

163.4.01 Limits

General Provisions 101 through 150.

163.5 Payment

A. Silt Control Gates

The specified silt control gates are paid for at the Contract Unit Price per each. Payment is full compensation for:

- Furnishing the material and labor
- Constructing the concrete apron as shown on the Plans
- Excavating and backfilling to place the apron
- Removing the gate

B. Temporary Slope Drains

Temporary slope drains are paid for by the linear foot (meter). Payment is full compensation for materials, construction, removal (if required), inlet spillways, velocity dissipaters, and outlet aprons.

When temporary drain inlets and pipe slope drains are removed, they remain the Contractor's property and may be reused or removed from the Project as the Contractor desires. Reused pipe or inlets are paid for the same as new pipe or inlets.

C. Temporary Sediment Basins

Temporary sediment basins, measured according to Subsection 163.4.C "Measurement," are paid for by the unit, per each, for the type specified on the Plans. Price and payment are full compensation for work and supervision to construct, and remove the sediment basin, including final clean-up.

D. Sediment Barriers

Sediment barriers are paid by the linear foot (meter). Price and payment are full compensation for work and supervision to construct, and remove the sediment barrier, including final clean-up.

E. Other Temporary Structures

Other temporary structures are not measured for payment. Costs for the entire structure complete, including materials, construction (including earthwork), and removal is included in the price bid for the drainage structure or for other Contract items.

F. Temporary Grass

Temporary grass is paid for by the acre (hectare). Payment is full compensation for all equipment, labor, ground preparation, materials, wood fiber mulch, polyacrylamide, and other incidentals. Lime (when required) is paid for by the ton (megagram). Mulch and fertilizer are paid for separately.

G. Mulch

Mulch is paid for by the ton. Payment is full compensation for all materials, labor, maintenance, equipment and other incidentals.

The weight for payment of straw or hay mulch will be the product of the number of bales used and the average weight per bale as determined on certified scales provided by the contractor or state certified scales. Provide written documentation to the Engineer stating the average weight of the bales.

The weight of erosion control compost mulch will be determined by weighing each loaded vehicle on the required motor truck scale as the material is hauled to the roadway, or by using recorded weights if a digital recording device is used. The contractor may propose other methods of providing the weight of the mulch to Engineer for approval.

H. Miscellaneous Erosion Control Items Not Shown on the Plans

These items are not paid for separately. They are included in the price bid for other contract items.

I. Diversion Channel

Diversion channels are not paid for separately. They are included in the price bid for other contract items.

J. Check Dams

Payment is full compensation for all materials, construction, and removal. Stone plain riprap, sand bag, baled wheat straw, or compost filter socks check dams are paid for per each. The required woven filter fabric required under each stone check dams is included in the bid price. Fabric check dams are paid for per linear foot.

K. Construction Exits

Construction exits are paid for per each. Payment is full compensation for all materials including the required geotextile, construction, and removal.

L. Retrofits

This item is paid for at the Contract Unit Price per each. Payment is full compensation for all work, supervision, materials (including the stone filter), labor and equipment necessary to construct and remove the retrofit device from an existing or proposed detention pond outlet structure.

M. Inlet Sediment Traps

Inlet sediment traps are paid for per each. Payment is full compensation for all materials, construction, and removal.

N. Rock Filter Dams

Rock filter dams are paid for per each. Payment is full compensation for all materials, construction, and removal for each. Clean reused stone Type 3 riprap and #57 stone are paid for on the same basis as new items. Plastic woven filter fabric is required under rock filter dams and is included in the price bid for each.

O. Stone Filter Berms

Stone filter berms are paid for per linear foot (meter). Payment is full compensation for all materials, construction, and removal for each. Clean reused stone Type 3 riprap and #57 stone are paid for on the same basis as new items. Plastic woven filter fabric is required under rock filter berms and is included in the price bid for linear foot (meter).

P. Stone Filter Rings

Stone filter rings are paid for per each. Payment is full compensation for all materials, construction, and removal for each. Clean reused stone Type 3 riprap and #57 stone are paid for on the same basis as new items. Plastic woven filter fabric is required under stone filter rings and is included in the price bid for each.

Q. Temporary Sediment Traps

Temporary sediment traps are paid for payment per each required. This includes the entire structure at each location and all the work necessary for construction.

The items in this section (except temporary grass and mulch) are made as partial payments as follows:

- When the item is installed and put into operation the Contractor will be paid 75 percent of the Contract price.
- When the Engineer instructs the Contractor that the item is no longer required and is to remain in place or is removed, whichever applies, the remaining 25 percent will be paid.

Temporary devices may be left in place at the Engineer's discretion at no change in cost. Payment for temporary grass will be made based on the number of acres (hectares) grassed. Mulch will be based on the number of tons (megagrams) used.

Payment is made under:

Item No. 163	Construct and remove silt control gates	Per each
Item No. 163	Construct and remove temporary pipe slope drains	Per linear foot (meter)
Item No. 163	Construct and remove temporary sediment barriers	Per linear foot (meter)
Item No. 163	Construct and remove sediment basins	Per each
Item No. 163	Construct and remove check dams except fabric dams	Per each
Item No. 163	Construct and remove fabric check dams	Per linear foot (meter)
Item No. 163	Construct and remove construction exits	Per each
Item No. 163	Construct and remove retrofits	Per each
Item No. 163	Construct and remove rock filter dams	Per each
Item No. 163	Construct and remove stone filter berms	Per linear foot (meter)
Item No. 163	Construct and remove stone filter rings	Per each
Item No. 163	Construct and remove inlet sediment traps	Per each
Item No. 163	Construct and remove temporary sediment traps	Per each
Item No. 163	Temporary grass	Per acre (hectare)
Item No. 163	Mulch	Per ton (megagram)

163.5.01 Adjustments

General Provisions 101 through 150.

**DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA**

SUPPLEMENTAL SPECIFICATION

Section 167—Water Quality Monitoring

Delete 167 and substitute the following:

167.1 General Description

This Specification establishes the Contractor's responsibility to meet the requirements of Part IV of the National Pollutant Discharge Elimination System (NPDES) Infrastructure Permit No. GAR100002. In the case of differing requirements between this specification and the Permit, whichever is the more stringent requirement shall be adhered to.

167.1.01 Definitions

Certified Personnel are defined as persons who have successfully completed the appropriate certification course approved by the Georgia Soil and Water Conservation Commission. For Department projects the certified person must also have successfully completed the Department's WECS certification course.

Water Quality Monitoring as used within this specification, the term "monitoring" shall be inclusive of the acts of detecting, noting, discerning, observing, etc. for the purpose of gauging compliance with the GAR100002.

Qualifying Rainfall Sampling Event means that which is defined in the current GAR1000002, Part IV.D.6.d(3).

167.1.02 Related References

A. Standard Specifications

Section 161—Control of Soil Erosion and Sedimentation

B. Referenced Documents

NPDES Infrastructure Permit No. GAR100002

GDOT WECS Seminar

EPD Rule Chapter 391-3-7

GSWCC Certification Level IA Course

OCCA 12-7-1

167.1.03 Submittals

General Provisions 101 through 150

167.2 Materials

General Provisions 101 through 150.

**167.2.01 Delivery, Storage, and
Handling**

General Provisions 101 through 150.

167.3 Construction Requirements

167.3.01 Personnel

Use GSWCC level IA certified and WECS certified personnel to perform all sampling, inspections, and rainfall data collection. Use the Contractor-designated WECS or select a prequalified consultant from the Qualified Consultant List (QCL) to perform water quality sampling, inspections, and rainfall data collection.

The Contractor is responsible for having a copy of the GAR100002 Permit onsite at all times.

167.3.02 Equipment

Provide equipment necessary to complete the Work or as directed by the Engineer.

167.3.03 Preparation

General Provisions 101 through 150.

167.3.04 Fabrication

General Provisions 101 through 150.

167.3.05 Construction

A. General

Perform inspections, rainfall data collection, testing of samples, and reporting the test results on the project according to the requirements in Part IV of the GAR100002 and this Specification.

Take samples manually or use automatic samplers, according to the GAR100002. Note that GAR100002 requires the use of manual sampling or rising stage sampling for qualifying events that occur after the first instance of the automatic sampler not being activated during a qualifying event. Analyze all samples according to the Permit, regardless of the method used to collect the samples.

If samples are analyzed in the field using portable turbidimeters, the sampling results shall state they are being used and a digital readout of NTUs is what is provided.

Submit bench sheets, work sheets, etc., when using portable turbidimeters. There are no exceptions to this requirement.

Perform required inspections and submit all reports required by this Specification within the time frames specified. Failure to perform the inspections within the time specified will result in the cessation of all construction activities with the exception of traffic control and erosion control. Failure to submit the required reports within the times specified will result in non-refundable deductions as specified in Subsection 161.5.01.B.

B. Water Quality Inspections

The Department will provide one copy of the required inspection forms for use and duplication. Inspection forms may change during the contract to reflect regulatory agency needs or the need of the Department. Any costs associated with the change of inspection forms shall be considered incidental and shall be borne by the Contractor. Alternate formats of the provided forms may be created, used and submitted by the Contractor

provided the required content and/or data fields and verbatim certification statements from the Department's current forms are included.

