equipment and Furnishings Options

Hubs aggregate field device communications and serve as backbone nodes in the NaviGAtor network. Field devices communicate via gigabit ethernet network to hubs, which contain a network layer-3 switch to route the communications through the NaviGAtor network. Preferred hub-to-hub communications schemes, organized from most to least advantageous for NaviGAtor network capacity and redundancy are:

- The hub network layer-3 switch communicates directly to multiple network layer-3 switches
- The hub network layer-3 switch communicates directly to a single network layer-3 switch on 2 channels, using two separate fiber optic cables in separate routes.
- The hub network layer-3 switch communicates directly to a single network layer-3 switch on 2 channels, using the same fiber optic cable.

Field device daisy chains are a group of field devices, usually adjacent to each other, which communicate on a single pair of fibers. Each field device daisy chain must communicate in a loop to allow redundancy for the network, in case of isolated power failure at a field cabinet, or a single fiber optic cable cut. However, it is preferable that the communications loop utilize a unique hub at either end. The maximum number of field devices which can be accommodated on a field device daisy chain are 8 field switch cabinet locations or 6 CCTV, whichever is reached first.

Multiple devices such as VDS, RDS, CMS, and ramp meters can be connected to the field switch at each cabinet location without impacting the communications performance. The only exception is CCTV cameras, for which the quantity is limited due to high and continuous network bandwidth requirements.

Several elements of the design task must be complete prior to the design of the hub network electronics. All field devices (CMS, CCTV, VDS, RDS, ramp meters) must be designed, including the station, location ID, and device ID. The fiber (device) allocation effort must be complete: all devices must be assigned to a field device daisy chain.

Next, quantify the CMS, CCTV, VDS, RDS, ramp meters, and trunk cable sections/ fiber counts needed and then furnish these quantities to the TMC Configuration Manager (see Section 2.4). Also list the existing field device locations or hub locations where existing equipment will be replaced or reconfigured. After receiving the ID labels assigned by the Configuration Manager, then insert these labels into the appropriate locations in the plans.

In the hub, all the equipment used to manage, aggregate, and process data is mounted in 19” wide equipment racks or frames that are lined up in rows. The number of racks installed in the initial hub installation will depend on the amount of hub equipment required from the network electronics design. If the racks required do not completely fill the row, then reserve those rack spaces for when the space is actually needed, in the future.

The equipment rack details sheets shows equipment installation positions in the racks (see example in the Appendix). The equipment positions are also provided by the naming scheme; as described in Section 11.2.

The trunk cables, upon entering a hub, are terminated in fiber distribution centers (FDCs). FDCs are passive, box-like, rack mounted devices which simply provide an enclosed space for termination of the individual trunk fibers and interface to FO jumpers which connect to other network electronics equipment. On the rear of the FDC is space for the individual trunk cable fibers to be spliced and then to
be connected to the termination panel (ports) in the FDC. On the front side of the FDC there is a panel of connectors to which FO jumpers are attached. Each port on the FDC is labeled as part of the device allocation task.

Splice trays will be used for proper storage of splices from FO trunk cable to pigtails for FDC fiber ports. The splice trays are located in rack space directly adjacent to the FDC served.

Trunk fiber is never attached directly to devices other than a FDC for several reasons:

- The FDC allows for transition from outside plant to inside plant cable suitable for indoor environments in the TCC building or hub building.
- The individual fibers coming out of the trunk cable are fragile; breakage is possible, and the trunk cable needs to be protected.
- FO Jumper cables can be replaced easily and cheaply, and are better protected than individual trunk fibers.
- If changes are made, FO jumpers can simply be reconnected to different devices; if different lengths are needed, FO jumpers corresponding to those lengths can be purchased.
- FO Jumpers help organize FO connections by differentiating between fiber modes, yellow jacket for single-mode fiber and orange jacket for multi-mode fiber.

The FO jumpers are used for connection to the terminated fibers (in the FDCs). Either simplex or duplex FO jumpers are used. A simplex FO jumper allows for a single fiber connection, while a duplex FO jumper connects a fiber pair.