The Engineer shall inspect the installation and condition of each erosion control device required by the erosion control plan within seven days after initial installation. This inspection is performed for each stage of construction when new devices are installed. The WECS shall ensure all installation deficiencies reported by the Engineer are corrected within two business days.

Ensure the inspections of the areas listed below are conducted by certified personnel and at the frequencies listed. Document all inspections on the appropriate form provided by the Department.

1. Daily (when any work is occurring):

Conduct inspections on the following areas:

- a. Petroleum product storage, usage, and handling areas for spills or leaks from vehicles or equipment
- b. All locations where vehicles enter/exit the site for evidence of off-site sediment tracking

Continue these inspections until a Notice of Termination (NOT) is submitted, and use the daily inspection forms.

2. Weekly and after Rainfall Events:

Conduct inspections on these areas every seven calendar days and within twenty-four hours after the end of a rainfall event that is 0.5 in (13 mm) or greater (unless such storm ends after 5:00 PM on any Friday or any non-working Saturday, non-working Sunday or any non-working Federal holiday in which case the inspection shall be completed by the end of the next business day and/or working day, whichever occurs first):

- a. Disturbed areas not permanently stabilized
- b. Material storage areas that are exposed to precipitation
- c. Structural control measures, Best Management Practices (BMPs) to ensure they are operating correctly
- d. Water quality sampling locations and equipment
- e. Discharge locations or points, e.g., outfalls and drainage structures that are accessible to determine if erosion control measures are effective in preventing significant impacts to receiving waters

Continue these inspections until all temporary BMPs are removed and a NOT is submitted. Use the EC-1 Form.

3. Monthly:

Once per month, inspect all areas of the site that have undergone final stabilization or have established a crop of annual vegetation and a seeding of target perennials appropriate for the region. Look for evidence of sediments or pollutants entering the drainage system and or receiving waters. Inspect all permanent erosion control devices remaining in place to verify the maintenance status and that the devices are functioning properly. Inspect discharge locations or points, e.g. outfalls, drainage structures, that are accessible to determine if erosion control measures are effective in preventing significant impacts to receiving waters.

Continue these inspections until the Notice of Termination is submitted and use the monthly inspection form.

C. Water Quality Sampling

When the sampling location is a receiving water, the upstream and downstream samples are taken for comparison of NTU values. When the sampling location is an outfall, a single sample is taken to be analyzed for its absolute NTU value.

D. Reports

1. Inspection Reports:

Summarize the results of inspections noted above in writing on the appropriate Daily, Weekly, Monthly, or EC-1 form provided by the Department and includes the following information:

- Date(s) of inspection
- Name of certified personnel performing inspection
- Construction phase
- Status of devices
- Observations
- Action taken in accordance with Part IV.D.4.a.(5) of the GAR100002 Permit
- Signature of personnel performing the inspection
- Any instance of non-compliance

When the report does not identify any non-compliance instances, the inspection report shall contain a statement that the best management practices are in compliance with the Erosion, Sedimentation, and Pollution Control Plan. (See the EC-1 form.)

The reports shall be made and retained at the site or be readily available at a designated alternate location until the entire site or that portion of a construction project that has been phased has undergone final stabilization and a Notice of Termination is submitted to the Georgia Department of Natural Resources Environmental Protection Division (GAEPD). Such reports shall be readily available by the end of the second business day and/or working day and shall identify all incidents of best management practices that have not been properly installed and/or maintained as described in the Plan. The inspection form certification sheet shall be signed by the project WECS and the inspector performing inspections on behalf of the WECS (if not the same person). Submit all inspection reports to the Engineer within twenty-four hours of the inspection. The Engineer will review the submitted reports to determine their accuracy. The Engineer will notify the certified personnel of any additional items that should be added to the inspection report.

Correct any items listed in the inspection report requiring routine maintenance within seventy-two (72) hours of notification or immediately during perimeter BMP failure emergencies. Deficiencies that interfere with traffic flow, safety, or downstream turbidity are to be corrected as soon as practical but in no case later than seven (7) calendar days following the inspection.

Assume responsibility for all costs associated with additional sampling as specified in Part IV.D.6.d.3.(c) of the GAR100002 if either of these conditions arises:

- BMPs shown in the Plans are not properly installed and maintained, or
- BMPs designed by the Contractor are not properly designed, installed and maintained.

2. Sampling Reports

a. All sampling shall be performed in accordance with the requirements of the GAR100002 Permit for the locations identified in the ESPCP approved by the Department.

b. Report Requirements

Include in all reports, the following certification statement, signed by the WECS or consultant providing sampling on the project:

"I certify under penalty of law that this report and all attachments were prepared under my direct supervision in accordance with a system designed to assure that certified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

When a rainfall event requires a sample to be taken, submit a report of the sampling results to the Engineer within seven working days of the date the sample was obtained. Include the following information in each report:

- 1) Date and time of sampling
- 2) Name of certified person(s) who performed the sampling and analyses.
- 3) Date the analyses were performed
- 4) Time the analyses were initiated
- 5) Rainfall amount on the sampling date (sampling date only)
- 6) NTU of each sample & analytical method
- 7) Location where each sample was taken (station number and left or right offset)
- 8) Identification of whether a sample is a receiving-water sample or an outfall sample
- 9) Project number and county
- 10) References and written procedures, whenever available, for the analytical techniques or methods used: whether the samples were taken by automatic sampler, rising-stage sampler, or manually (grab sample)
- 11) The results of such analyses, including the bench sheets, instrument readouts, computer disks or tapes, etc., used to determine these results
- 12) A clear note if a sample exceeds 1000 NTUs by writing "exceeds 1000 NTUs" prominently upon the report.

c. Report Requirements with No Qualifying Rainfall Events

In the event a qualifying rainfall event does not produce a discharge to sample, or sampling is "impossible", as defined in the GAR100002 Permit, a written justification must be included in the report as required at Part IV.D.4.a.(6) of the GAR100002 Permit.

d. Sampling Results

Provide sampling results to the Project Engineer within 48 hours of the samples being analyzed. This notification may be verbal or written. This notification does not replace the requirement to submit the formal summary to the Engineer within 7 working days of the samples being collected. The Engineer will ensure submission of the sampling report to GAEPD by the 15th of the month following the sampling results as per the GAR100002 Permit. The WECS will be held accountable for delayed delivery to the Department which results in late submissions to EPD resulting in enforcement actions.

3. Rainfall Data Reports:

Record the measurement of rainfall once each twenty-four hour period, except for non-working Saturdays, non-working Sundays and non-working Federal Holidays until a Notice of Termination is submitted. Project rain gauges and those used to trigger the automatic samplers are to be emptied after every rainfall event. This will prevent a cumulative effect and prevent automatic samplers from taking samples even though the rainfall event is not a qualifying event. The daily rainfall data supplied by the WECS to the Engineer will be the official rainfall data for the project.

167.3.06 Quality Acceptance

General Provisions 101 through 150.

167.3.07 Contractor Warranty and Maintenance

General Provisions 101 through 150.

167.4 Measurement

Water Quality Inspections in accordance with the inspection and reports sub-sections will be measured for payment by the month up to the time the Contract Time expires. Required inspections and reports after Contract Time has expired will not be measured for payment unless a time extension is granted by the Department.

Water Quality Sampling is measured per each. "Each" means each qualifying rainfall sampling event, not each sampled site.

When the sampling location is a receiving water, the upstream and downstream samples constitute one sample for comparison. When the sampling location is an outfall, a single outfall sample constitutes the entire sample.

167.4.01 Limits

General Provisions 101 through 150. Submit the monitoring summary report to the Engineer within 7 working days

167.5 Payment

Payment for Water Quality Inspections and Water Quality Sampling will be made as follows:

Water Quality Inspections will be paid at the Contract Price per month. This is full compensation for performing the requirements of the inspection section of the GAR100002 and this Specification, any and all necessary incidentals, and providing results of inspections to the Engineer, within the time frame required by the GAR100002 and this Specification.

Water Quality Sampling per each qualifying rainfall sampling event is full compensation for meeting the requirements of the sampling sections of the GAR100002 and this Specification, obtaining samples, analyzing samples, any and all necessary incidentals, and providing results of turbidity tests to the Engineer, within the time frame required by the GAR100002 and this Specification. This item is based on the rainfall events requiring sampling as described in Part IV.D. 6 of the GAR100002. The Department will not pay for samples taken and analyzed for rainfall events that are not qualifying events as compared to the daily rainfall data supplied by the WECS.

Payment will be made under:

Item No. 167	Water quality inspections	Per month
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Water Quality Sampling will be paid per each qualifying rainfall sampling event.

Payment will be made under:

Item No. 167	Water quality sampling	Per each
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167.5.01 Adjustments

General Provisions 101 through 150.

Office of Design Policy and Support

**DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA**

SPECIAL PROVISION

Section 171—Silt Fence

Delete Section 171 and substitute the following:

171.1 General Description

This work includes furnishing, installing, and removing a water permeable filter fabric fence to remove suspended particles from drainage water.

171.1.01 Definitions

General Provisions 101 through 150.

171.1.02 Related References

A. Standard Specifications

Section 163—Miscellaneous Erosion Control Items

Section 700—Grassing

Section 862—Wood Posts and Bracing

Section 881—Fabrics

Section 894—Fencing

B. Referenced Documents

ASTM D 3786

ASTM D 4355

ASTM D 4632

ASTM D 4751

GDT 87

QPL 36

171.1.03 Submittals

General Provisions 101 through 150.