The label of each FO jumper is assigned by the TMC Configuration Manager. There are two functions for FO jumpers in the hubs:

- Link between a field device daisy chain and the network layer-3 switch. A duplex FO jumper connects two FDC ports with a GBIC port on the network layer-3 switch.
- Link between two FDCs to allow a communications channel to bypass the hub. A duplex FO jumper connects the two pairs of FDC ports.

A system block diagram must be prepared to logically show the interconnections between the various network electronics, as shown in the sample in the Appendix. Not only does this diagram show the different types of equipment, and their interconnection, but it also shows the FDCs, cable IDs, the quantities of the equipment (including FO jumpers), and the equipment configuration list. As a general guide for determining quantities of network electronics equipment, see Table 1.
At this point, the incomplete tables NE1, NE2, and NE3, and the draft System Block Diagram can be furnished to the TMC Configuration Management Section for assignment of ID labels. This effort needs to be coordinated in advance of delivery, and at least four weeks needs to be allowed for the Configuration Manager to complete the effort. Upon receipt of the ID label information from the Configuration Manager, that information should be entered in the appropriate sections of the table and the Block Diagram.

11.2 Hub Equipment Designs, Naming Scheme, Connections, and Standards

This section explains the equipment design and naming conventions applied to all GDOT ITS projects. All examples shown in this section use Hub U as the example hub name.

11.2.1 New Hub Equipment Designs

Freeway ITS projects that require installation of a typical size hub (16’ x 24’) will likely include installation of the following equipment:

1. One hub uninterruptible power supply
2. Gig E network switch (type to be determined by designer)
3. Between Three and Nine equipment frames
4. FDCs (one per fiber trunk cable entering the hub; FDC size equal to the associated cable size)
5. Fusion splices (equal to the # of FDC ports installed)

For a typical new hub installation, follow the guidelines below for equipment installation locations.

Rack or Frame 1: County/ City equipment
Rack or Frame 2: Spare – County/ City equipment
Rack or Frame 3: Top of Rack: Network Switch  
Bottom of Rack: Hub UPS

Rack or Frame 8: Spare – FDCs and splice trays

Rack or Frame 9: FDCs and splice trays

11.2.2 Existing Hub Equipment Designs
For projects that will install equipment in an existing hub, the designer should inventory the hub equipment and assess whether additional capacity is required for any network electronics equipment to support the new project. Additionally, the designer must coordinate with the Configuration Manager to determine if there are other new projects placing equipment in the same hub.

11.2.3 Network Electronics Tables
Up to three network electronics (NE) tables are used to show equipment connections and assigned ports in a hub. The tables are:

- NE1 – Device Allocation Details
- NE2 – Hub Network Switch Port Interconnection
- NE3 – Hub FDC Interconnection

Table NE1 also includes device fiber splicing from drop fibers to trunk fibers.

11.2.4 Fiber Optic Distribution Centers (FDC)
FDC port assignments are shown in tables NE1, NE2, and NE3.

The process of naming the FDC port is as follows:

**Hub ID + FODISTR + Rack ID + Position ID + Module ID + Port ID**

*Example:*

HUB0UFODISTR08020101

- **HUB0U** = Hub U (name of hub)
- **FODISTR** = Fiber Optic Distribution
- **08** = Rack number 8
- **02** = Position 2 beginning from the top of the rack or frame
- **01** = 1st module (column) in the FDC
- **01** = 1st port (row) in the FDC

Twenty (20) characters total.

FDCs have 6 ports per module. The number of modules depends on the size of the FDC.

11.2.5 Network Data Patch Cords
Network data patch cords are used for connection between Hub UPS and the layer 3 network switch.

The process of naming network data patch cords is as follows:
**Hub ID + SD + Patch Cord Number**

*Example:*

HUB0U-SD0101

- **HUB0U** = Hub U (name of hub)
- **SD** = Serial Data
- **0101** = Patch Cord number 0101

Eleven (11) characters total.

**11.2.6 Duplex Fiber Optic Jumpers**

Duplex FO jumpers are used in table NE2 and NE3.

The process of naming the duplex fiber optic jumpers is as follows:

**Hub ID + D + Jumper number**

*Example:*

HUB0U-D004

- **HUB0U** = Hub U (name of hub)
- **D** = Duplex
- **004** = Duplex Jumper number 4

Nine (9) characters total.

In a new hub building, first assign names for table NE1 with the first one named as HUB0U-D001. The remaining numbers shall be consecutive in the order they appear in the tables.

**11.2.7 Network Switches**

The network switch name is shown in the Hub Block Diagram.

The process of naming layer 3 network switches is as follows:

**Hub ID + NSL3G + Switch Type + Rack or Frame ID + Position ID**

*Example:*

HUB0UNSL3GA0201

- **HUB0U** = Hub U (name of hub)
- **NSL3G** = Network Switch Layer 3 GigE
- **E** = Type E GBIC (One GBIC is used per communications channel. There are 2 types used in network switches— E and F, providing LX and XD communications strength, respectively. Appropriate GBIC selection is based on communication link loss budget.)
- **02** = Rack or frame number 2
- **01** = Position number 1

Fifteen (15) characters total.

**11.3 Pay Item Selection**

- Network electronics
  - 935-XXX = Network electronics (FDCs)
  - 939-XXXX = Network electronics (communications equipment)
- Splice requirements (type and number)
Only fusion splices, (935-4010) are to be used on GDOT ITS projects. Note that the splice pay item is per each splice. Designers should note that fusion splices must be called out and paid for individually where the trunk cables are spliced to FDCs in hub buildings.

- Hub furnishings
  - 939-3XXX = Furnishings
12. TRAFFIC CONTROL CENTER DESIGN

Traffic Control Centers (TCC) as defined within the GDOT NaviGAtor System are manned facilities that provide regional monitoring and control of traffic management devices. TCCs are nodes of the NaviGAtor System with the Traffic Management Center in Atlanta as the central control point. TCCs are either owned and operated by GDOT or by a local agency. A TCC can range in size from a small office in an existing building to a totally new building specifically built to house a TCC.

TCCs typically consist of an operations area and an equipment room. The operations area provides a work area where personnel view surveillance cameras, monitor traffic measurement devices, control field devices, and disseminate traveler information. The equipment room houses the equipment racks and cabinets. Depending on the facility, communications terminations, such as fiber modems and telephone circuits, may reside in the equipment room in addition to NaviGAtor servers and video display and switching equipment. The communications equipment in the equipment room area of a TCC essentially mirrors the equipment located in hub buildings in the field.

The design of a TCC requires a thorough understanding of the needs of the facility users and the role the facility will play within NaviGAtor. The selection of the individual equipment elements to be installed in a TCC is not addressed in this section; the engineer tasked with TCC design must coordinate with the facility users and the GDOT IT department to determine the specific systems and equipment. This document will focus on the issues a designer must consider when they design or define the interior elements of a TCC. The design for fiber terminations or other communications media at the building or in the equipment room is covered in Chapters 10 and 11. However, there are several equipment items unique to the TCC equipment room which are described in this section, along with appropriate labeling and network electronics tables. Traffic Control Center equipment is specified in the 939 Special Provision.

12.1 Placement Guidelines

Placement guidelines in this chapter apply to locating a TCC. As stated in TMC Planning Section’s Design Criteria document:

In many smaller to mid-size cities in Georgia, it may be beneficial to consolidate the transportation management efforts of several agencies at different levels of government. This way, the various agencies can share the capital cost of constructing the system, as well as staffing the control center/maintenance units. In such a situation, each agency retains “control” of its respective roads (i.e., State agency – Interstates and State routes, County agency – county roadways, city agency – city streets). However, in off-peak times or crisis situations, duties can be shared among available staff. Joint-use facilities can be constructed on property owned by any of the participating agencies. Certain memorandums of understanding and implementation plans must be written to effect such an operation.

Obtain all city/county/GDOT joint use and maintenance agreements, including the approval of all appropriate administrators.

Locate the TCC in a location that is central to the system in the field. Government-owned property is preferable, whether it be city, county, or state property. A TCC may be either a new building or modification of existing space in one of the partner’s facilities. Important factors include a determination of the space needed, considering future expansion and the agencies participating. Ensure that all major stakeholders in a regional transportation management effort are provided space as desired.