171.2 Materials

Materials shall meet the requirements of the following Specifications:

Material	Section
Filter Fabrics	<u>881</u>
Fencing	<u>894</u>
Wood Posts and Bracing	<u>862</u>

Conditions during Project construction will affect the quantity of the silt fence to be installed.

The Engineer may increase, decrease, or eliminate the quantity at his or her direction. Variations in quantity are not changes in details of construction or in the character of the work.

For Type A, B, and C fences, use fabric as specified in Subsection 881.2.07, "Silt Fence Filter Fabric."

171.2.01 Delivery, Storage, and Handling

During shipment and storage, wrap the fabric in a heavy-duty covering protecting the cloth from sunlight, mud, dust, dirt, and debris. Do not expose the fabric to temperatures greater than 140 °F (60 °C).

When installed, the Engineer will reject the fabric if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or storage.

171.3 Construction Requirements

171.3.01 Personnel

General Provisions 101 through 150.

171.3.02 Equipment

General Provisions 101 through 150.

171.3.03 Preparation

General Provisions 101 through 150.

171.3.04 Fabrication

General Provisions 101 through 150.

171.3.05 Construction

Install the silt fence according to this Specification, as shown on the Plans, or as directed by the Engineer

A. Install Silt Fence

1. Install silt fence by either of the following methods:
 - a. Excavated Trench Method
Excavate a trench 4 to 6 in (100 to 150 mm) deep using equipment such as a trenching machine or motor grader. If equipment cannot be operated on the site, excavate the trench by hand.
 - b. Soil Slicing Method
Create a mechanical slice in the soil 8 to 12 in (200 to 300 mm) deep to receive the silt fence. Ensure the width of the slice is not more than 3 in (75 mm). Mechanically insert the silt fence fabric into the slice in a simultaneous operation with the slicing ensuring consistent depth and placement.
2. Install the first post at the center of the low point (if applicable). Space the remaining posts a maximum of 6 ft (1.8 m) apart for Types A and B fence and 4 ft (1.2 m) apart for Type C fence.
3. Bury the posts at least 18 in (450 mm) into the ground. If this depth cannot be attained, secure the posts enough to prevent the fence from overturning from sediment loading.
4. Attach the filter fabric to the post using wire, cord, staples, nails, pockets, or other acceptable means.
 - a. Staples and Nails (Wood Posts): Evenly space staples or nails with at least five per post for Type A fence and four per post for Type B fence.
 - b. Pockets: If using pockets and they are not closed at the top, attach the fabric to a wood post using at least one additional staple or nail, or to a steel post using wire. Ensure the additional attachment is within the top 6 in (150 mm) of the fabric.
 - c. Install the filter fabric so 6 to 8 in (150 to 200 mm) of fabric is left at the bottom to be buried. Provide a minimum overlap of 18 in (450 mm) at all splice joints.
 - d. For Type C fence:
 - 1) Woven Wire Supported
 - Steel Post: Use wire to attach the fabric to the top of the woven wire support fence at the midpoint between posts. Also, use wire to attach the fabric to the post.
 - 2) Polypropylene Mesh Supported
 - Wood Post: Use at least six staples per post. Use two staples in a crisscross or parallel pattern to secure the top portion of the fence. Evenly space the remaining staples down the post.
 - Steel Post: Use wire to attach the fabric and polypropylene mesh to the post.

5. Install the fabric in the trench so 4 to 6 in (100 to 150 mm) of fabric is against the side of the trench with 2 to 4 in (50 to 100 mm) of fabric across the bottom in the upstream direction.
6. Backfill and compact the trench to ensure flow cannot pass under the barrier. When the slice method is used, compact the soil disturbed by the slice on the upstream side of the silt fence first, and then compact the downstream side.
7. When installing a silt fence across a waterway producing significant runoff, place a settling basin in front of the fence to handle the sediment load, if required. Construct a suitable sump hole or storage area according to Section 163.

B. Remove the Silt Fence

1. Keep all silt fence in place unless or until the Engineer directs it to be removed. A removed silt fence may be used at other locations if the Engineer approves of its condition.
2. After removing the silt fence, dress the area to natural ground, grass and mulch the area according to Section 700.
3. The silt fence shall remain until the Project is accepted or until the fence is removed. Also, remove and dispose of the silt accumulations at the silt fence.
4. Remove and replace any deteriorated filter fabric reducing the effectiveness of the silt fence.
5. Repair or replace any undermined silt fence at no additional cost to the Department.

171.3.06 Quality Acceptance

Approved silt fence is listed in QPL 36. Approved fabrics must consistently exceed the minimum requirements of this Specification as verified by the Office of Materials and Research. The Office of Materials and Research will remove fabric failing to meet the minimum requirements of this specification from the QPL until the products' acceptability has been reestablished to the Department's satisfaction.

At the time of installation, the Engineer will reject the fabric if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or storage.

171.3.07 Contractor Warranty

The silt fence shall remain until the Project is accepted or until the fence is removed. Also, remove and dispose of the silt accumulations at the silt fence.

Remove and replace any deteriorated filter fabric that reduces the effectiveness of the silt fence.

Repair or replace any undermined silt fence at no additional cost to the Department.

171.4 Measurement

The quantity of silt fence to be paid for is the actual number of linear feet (meters) of silt fence, measured in place from end post to end post of each separate installation. The silt fence must be complete and accepted.

171.4.01 Limits

General Provisions 101 through 150.

171.5 Payment

Silt fence Type A, B, or C measured as defined in Subsection 171.4, "Measurement," is paid for at the Contract Unit Price bid per linear foot (meter).

Payment is full compensation for the following:

- Furnishing materials
- Erecting the fence
- Dressing and grassing, when required
- Removing the fence, when required

Payment for this Item is made as follows:

- Seventy-five percent of the Contract Price bid per linear foot (meter) is paid when each fence is complete in place.
- Twenty-five percent is paid at removal or acceptance.

If the silt fence must be repaired or removed, as the result of neglect or damage, perform the work at no additional cost to the Department.

Payment will be made under:

Item No. 171	Silt fence, type__	Per linear foot (meter)
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171.5.01 Adjustments

General Provisions 101 through 150.

Office of Design Policy and Support

**DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA**

SUPPLEMENTAL SPECIFICATION

Section 201 – Clearing and Grubbing Right of Way

Delete Subsection 201.3.05.E.3 and substitute the following:

3. Solid Waste Material

a. Nonregulated Material

- 1) Common fill is defined as soil, rock, brick, concrete without reinforcement, concrete with reinforcement where the reinforcement has been removed flush with the surface of the concrete and cured asphalt, provided that such material does not contain hazardous waste constituents above background levels and the material results from Department funded construction contracts. Such fill is not subject to the Georgia Comprehensive Solid Waste Management Act of 1990 and the Solid Waste Management Rules when used as fill material on Department funded construction contracts or Department property or when used as fill material on property not owned by the Department when all requirements of this specification are fully met. Common fill meeting this definition may be placed as follows:

a. At a permitted municipal, construction and demolition materials or inert landfill fully meeting all requirements of the Solid Waste Rules and Act and any other applicable laws or ordinances.

b. At an off-site engineered fill location in accordance with the following requirements;

- Place the material in uniform layers 3 ft thick or less and distributed to avoid the formation of large voids or pockets.
- Fill voids with finer material.
- Cover the last layer of fill with at least 2 ft of soil.
- Construct the fill according to Section 208, except compact it to at least 90 percent of the maximum laboratory dry density.
- A Georgia registered professional engineer shall document, certify and submit the following information on behalf of the Contractor to the Department; compaction rates, waste description including average particle size, and the depth of clean earthen fill lying above the engineered fill.

c. On site as compacted fill if prior written approval has been granted by the Engineer and in accordance with the following requirements:

- As compacted fill incorporated into embankment only. No area shall be excavated for the sole purpose of disposing of common fill.
- Place the material in uniform layers 3 ft thick or less and distributed to avoid the formation of large voids or pockets.
- Fill voids with finer material.
- Cover the last layer of fill with at least 2 ft of soil.
- Construct the fill according to Section 208, except compact it to at least 90 percent of the maximum laboratory dry density.
- Records of the exact location by station and offsets, amount disposed per location in cubic yards, waste description including average particle size, compaction rates and depth of clean earthen fill lying above the composite materials shall be kept by the Engineer.

d. Materials that may be recycled or reused such as asphaltic concrete, Portland cement concrete, plastic, metal and materials that qualify under EPD regulations for sale or use may be reclaimed by the Contractor.

b. Regulated Material

- 1) Inert waste is defined as organic debris such as stumps, limbs and leaves, cured asphalt and any of the aforementioned common fill items that do not meet the compaction requirements when placed in an excess materials pit. An inert waste landfill permit shall be obtained in accordance with GDNR/EPD Rules to properly record the disposal of inert waste when compaction requirements are not met at an excess materials pit. If disposed of at a landfill, inert waste may only be disposed at a permitted municipal, construction and demolition materials or inert landfill fully meeting all requirements of the Solid Waste Rules and Act and any other applicable laws or ordinances.
- 2) Construction and demolition waste is defined as construction forms, barrels, scrap metal, and other such by-products of construction not specifically listed above as either common fill or inert waste. Construction and or demolition waste must be disposed of at a permitted municipal, construction and demolition materials, or inert landfill fully meeting all requirements of the Solid Waste Rules and Act and any other applicable laws or ordinances.
- 3) Dispose of oils, solvents, fuels, untreated lead paint residue, and other solid hazardous waste through a properly licensed hazardous waste disposal facility.