An Implementation Plan is required prior to Federal Highway Administration authorization of any project using Federal funds. An Operations Plan for the new TCC should be written prior to any construction. Please see Section 2.1 for additional placement guidelines.
12.2 Design Considerations

A TCC consists of two main areas: the operations room and the equipment room. These areas are functionally quite different but share a number of common requirements. Both areas will require careful engineering in order to provide the functionality required by a TCC.

The designer is responsible for the following areas:

1. Equipment room layout (equipment placement)
2. Equipment rack elevations and equipment interconnections
3. Operations area layout (equipment placement)
4. Electrical and environmental infrastructure within the TCC area.

These four areas cover a wide range of engineering expertise and are, in some cases, not something we work with everyday. Fortunately, when we are called on to provide guidance in these unfamiliar areas, we are usually working with specialists who can translate our requirements into effective designs. The following sections will provide you with some tools and concepts that you can use when designing a TCC.

12.2.1 Equipment Room Layout & Equipment Rack Elevations and Equipment Interconnections

Requirements 1 and 2 are familiar to engineers who have been involved in Hub design and implementation. However, the space requirements in an existing TCC will most likely not match the very well defined and uniform spaces in hub buildings. The TCC designer must be flexible and may be required to install equipment in some non-typical configurations. Installations in existing spaces can be quite challenging but functionality and maintainability must always be provided. An example of an unorthodox installation might be found when installing TCC equipment in an existing building. In this case, you might encounter the following problem areas:

- The allocated area is too small
- The allocated space is poorly configured – oddly shaped
- Cable paths are convoluted and interfere with building structures
- New equipment required to co-locate with existing equipment and systems

You need to identify these problem areas early in the design process and communicate them to the agency. Quick identification and communication of problems will always minimize the impact of project constraints. Many times, the designer can negotiate a more desirable layout when they clearly identify the issues and their impact on the project. In this case, clearly identifying the functional goals of the agency and the technical requirements of the supporting equipment will enable you to successfully design the TCC.

12.2.2 Operations Area Layout

A typical TCC operations room consists of the following items:

1. Large screen video display(s) (optional)
2. NaviGAtor workstation (computer)
3. Small video monitors
4. Telephone and radio communications (radio optional)

This suite of equipment typically provides one TCC operating position. Video displays of various sizes and numbers can be added per the agency’s requirements. In a minimum configuration, this equipment can be placed on a desk in an office with very little additional design or engineering.
Larger TCCs with multiple operator positions require the assistance of control room design specialists. Custom control room operator’s furniture is often specified to house the NaviGAtor workstation and associated video monitors and communications equipment. Large screen video projectors with theater-sized screens may also be required.

The engineer should also be aware that design of a TCC control room becomes an ergonomic design exercise that is quite subjective. Success in designing a TCC will require the engineer to work closely with the architect, control room designer, and the agency. Agency sign off on all phases of control room design is imperative.

12.2.3 Electrical and Environmental Infrastructure

Providing appropriate electrical and environmental support for a TCC is of utmost importance. Rarely will existing spaces be appropriately wired or air-conditioned to support TCC operations. New or proposed TCC buildings will, most likely, not be initially designed to adequately provide for the needs of a TCC. The following section will highlight some of the issues a designer should be aware of when designing or recommending changes or additions to building infrastructure. You will usually be working with an Architect or Electrical or Air Conditioning Engineer who can implement your requirements. The following items relate equally to designing the equipment room and control room.

The engineer should specify or confirm the following:

1. Electrical outlets in sufficient quantity
2. Electrical outlets in appropriate places
3. Circuits of appropriate capacity and wire size
4. Circuit strings for specific equipment
5. Emergency generator circuits
6. UPS circuits and capacity
7. Lighting, type and placement
8. Light switches in appropriate places
9. High temperature alarm sensors for equipment room
10. Water alarms under raised floors
11. Conduit sizes for facility expansions
12. Extra conduit for future equipment
13. Placement and termination of conduit for interconnection of all equipment
14. Appropriate air conditioning capacity in all locations
15. Thermostat placement (separate thermostat for equipment room)

12.3 TCC Equipment Room Options

Most of the equipment installed in a TCC is the same as that installed in hubs (Sec 11). For viewing the video footage from field CCTVs, additional equipment is necessary. The video data must be converted from digital to analog communications using one or more video decoders.

12.3.1 Network Electronics Tables

In addition to the network electronics tables shown in Sec 11 add the following:

- NE4 - Network Switch Video Decoder Port Interconnection
12.3.2 Coaxial Video Patch Cord

TCC ID + X + Patch Cord Number

Example:

TCC2-X0001

- TCC2 = TCC 2 (name of TCC)
- X = Coax
- 0001 = Coaxial Video Patch Cord number 1

Ten (10) characters total.

12.4 Construction Coordination

Engineers involved in the specification and design of a TCC should be involved in the supervision of construction and implementation. Due to the custom nature of a TCC design, there tend to be areas that most electrical contractors are not familiar with. The best way to prevent the Contractor from deviating from the plans or improperly interpreting the specifications is through close supervision of construction and implementation. The Engineer must also maintain a constant dialog with the agency to ensure the project fulfills their needs and expectations. Active management of both the agency and the contractor through all the phases of the project is the best way to ensure the project is completed as designed and to the satisfaction of the agency.

12.5 Special Provisions

Specifications for the equipment and design of a TCC will, for the most part, be defined in a special provision. Existing specifications for much of the equipment typically located in a TCC Equipment Room are found within the 935 and 939 Special Provisions. Be aware that many existing specifications will require modifications prior to use on new projects due to changes in technology and the agency’s special requirements.

12.6 Pay Item Selection

Pay items for a number of items related to TCC construction exist and can be used on TCC projects.

- **TCC Equipment**
  
  *NOTE: These pay items are given as examples only. They were created for the expansion of Clayton County’s TCC, project no. CM-0000-00(674). These are not standard items and therefore special provisions are required to use them.*

  - 939-2511 = Large Screen Plasma Display
  - 939-2611 = Operator Consoles
  - 939-2711 = Video Multiplexer 10 x 1
  - 939-2811 = Workstation Assembly

- **Network electronics**
  - 939-XXXX = Network electronics

- **Hub furnishings**
  - 939-3XXX = Furnishings
13. SPECIFICATIONS

The following special provisions, which were current at the time of publication, are included on CD in this document in portable document format (.pdf). The most current version of these specifications can be acquired from the GDOT TMC Configuration Management Section.

- Section 631 – Changeable Message Signs
- Section 682 – Electrical Wire, Cable, and Conduit
- Section 694 – Weather Monitoring and Reporting System
- Section 797 – Hub Building
- Section 935 – Fiber Optic System
- Section 936 – Closed Circuit Television (CCTV)
- Section 937 – Video Detection System
- Section 938 – Detection
- Section 939 – Communication and Electronic Equipment
- Section 940 – NaviGAtor Advanced Transportation Management System Integration
14. APPENDICES

1 – Plans Checklist
2 – ITS Plans Legend
3 – ITS Device Installation Sheets
4 – Fiber Optic Cable Installation Sheets
5 – Communications Design Sheets
6 – Supporting Sheets
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   - Map w/Beginning and Ending Stations
   - Location Sketch
   - Project Length
   - % in Counties and Congressional District(s)
   - Standard Notes
   - Functional Classification
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B. Index

C. Revision Summary Sheet

D. General Notes (may contain Utility Contact Information)

E. Summary of Quantities Sheet(s)
   - Summary Block for each Pay Item
   - Surveillance System Location
   - Changeable Message Signs Locations

F. Quantities by Amendment

G. Quantities on Construction

H. Detailed Estimate

I. Legend Sheet

J. Typical Section

K. Plan Sheets

L. Utility Plan Sheets (if not shown on design plan sheets)

M. CMS Clearance Diagrams (if the project contains changeable message signs)

N. Fiber Routing Schematic

O. Hub Block Diagram

P. Hub Racks

Q. Typical Details
   - Conduit Installation Details
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Appendices

– Electrical Communication Box
– Pull Boxes
– Electrical Service Detail
– CCTV/VDS/Microwave Radar Detection Assembly and Typical Erection Details
– Structural Number Placement
– Fiber Optic Cable Installation Details
– Aerial Attachment Details
– Guying and Anchoring Typical Details
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R. Bridge Attachment Detail
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U. Concrete barrier – temporary details
V. Georgia Standards
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