- 4) Remove municipal solid waste discovered during construction or shown on the Plans according to Section 215.

c. Solid Waste Handling and Disposal Documentation Requirements:

- 1) Waste disposed at a permitted municipal or construction and demolition landfill – all tipping receipts generated by the receiving landfill shall be provided to the Engineer.
- 2) Waste disposed at inert landfill – a copy of the landfill's Permit By Rule notification, and for landfills exceeding one acre, a copy of the landfill's NPDES General Storm water Permit Notice of Intent (NOI) and any local jurisdiction Land Disturbing Activity Permit, if applicable, shall be provided to the Engineer.
- 3) Any necessary documentation regarding a disposal site's permit status must be obtained by the Contractor and verified by the Department before any common fill, inert waste, or other solid waste is allowed to leave the site.
- 4) The documentation listed herein shall be maintained on-site in the project files and at any other location the Department deems necessary until a valid NPDES Notice of Termination is filed.

Recyclable materials must be separated from all waste materials and shall be properly stored in containers when practicable.

Excluding the above allowances, all types of waste shall be handled in full compliance with the following:

- The Georgia Solid Waste Management Rules, as amended (391-3-4)
- Georgia Comprehensive Solid Waste Management Act of 1990, as amended (O.C.G.A. 12-8-20)
- The Georgia Erosion & Sedimentation Act as amended (O.C.G.A. 12-7-1) and any applicable Local and State requirements as well as the General Permits of the Georgia Water Quality Control Act
- Any other applicable Federal, State, or Local rules or laws

Office of Construction

**DEPARTMENT OF TRANSPORTATION
STATE OF GEORGIA**

SPECIAL PROVISION

**P.I. No.: 0013163
DISTRICT 7**

Section 939—Communication and Electronic Equipment

Delete Section 939 and substitute the following:

Section 939 –Communication and Electronic Equipment

939.1 General Description

This work includes installation, acceptance testing, warranty, and guaranty of items that are either components of several NaviGator subsystems or elements of the communication network.

Provide all equipment and materials of like kind and function to be of the exact same manufacture, model, revision, firmware, etc.

Provide all equipment, materials, and work in accordance with all manufacturers' recommendations.

939.1.01 Definitions

- Caltrans TEES – Caltrans Transportation Electrical Equipment Specifications, as published by the State of California Business, Transportation & Housing Agency; Department of Transportation, Current Edition, and all current addenda.
- Caltrans TSCES – Caltrans Traffic Signal Control Equipment Specifications, as published by the State of California Business, Transportation & Housing Agency; Department of Transportation, Current Edition, and all current addenda.
- Type A Cabinet – The Type A cabinet housing is a standard Model 336 stretch (336S) housing with approximate exterior dimensions of 46 in. (1.2 m) (H) x 24 in. (0.61 m) (W) x 23 in. (0.58 m) (D).
- Type B Cabinet - The Type B cabinet housing is a standard Model 337 housing with approximate exterior dimensions of 35 in. (0.89 m) (H) x 20 in. (0.5 m) (W) x 17 in. (0.43 m) (D).
- Type C Cabinet - The Type C cabinet housing is a standard Model 332 housing with approximate exterior dimensions of 64 in. (1.6 m) (H) x 24 in. (0.61 m) (W) x 30 in. (0.76 m) (D).
- Type D Cabinet – The Type D cabinet housing is a standard Model 336 stretch (336S) housing with approximate exterior dimensions of 46 in. (1.2 m) (H) x 24 in. (0.61 m) (W) x 23 in. (0.58 m) (D). The difference between a Type D and Type A cabinet is the difference in interior cabinet configuration as shown in the Detail Drawings in this section.
- Type F Cabinet - The Type F cabinet housing shall be a standard ITS Cabinet Housing #3 with approximate exterior dimensions of 67 in. (1.7 m) (H) x 44 in. (1.2 m) (W) x 26 in. (0.66 m) (D).

939.1.02 Related References

A. Georgia Standard Specifications

- Section 631 – Permanent Changeable Message Sign
- Section 682 – Electrical Wire, Cable and Conduit
- Section 797 –Buildings
- Section 922 – Electrical Wire and Cable
- Section 923 – Electrical Conduit
- Section 925 – Traffic Signal Equipment
- Section 935 – Fiber Optic System
- Section 936 – Closed Circuit Television System (CCTV)
- Section 937 – Video Detection System
- Section 938 – Detection
- Section 940 – NaviGator Advanced Transportation Management System Integration

B. Referenced Documents

- American Society of Testing and Materials (ASTM)
- American National Standards Institute (ANSI)
- Caltrans TEES
- Canadian Standards Association (CSA)
- Deutsches Institut für Normung {German Institute for Standardization} (DIN)
- Electronics Industry Association (EIA)
- Standards of the European Committee for Standardization (EN)
- ICEA Table K.2/Method I
- Institute of Electrical and Electronics Engineers (IEEE)
- International Electrotechnical Commission (IEC)
- International Standards Organization (ISO)
- International Telecommunications Union (ITU)
- Motion Pictures Expert Group (MPEG)
- National Electric Code (NEC)
- National Electric Safety Code (NESC)
- National Electrical Manufacturers Association (NEMA)
- National Television System Committee (NTSC)
- National Transportation Communications for ITS Protocol (NTCIP)
- Telecommunications Industry Association (TIA)
- Underwriter's Laboratory Incorporated (UL)
- Association for Electrical, Electronic & Information Technologies [Germany] (VDE)

939.1.03 Submittals

The following chart provides the Contractor with an outline of the submittal requirements for the equipment and components for this pay item. This chart is to be used as a guide and does not relieve the Contractor from submitting additional information to form a complete submittal package.

Section 939 Submittal Requirements								
Item	Specification Subsection	Catalog Cuts	Factory Specifications	Independent Test Lab Certification	Installation Procedure	Test Plans	Maintenance Procedures	Submittal Due Date (Cal. Days after NTP)
Serial Data Terminal Server (All Types)	939.2.02	X	X		X	X	X	60 Days
Patch Cords	939.2.03	X	X					60 Days
Hub UPS	939.2.04	X	X		X	X	X	60 Days
Network Switch, Layer 3 Gig-E (All Types)	939.2.05	X	X	X	X	X	X	60 Days
GBIC Routing Switch Module (All Types)	939.2.06	X	X	X	X	X	X	60 Days
GBICs (All Types)	939.2.07	X	X	X	X	X	X	60 Days
Field Switch (All Types)	939.2.08	X	X	X	X	X	X	60 Days
Video Encoder (All Types)	939.2.09	X	X	X	X	X	X	60 Days
Video Decoder (All Types)	939.2.10	X	X	X	X	X	X	60 Days
Equipment Rack	939.2.11	X	X	X	X			60 Days
Equipment Frame	939.2.12	X	X	X	X			60 Days
Dial-up modem	939.2.13	X	X		X	X	X	60 Days
Equipment Cabinet Assembly (All Types)	939.2.13.A	X	X		X	X	X	60 Days
Training Plan	939.3.08				X		X	60 Days

- Submit submittal data for all equipment, materials, test procedures, and routine maintenance procedures required for these items within sixty (60) calendar days after the Notice To Proceed and prior to any installation, unless noted otherwise in the Contract Documents.
- Submit to the Engineer for approval, two (2) copies of the manufacturer's descriptive literature (catalog cuts), technical data, operational documentation, service and maintenance documentation and all other materials required within these specifications. An electronic copy, which includes all the aforementioned documents, shall be placed on a CD as pdf documents and delivered to the Engineer.
- Provide submittal data that is neat, legible, and orderly. Neatly organize each package of submittal data and separate by hardware item. Use the "Materials Certification Package Index and Transmittal Form", contained in Section 105.02 of the Special Provisions, for each pay item to document and list all material and components that are included in the submittal package. Any submittal data submitted without the Index/Transmittal form or that is incomplete will be rejected.

A. Equipment

Equipment

Materials submittal data for items specified herein shall include, but not be limited, equipment performance and technical specifications, electrical/power specifications, size/weight/mounting configuration requirements, and environmental operating conditions.

Provide a diagram showing the location of all equipment within the TCC, Hub and/or Equipment Cabinet, 30 days prior to any installation activities at the site. Include in this diagram the dimensions, power requirements, power service materials and heat dissipation specifications for all of the equipment.

Submit and provide all equipment and corresponding ancillary and incidental materials of a like kind to be the exact same manufacturer, model, revision, firmware, etc. for the entire quantity in the project. Like kind equipment shall include but is not limited to serial data terminal servers, uninterruptible power supplies, network switches, GBIC routing switch modules, GBICs, field switches, video encoders and decoders, equipment racks, equipment frames, and dial-up modems.

Submittal Review Demonstration Test Set

Submit demonstration test set(s) for Department evaluation after the Engineer approves the submittal materials for the equipment and materials listed below. The demonstration test sets shall be connected to and operated through the NaviGator system by the Engineer. Deliver the test set to the Department at the location specified by the Engineer. Request a delivery and test time a minimum of 30 days in advance. Provide demonstration test sets of the materials, types and quantities as shown below:

- Serial Data Terminal Server, all types (quantity 2 of each type)
- Network Switch, Layer 3 Gig-E, all types (quantity 1 of each type)
- Field Switch, all types (quantity 4 of each type)
- Video Encoder, all types (quantity 2 of each type)
- Video Decoder, all types (quantity 2 of each type)

A demonstration test set shall include all materials, components, assemblies, control software and documentation of the equipment and shall be complete and fully functional for communications with the NaviGator system. All equipment shall be configured for locating on a benchtop, or else provide a desktop stand to secure the equipment. Provide a high-density chassis cage for video encoders and decoders when the cage is required on a project. Provide an RS232 serial cable for console connection for each type of equipment item. Provide a NEMA 5-15 cord for power service to all equipment.

Review of the demonstration test set submittal shall be conducted in two parts. The first part of the review shall be performed by the Contractor in the presence of the Engineer and shall include the setup and configuration of the demonstration test set on the NaviGator system. The first part of the review shall be conducted during normal Department weekday business hours and shall be conducted for the period of time necessary to the satisfaction of the Engineer. The second part of the review shall be a 60-day period during which the Engineer shall operate and evaluate the demonstration test set with the NaviGator system. The second part of the review shall commence only upon the Engineer's approval of the first part of the review. Retrieve the demonstration test set upon completion of the second part of the review as notified by the Engineer.

B. Testing

Provide test equipment and system set-up and diagnostic software required for the testing, operation, maintenance and troubleshooting of the equipment, along with Operations, Installation and Maintenance manuals for these software packages.

Submit all testing plans and procedures for Department approval in accordance with the chart above.

C. Equipment Cabinet Assembly

Submit materials submittal data for the equipment cabinet and all individual component and hardware items that make up the complete assembly. These items shall include, but are not limited to, cabinet shell specifications, electrical component description and performance specifications, wiring and cabling equipment and materials, electrical/power specifications, and all documentary items.

Submit materials submittal data for all materials and hardware necessary for the patch and electrical cabling, conduit and power service. These items include but are not limited to cabling, wire and conduit materials, service disconnect breaker/surge suppression/termination/housing description and performance specifications, ground rod and conductor, proposed conduit route from service point to equipment cabinet, and all miscellaneous hardware and accessories.

Submit and provide all equipment cabinet assemblies and corresponding ancillary and incidental materials of a like kind from the exact same manufacturer, model, revision, firmware, etc. for the entire quantity in the project. Like kind equipment shall include, but is not limited to, cabinet housings, internal cabinet assembly components, and electrical components including surge suppressors, terminal blocks, rack-mount equipment outlets, and side and support panels.

939.2 Materials

939.2.01 Not Applicable

939.2.02 Serial Data Terminal Server

Provide multiport Serial Data Terminal Servers (terminal servers) that are compatible with the existing NaviGator serial port control system. The existing serial port control system consists of serial data terminal servers (Digiboard PortServer II) addressed with the Digiboard RealPort system interface.

Ensure all terminal servers meet the following requirements:

- Compatible with the existing NaviGator serial port control system.
- IP addressable supporting Ethernet 10/100Base-T/TX with RJ45 port.
- RS-232 serial ports with RJ45 ports.
- Management access by HTTP, telnet, and console ports, all password protected.
- SNMP read/write management of terminal server and individual serial ports.
- Each serial port individually configurable comm. settings and TCP/UDP socket support.
- Each serial port with minimum 64kbps buffering and data capture.
- Firmware upgradeable by FTP/TFTP.
- Upload/download of configuration settings.
- Diagnostic LEDs for Ethernet connection and unit status.
- UL approval.

Ensure Serial Data Terminal Server, 16 Port, meet the following additional requirements:

- EIA 19-inch rack-mounted units with maximum vertical height of 1.75 inch (44.4 mm).
- 16 RS-232 ports mounted on the front of the unit.
- Internal 120VAC power supply.

Ensure Serial Data Terminal Server, Type B, meet the following additional requirements:

- Operating temperature of unit and power supply of -31°F to 165°F (-35°C to 74°C).
- Conformal-coated circuit boards.
- Capable of being panel-mounted, rack-mounted and shelf-mounted in equipment cabinets.
- Minimum of two (2) RS-232 ports mounted on the front of the unit.
- Internal or external 120VAC power supply.

939.2.03 Patch Cords

General Requirements:

- a. Provide all necessary patch cords with all electronic equipment for interconnection. Verify that patch cords consist of a length of cable that is connectorized on both ends, primarily used for interconnecting termination or patching facilities and/or equipment.
- b. All patch cords shall be factory assembled and connectorized and be certified by the patch cord manufacturer to meet the relevant performance standards required below. All connectors shall incorporate mechanical cable strain relief and protective boots.
- c. Coaxial Video Patch Cords: Ensure that coaxial video patch cords are 75-ohm precision double-shielded cables with tinned copper braid shield and minimum #22AWG solid copper stranded center conductor. Use BNC

connectors with gold-plated center pins at both ends. Connectorized coaxial video patch cords shall be 100% sweep tested. Provide only adapters with gold-plated pins.

- d. Network/Field Switch/Data Patch Cords: Verify that network//field/data patch cords meet all ANSI/EIA/TIA requirements for Category-6 4-pair unshielded twisted pair cabling with stranded conductors and RJ45 connectors.
- e. Voice/Telephone Patch Cords: Provide voice/telephone patch cords that meet all ANSI/EIA/TIA requirements for Category 3 unshielded twisted pair cabling with stranded conductors, unless otherwise required by the voice/telephone equipment manufacturer.
- f. Fiber Optic Patch Cords: Provide fiber optic patch cords that meet all requirements of Section 935.

939.2.04 Hub Uninterruptible Power Supply

Ensure the Hub UPS provides AC back-up power for network electronics and other equipment as shown in the contract documents. Provide a Hub UPS meeting the following requirements:

- 19" rack mounted, maximum height of six (6) rack units (10.5").
- 120 VAC single phase 60 HZ output
- Input line cord plug type NEMA L5-30P
- 8 output receptacles type NEMA5-15R
- Pure sine wave output at 115 VAC +/- 5%
- Transfer time of 4 ms or less
- Capacity of 2200 VA/1600 W
- Load factor range of 0.5 to 1.0
- Peak current capability of 6.5 KVA
- Software adjustable high and low voltage buck/boost function
- SNMP manageable hardware and software with 10Base-T connection (RJ-45)
- Addressable SNMP command set shall minimally include: UPS state, battery condition (capacity, age, internal temperature); current AC input conditions (voltage, phase, frequency, failure condition); current AC output conditions (voltage, frequency, load); and diagnostic/self-test control and status.
- Remote environmental sensing hardware and software integrated with SNMP minimally capable of temperature and humidity monitoring and 4 dry contact closures
- Network connection to Ethernet port on Hub Network Switch, Layer 3 GigE
- Printed and electronic user documentation for all management, configuration and operation hardware and firmware settings, installation procedures, and the MIB.
- Sealed maintenance-free lead-acid batteries
- Maximum audible noise of <53 dBA at 3 ft (0.9 m).
- Upgradeable for increased runtime capacity (minimum 2.5X) with additional battery packs
- Expansion battery pack that is 19" rack mounted, with maximum height of five (5) rack units (8.75").

939.2.05 Network Switch, Layer 3 GigE

Furnish a Gigabit Ethernet Layer 3 network routing switch that is compatible with the existing GDOT Ethernet switching network. The existing network consists of Nortel Networks 8600 Layer 3 routing switches. The network switches shall be manageable using the Department's existing Device Manager network management software. Furnish and configure the network switches as complete compatible assemblies. Configure the network switch(es) at the locations shown in the Plans, as applicable, to the following minimum requirements:

- Minimum 6-slot chassis with hot-swappable card capability

- Two (2) Enterprise Routing Switch Module CPU/Switch Fabric Modules with PCMCIA flash memory card and a processing capability of 380 million packets-per-second
- One (1) 30-port 1000 Base SFP GBIC Routing Switch Module.
- One (1) 48-port auto-sensing 10/100/1000 Base-T/TX Ethernet Layer 3 switching interface Module.
- Three (3) 100-240VAC power supplies including North American power cables, configured for 120VAC service
- Ethernet Routing Switch 8600 software license, latest version, including license, agent software, management software, and all software documentation
- EIA 19" rack mounted

Additionally configure each Network Switch, Layer 3 GigE, Type E, with four (4) Type E GBICs. Include four (4) duplex fiber optic single-mode patch cords, 30 ft. (9 m) in length, in accordance with Section 935 and with ST-connectors on one end (at the FDC) and an LC-connector on the other end (at the network switch.)

Additionally configure each Network Switch, Layer 3 GigE, Type F, with four (4) Type E GBICs and four (4) Type F GBICs. Include eight (8) duplex fiber optic single-mode patch cords, 30 ft. (9 m) in length, in accordance with Section 935 and with ST-connectors on one end (at the FDC) and an LC-connector on the other end (at the network switch.)

939.2.06 GBIC Routing Switch Module

Provide a GBIC Routing Switch Module, Type B, which consists of 30-1000Base SFP GBIC ports populated with GBICs as called-out on the Plans and as specified herein. All Modules and GBICs provided shall be compatible with the Network Switch, Layer 3 GigE.

939.2.07 GBIC (Gigabit interface converter)

The GBICs shall meet the following minimum requirements:

- Support single-mode operation
- Fully compliant with IEEE 802.3z standards
- Operate at 1000Mbps and full-duplex two fiber operation supporting the following types:
 - GBIC, Type A (LX): (SMFO at 1310nm); optical link budget: 10.5dB, typical
 - GBIC, Type B (XD): (SMFO at 1550nm); optical link budget: 17.0dB, typical
 - GBIC, Type C (ZX): (SMFO at 1550nm); optical link budget: 22.0dB, typical
 - GBIC, Type D (SFP LX): (SMFO at 1310nm); optical link budget: 10.5dB, typical
 - GBIC, Type E (SFP XD): (SMFO at 1550nm); optical link budget: 17.0dB, typical
 - GBIC, Type F (SFP ZX): (SMFO at 1550nm) optical link budget: 20.0dB, typical
 - GBIC, Type G (SFP SX): (MMFO at 850nm) optical link budget: 7.0dB, typical
- Allow for hot swapping failed components.
- Operate as its own switched port.
- Support detecting and shutting down one-way link failures, using auto-negotiation.
- The GBIC optical receiver saturation level shall be greater or equal to the maximum optical output of the mating transmitter minus 5db. Where required for manufacturer's recommended operations, provide fiber optic patch cords in accordance with Section 935 with integral optical attenuators for optical power control in accordance with the Ethernet switch (network switch, field switch, etc.) manufacturer's recommendations.
- GBICs, all types, furnished with field switches shall meet the same environmental operating requirements as the field switch.

939.2.08 Field Switch

All Field Switches shall meet the following requirements:

a. General Characteristics and Capabilities:

- 1) Meet the IEEE 802.3 (10Mbps Ethernet) standard.
- 2) Meet the IEEE 802.3u (Fast Ethernet 100 Mbps) standard
- 3) Provide Gigabit-Ethernet SFP GBIC sockets as specified in Field Switch Types subsection.
- 4) Provide a minimum of six (6) 10/100 Base-T/TX ports unless otherwise specified in the Field Switch Types subsection. Each 10/100Base-T/TX port shall connect via RJ45 connector. The ports shall operate as half-duplex or full-duplex (IEEE 802.3x) over 100m segment lengths and provide auto-negotiation.
- 5) Bit Error Ratio (number of erroneous bits divided by the total number of bits transmitted, received, or processed) shall not increase over the optical channel when two units are connected with a fiber optic jumper having total optical losses of 6dB, including connector losses.
- 6) Operate non-blocking, at full wire speed
- 7) Support remote reset and remote management
- 8) Minimum MTBF of 100,000 hrs using Bellcore TS-332 standard.

b. Network Capabilities and Features:

The Field Switch shall support/comply with the following minimum requirements:

- 1) Provide full implementation of IGMPv2 and IGMP snooping
- 2) Meet the IEEE 802.3x (Full Duplex with Flow Control) standard.
- 3) Meet the IEEE 802.1p (Priority Queuing) standard.
- 4) Meet the IEEE 802.1Q (VLAN) standard per port for up to four VLAN's.
- 5) The switch shall meet the IEEE 802.1D (Spanning Tree Protocol) and IEEE 802.1w (Rapid Spanning Tree) standards.
- 6) Meet the IEEE 802.3ad (Link Aggregation) standard for a minimum of two groups of four ports.
- 7) Full implementation of GVRP (Generic VLAN Registration Protocol).

c. Port Security:

The Field Switch shall support/comply with the following (remotely) minimum requirements:

- 1) Ability to configure static MAC addresses access
- 2) Ability to disable automatic address learning per ports; know hereafter as Secure port. Secure Ports only forward statically configured Mac addresses.
- 3) Trap and alarm upon any unauthorized MAC address and shutdown. Port shutdown requires administrator to manually reset the port before communications are allowed.

d. Network Management Functions:

The Field Switch shall support/comply with the following minimum requirements:

- 1) Password manageable
- 2) Full implementation of SNMPv1 and SNMPv2c.
- 3) Full implementation of RMON I statistics, history, alarms, and events objects.
- 4) Capable of mirroring any port to any other port within the switch.

e. Remote Management and Configuration:

The Field Switch shall support/comply with the following minimum requirements:

- 1) SNMP
- 2) Telnet/CLI
- 3) HTTP (Embedded Web Server) with Secure Sockets Layer (SSL).
- 4) Full implementation of RFC 783 (TFTP) to allow remote firmware upgrades.

f. Mounting:

The Field Switch shall be rack mountable as shown on the Detail Drawings in this section. All necessary hardware and adaptors for mounting shall be included. Provide a perforated shelf and secure with rack mounting hardware for a Field Switch that is not rack mountable with integral "rack ears."

Provide a sufficient quantity of fiber optic patch cords to match the populated optical ports on the Field Switch. Include duplex fiber optic single-mode patch cords, 3 ft. (1 m) in length, in accordance with Section 935 and with ST-connectors on one end (at the FDC) and an LC-connector on the other end (at the Field Switch.)

g. Environmental:

The Field Switch shall support/comply with the following minimum requirements:

- 1) Operate between -34 to +74 degree Celsius. (-29°F to +165°F). No fans are permitted.
- 2) Operate from 10% to 90% humidity
- 3) Maximum size of 1 rack unit high by 12.5 in (320 mm) deep

h. Electrical/Safety:

The Field Switch shall support/comply with the following:

- 1) Operate from 100 VAC to 200 VAC (120VAC nominal, 60Hz) as shown on the Detail Drawings in this section.
- 2) The Field Switch shall be provided with all power conversion which is temperature hardened from -34 to +70 degrees Celsius (-29°F to +165°F) and all regulation necessary to support electronics operation. The power input circuitry shall be designed to protect the electronics from damage by a power surge or under voltage condition.
- 3) All power transformers provided shall be "fastening mechanism" type. No plug-in types will be provided. All corded transformers shall be mountable with the ability to neatly secure power cords.
- 4) Include UL approval
- 5) Provide rubber dust caps/covers with insertion/removal handles that completely seal the port opening for all unused copper and optical ports.

i. Status Indicators:

The Field Switch shall support/comply with the following minimum requirements:

- 1) Power: On, Off
- 2) Network Status per port: Transmit, Receive, Link, Speed
- 3) Status indicators shall be LED.

j. Field Switch Types:

In addition to meeting all the requirements specified herein, the Field Switch SFP GBIC sockets shall be populated as indicated on the Plans. The Field Switch types are defined as follows:

- Field Switch, Type A – provide a minimum of three (3) Gigabit-Ethernet SFP GBIC sockets, populated with three (3) GBIC, Type D (SFP LX)
- Field Switch, Type B – provide a minimum of three (3) Gigabit-Ethernet SFP GBIC sockets, populated with one (1) GBIC, Type D (SFP LX) and two (2) GBIC, Type E (SFP XD)

- Field Switch, Type C – provide a minimum of two (2) Gigabit-Ethernet SFP GBIC sockets, populated with two (2) GBIC, Type D (SFP LX)
- Field Switch, Type D – provide a minimum of two (2) Gigabit-Ethernet SFP GBIC sockets, populated with one (1) GBIC, Type D (SFP LX) and one (1) GBIC, Type E (SFP XD)
- Field Switch, Type E – provide a minimum of two (2) Gigabit-Ethernet SFP GBIC sockets, populated with two (2) GBIC, Type E (SFP XD)
- Field Switch, Type F – provide a minimum of eight (8) Gigabit-Ethernet SFP GBIC sockets, populated with four (4) GBIC, Type D (SFP LX). One 10/100 Base-TX port is required unless otherwise specified.
- Field Switch, Type G – provide a minimum of (3) Gigabit-Ethernet SFP GBIC sockets, populated with two (2) GBIC, Type D (SFP LX) and one (1) GBIC, Type E (SFP XD)

939.2.09 Video Encoder (All Types)

Provide a Video Encoder in accordance with the minimum requirements below for the encoding of analog video inputs and transmission as digital streams over a network.

A. Video Encoder, Type B

Video Encoder, Type B is a standalone, environmentally hardened encoder for a single video signal, suitable for field cabinet use.

1. General

a. Chassis

- 1) Furnish rack-mountable or shelf-mountable units.
- 2) Rack-mountable units shall include integrated brackets for mounting in standard EIA 19-inch rack mountings, and shall be no more than one (1) rack unit (1.75 inches (45 mm)) high and 13 in. (330 mm) deep.
- 3) Shelf-mountable units shall be no more than 3.5 in. (89 mm) (H) x 9 in. (229 mm) (W) x 11 in. (280 mm) (D), and shall include a perforated ventilated shelf for mounting in a standard EIA 19-inch rack, no more than 13 inches (330 mm) deep with mounting flanges of two (2) rack units (3.5 in. (89 mm)) and a minimum 20 lb (9 kg) load rating.

b. Labeling and Identification

- 1) Provide external silk-screened markings for all connectors, indicators, switches, and replaceable components.
- 2) Provide external labeling on the front or rear enclosure face for the manufacturer's name, product, model and part numbers, revision numbers, serial number, and MAC address.

c. Environmental

- 1) Operating temperature of -30 degrees F (-34 C) to 165 degrees F (74 C) with relative humidity between 10% to 90% non-condensing.
- 2) Ventilation fans are not permitted.

d. Power

- 1) Nominal power input voltage of 120 VAC.
- 2) Maximum power consumption of 20 watts.
- 3) If external power supplies are used, they shall fit into the allotted space for the encoder, and shall meet the same operating temperature and relative humidity requirements.

e. Connectors

- 1) Video Input: BNC connector with gold-plated center socket.
- 2) Network: RJ-45 jack

- 3) Serial Data: 9-pin D-subminiature (DE-9), keyed pluggable locking terminal block, or keyed locking connector jack. If DE-9 connector is used, comply with TIA-574. If keyed locking connector jack is used, furnish an adapter cable (no greater than 1m in length) with the required DE-9F/TIA-574 connector and labeled "DATA".
 - 4) Console: Female 9-pin D-subminiature (DE-9F) connector for RS-232 DCE (data circuit equipment) console interface compliant with TIA-574. If encoder housing has a connector interface other than DE-9F, furnish an adapter cable (no greater than 1m in length) with the required DE-9F connector for each encoder and labeled "CONSOLE".
 - 5) Power: NEMA 5-15 plug
2. Interfaces
- a. Video Input: Color NTSC signal, 1 volt peak-to-peak.
 - b. Serial Data
 - 1) RS-232 operation, bidirectional with minimum data receive, data transmit, and ground signal connections.
 - 2) Baud-rate selectable between 1200 and 38400 bits per second.
 - 3) Line parameters of 1 start bit, 8 data bits, no parity, and no flow control.
 - c. Console: RS-232 operation for PC communications.
 - d. Ethernet
 - 1) IEEE 802.3/802.3u 10/100Mbps Ethernet.
 - 2) Auto-negotiation of speed/duplex operation according to IEEE 802.3ab.
3. Network Communication
- a. Provide a fully functional IP stack and interface that is both standards compliant and consistent with established practices. IP stack must include TCP (per RFC 793), UDP (per RFC 768), IGMPv2 (per RFC 2236), ARP (per RFC 826), ICMP (per RFC 792), SNMP (per RFC 1157), and unicast/broadcast/multicast support.
 - b. Provide statically configurable IP address, subnet netmask, and default gateway.
 - c. Provide support for managing the following network communication parameters via the Local Management functionality required herein.
 - IP Address
 - Subnet Mask
 - Default Gateway
4. Video Encoding and Streaming
- a. Encode video input using ISO/IEC 14496-2:2004/Amd.2:2005 MPEG-4 Part 2 Simple Profile Level 5 or ISO/IEC 14496-2:2004 MPEG-4 Part 2 Advanced Simple Profile Level 5.
 - b. Support streaming via RTP (per RFC 3550) to configurable unicast or multicast address and port.
 - c. Support configurable multicast time-to-live (TTL) parameter.
 - d. Maintain 4:3 frame aspect ratio.
 - e. Support the following simultaneous settings:
 - Minimum encoded image resolution of 704x480
 - 30 frames-per-second frame rate
 - I-to-P (group of pictures) ratio of 1:30
 - 4Mbps encoding bit rate
 - Constant bit rate encoding or constrained variable bit rate encoding

- f. Support access to SDP file (per RFC 4566) matching current stream configuration via HTTP (per RFC2616), RTSP (per RFC 2336), or SAP (per RFC 2974).
 - g. Upon loss of sync on the video input, continue streaming with a solid black image or some indication of “video loss” other than interrupting the stream.
 - h. Any on-screen text or title overlay features shall be configurable to be fully disabled.
 - i. Provide maximum encoding and transmission latency of 300 milliseconds with minimal transmission jitter and no video image degradation or transmission interruptions.
 - j. RTP packet stream’s timestamp is derived from the encoder’s 90KHz clock reference. Reference clock must be synchronized with the actual wall-clock time and the MPEG4 stream, with no noticeable clock drift, for an interval of at least one (1) hour.
 - k. Provide support for managing the following video streaming parameters via the Remote Management functionality required herein.
 - Target address and port
 - TTL parameter
 - Resolution
 - Frame rate
 - I/P ratio
 - Encoding bit rate
 - On-screen text or title overlay features
5. Serial Data Communication
- a. Support network/serial data pass-through operation via UDP or TCP.
 - b. Pass traffic between the UDP/TCP port and the serial data port without modifying the payload, defined as raw pass-through with no TELNET or other character escaping.
 - c. Support configurable TCP or UDP listener port number.
 - d. UDP network/serial data pass-through implementation shall not require pre-configuration of the IP address for return traffic from an attached serial device. Forwarding incoming serial data to the originating source address and port of the most recently received UDP pass-through traffic is an acceptable implementation.
 - e. TCP network/serial data pass-through implementation shall include a method of automatic network fault recovery initiated by the encoder in 60 seconds or less. TCP keepalives with configurable parameters for inactivity period, number of probes to send, and probe timeout interval is an acceptable implementation.
 - f. Provide support for managing the following serial data parameters via the Remote Management functionality required herein:
 - Serial data line parameters including baud rate, parity, data and stop bits, and flow control.
 - Network protocol (TCP or UDP) and port number
6. Management
- a. Local Management
 - 1) Provide a command-line interface on the console port.
 - 2) Support configuration via the local management interface of the parameter groups detailed in the following sections:
 - Network Communication
 - Administrative Security
 - b. Remote Management
 - 1) Configuration

- a) Support remote configuration using either the SNMP Agent required herein or a documented and programmatically parsible file accessible for upload and download via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or HTTP server.
 - b) No manufacturer-sourced configuration utilities, applications, or drivers shall be required to configure the encoder.
 - c) Support interactive remote management interface using one or more of the following:
 - Command-line interface via TELNET and/or SSH
 - Embedded HTTP server
 - d) Support configuration of all settings in the following parameter groups via the remote management interface(s).
 - Video Encoding and Streaming
 - Serial Data
 - SNMP Agent
 - SNMP Traps
- 2) SNMP Agent
- a) Provide an SNMPv1 agent accessible on UDP port 161 over the network interface per RFC 1157.
 - b) Support separate configurable read-only and read-write community strings.
 - c) Provide the standard MIB-II objects per RFC 1213.
 - d) Provide the following data in MIB-II object "sysDescr":
 - Manufacturer name
 - Manufacturer model number
 - Manufacturer part number
 - Version identifiers for hardware and firmware components
 - e) Provide the following information via SNMP; using vendor-specific MIB object(s) when necessary:
 - Video Status – whether sync is detected in the video input or not
 - f) Furnish list of all industry standard MIBs that are supported.
 - g) Furnish properly formatted MIB files detailing all vendor-specific objects supported. All MIB files should conform to RFC 1155 and RFC 1212.
 - h) Provide support for managing the following SNMP Agent parameters via both the Local and Remote Management interfaces required herein.
 - Read-only and read-write community strings
- 3) SNMP Traps
- a) Provide support for transmitting SNMPv1 traps over the network interface to UDP port 162 on configured receivers per RFC 1157 and RFC 1215.
 - b) Support a minimum of four (4) configurable trap receivers with corresponding IP addresses and community strings.
 - c) Provide traps reporting changes in the state of the video input sync (i.e. video input sync lost, video input sync restored).
 - d) Furnish list of all industry standard traps that are supported.
 - e) Furnish properly formatted MIB files detailing all vendor-specific trap objects supported. All MIB files should conform to RFC 1155 and RFC 1212.

- f) Provide support for managing the following SNMP Trap parameters via both the Local Management and Remote Management interfaces required herein.
 - Trap receiver IP addresses and corresponding community strings.
- c. Firmware Updates
 - 1) Provide firmware update mechanism via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or HTTP server.
No manufacturer-sourced firmware update utilities, applications, or drivers shall be required to perform firmware updates.
 - 2) Provide password protection for firmware update mechanism or support for enabling and disabling the mechanism if the protocol doesn't support authentication (i.e. embedded TFTP server).
 - 3) Provide support for managing the following firmware update parameters via both the Local Management and Remote Management interfaces required herein.
 - Enable/disable insecure firmware update mechanism
- d. Administrative Security
 - 1) Provide administrative access control via a configurable password.
 - 2) Provide support for managing the following administrative security parameters via both the Local Management and Remote Management interfaces required herein.
 - Administrative password
- e. Factory Reset
 - 1) Provide mechanism of resetting the device to a known and documented factory default configuration.
 - 2) Prior knowledge of the current administrative password or current network configuration shall not be necessary to reset the unit to the factory default configuration.
 - 3) Opening the encoder case or enclosure shall not be necessary to reset the unit to the factory default configuration.
- f. LED Indicators
Provide separate LED indicators on the exterior of the unit indicating:
 - Power
 - Video input status (video input sync detected or not detected)
 - Network link status and activity

B. Video Encoder, Type C

Video Encoder, Type C is a high density encoder unit for multiple video signals, with one encoder per video signal, suitable for control center use.

1. General

a. Chassis

- 1) Furnish rack-mountable units.
- 2) Rack-mountable units shall include integrated brackets for mounting in standard EIA 19-inch rack rack-mountings, and shall be no more than one (1) rack unit (1.75 inches (45 mm)) high and 13 in. (330 mm) deep.
- 3) High density rack-mountable units are either self-contained, or a card/module-based chassis cage with individual encoders.
- 4) Furnish a high-density modular chassis cage when card/module-based encoders units are used.
- 5) High density rack-mountable units shall hold a minimum of eight (8) individual encoders.

- b. Labeling and Identification
 - 1) Provide external silk-screened markings for all connectors, indicators, switches, and replaceable components.
 - 2) Provide external labeling on the front or rear enclosure face for the manufacturer's name, product, model and part numbers, revision numbers, serial number, and MAC address(es).
 - c. Environmental
 - 1) Operating temperature of 32 degrees F (0 C) to 113 degrees F (45 C) with relative humidity between 20% to 80% non-condensing.
 - d. Power
 - 1) Nominal power input voltage of 120 VAC.
 - 2) If external power supplies are used, they shall fit into the allotted space for the high density unit, and shall meet the same operating temperature and relative humidity requirements.
 - 3) High density unit shall be powered from a single power connection.
 - e. Connectors
 - 1) Video Inputs: Multiple BNC connectors with gold-plated center sockets.
 - 2) Network: Single network connection, RJ-45 jack
 - 3) Power: Single power connection, NEMA 5-15 plug
2. Interfaces
- a. Video Inputs: 1 input for each video signal, color NTSC signal, 1 volt peak-to-peak.
 - b. Ethernet
 - 1) IEEE 802.3/802.3u 10/100Mbps Ethernet.
 - 2) Auto-negotiation of speed/duplex operation according to IEEE 802.3ab.
 - 3) High density unit shall be connected with a single network cable connection.
3. Network Communication
- a. Provide a fully functional IP stack and interface, on a per encoder unit or per high density unit basis, that is both standards compliant and consistent with established practices. IP stack must include TCP (per RFC 793), UDP (per RFC 768), IGMPv2 (per RFC 2236), ARP (per RFC 826), ICMP (per RFC 792), SNMP (per RFC 1157), and unicast/broadcast/multicast support.
 - b. Provide statically configurable IP address, subnet netmask, and default gateway.
 - c. Provide support for managing the following network communication parameters via the Local Management functionality required herein.
 - IP Address
 - Subnet Mask
 - Default Gateway
4. Video Encoding and Streaming
- a. For each video input, encode video input using ISO/IEC 14496-2:2004/Amd.2:2005 MPEG-4 Part 2 Simple Profile Level 5 or ISO/IEC 14496-2:2004 MPEG-4 Part 2 Advanced Simple Profile Level 5.
 - b. Support streaming via RTP (per RFC 3550) to configurable unicast or multicast address and port.
 - c. Support configurable multicast time-to-live (TTL) parameter.
 - d. Maintain 4:3 frame aspect ratio.
 - e. Support the following simultaneous settings on all encoder inputs:

- Minimum encoded image resolution of 704x480
 - 30 frames-per-second frame rate
 - I-to-P (group of pictures) ratio of 1:30
 - 4Mbps encoding bit rate
 - Constant bit rate encoding or constrained variable bit rate encoding
- f. Support access to SDP file (per RFC 4566) matching current stream configuration via HTTP (per RFC2616), RTSP (per RFC 2336), or SAP (per RFC 2974).
 - g. Upon loss of sync on a video input, continue streaming with a solid black image or some indication of “video loss” other than interrupting the stream.
 - h. Any on-screen text or title overlay features shall be configurable to be fully disabled.
 - i. Provide maximum encoding and transmission latency of 300 milliseconds with minimal transmission jitter and no video image degradation or transmission interruptions.
 - j. RTP packet stream’s timestamp is derived from the encoder’s 90KHz clock reference. Reference clock must be synchronized with the actual wall-clock time and the MPEG4 stream, with no noticeable clock drift, for an interval of at least one (1) hour.
 - k. Provide support for managing the following video streaming parameters via the Remote Management functionality required herein.
 - Target address and port
 - TTL parameter
 - Resolution
 - Frame rate
 - I/P ratio
 - Encoding bit rate
 - On-screen text or title overlay features
 - l. Video parameters for each encoder input shall be individually configurable.
 - m. Encoders shall provide a method of reporting video input sync status via an SNMP Agent or HTTP server.

5. Management

a. Local Management

Provide a command-line or HTTP server interface for configuring the parameter groups detailed in the following sections:

- Network Communication
- Administrative Security

b. Remote Management

1) Configuration

- a) Support remote configuration using either the SNMP Agent required herein or a documented and programmatically parsible file accessible for upload and download via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or HTTP server.
- b) No manufacturer-sourced configuration utilities, applications, or drivers shall be required to configure the encoders.
- c) Support interactive remote management interface using one or more of the following:
 - Command-line interface via TELNET and/or SSH
 - Embedded HTTP server

- d) Support configuration of all settings in the following parameter groups via the remote management interface(s).
 - Video Encoding and Streaming
 - SNMP Agent
- 2) SNMP Agent
 - a) Provide an SNMPv1 agent accessible on UDP port 161 over the network interface per RFC 1157.
 - b) Support separate configurable read-only and read-write community strings.
 - c) Provide the standard MIB-II objects per RFC 1213.
 - d) Provide the following data in MIB-II object "sysDescr":
 - Manufacturer name
 - Manufacturer model number
 - Manufacturer part number
 - Version identifiers for hardware and firmware components
 - e) Furnish list of all industry standard MIBs that are supported.
 - f) Furnish properly formatted MIB files detailing all vendor-specific objects supported. All MIB files should conform to RFC 1155 and RFC 1212.
 - g) Provide support for managing the following SNMP Agent parameters via both the Local and Remote Management interfaces required herein.
 - Read-only and read-write community strings
- c. Firmware Updates
 - 1) Provide firmware update mechanism via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or IHTTP server.
 - 2) No manufacturer-sourced firmware update utilities, applications, or drivers shall be required to perform firmware updates.
 - 3) Provide password protection for firmware update mechanism or support for enabling and disabling the mechanism if the protocol doesn't support authentication (i.e. embedded TFTP server).
 - 4) Provide support for managing the following firmware update parameters via both the Local Management and Remote Management interfaces required herein.
 - Enable/disable insecure firmware update mechanism
- d. Administrative Security
 - 1) Provide administrative access control via a configurable password.
 - 2) Provide support for managing the following administrative security parameters via both the Local Management and Remote Management interfaces required herein.
 - Administrative password
- e. Factory Reset
 - 1) Provide mechanism of resetting the device to a known and documented factory default configuration.
 - 2) Prior knowledge of the current administrative password or current network configuration shall not be necessary to reset the unit to the factory default configuration.
 - 3) Opening the encoder case or enclosure shall not be necessary to reset the unit to the factory default configuration.
- f. LED Indicators

Provide separate LED indicators on the exterior of the unit indicating:

- Power
- Network link status and activity

939.2.10 Video Decoder (All Types)

A. Video Decoder, Type B

Video Decoder, Type B is a standalone decoder for a single RTP video stream, suitable for dedicated point-to-point analog video transport links, or viewing encoded video on a single monitor.

1. General

a. Chassis

- 1) Furnish rack-mountable or shelf-mountable units.
- 2) Rack-mountable units shall include integrated brackets for mounting in standard EIA 19-inch rack rack-mountings, and shall be no more than one (1) rack unit (1.75 inches (45 mm)) high and 13 in. (330 mm) deep.
- 3) Shelf-mountable units shall be no more than 3.5 in. (89 mm) (H) x 9 in. (229 mm) (W) x 11 in. (280 mm) (D), and shall include a perforated ventilated shelf for mounting in a standard EIA 19-inch rack, no more than 13 inches (330 mm) deep with mounting flanges of two (2) rack units (3.5 in. (89 mm)) and a minimum 20 lb (9 kg) load rating.

b. Labeling and Identification

- 1) Provide external silk-screened markings for all connectors, indicators, switches, and replaceable components.
- 2) Provide external labeling on the front or rear enclosure face for the manufacturer's name, product, model and part numbers, revision numbers, serial number, and MAC address.

c. Environmental

- 1) Operating temperature of -30 degrees F (-34 C) to 165 degrees F (74 C) with relative humidity between 10% to 90% non-condensing.
- 2) Ventilation fans are not permitted.

d. Power

- 1) Nominal power input voltage of 120 VAC.
- 2) Maximum power consumption of 20 watts.
- 3) If external power supplies are used, they shall fit into the allotted space for the decoder, and shall meet the same operating temperature and relative humidity requirements.

e. Connectors

- 1) Video Output: BNC connector with gold-plated center socket.
- 2) Network: RJ-45 jack
- 3) Console: Female 9-pin D-subminiature (DE-9F) connector for RS-232 DCE (data circuit equipment) console interface compliant with TIA-574. If decoder housing has a connector interface other than DE-9F, furnish an adapter cable (no greater than 1 m in length) with the required DE-9F connector for each decoder and labeled "CONSOLE".
- 4) Power: NEMA 5-15 plug

2. Interfaces

- a. Video Output: Color NTSC signal, 1 volt peak-to-peak.
- b. Console: RS-232 operation for PC communications.

- c. Ethernet
 - 1) IEEE 802.3/802.3u 10/100Mbps Ethernet.
 - 2) Auto-negotiation of speed/duplex operation according to IEEE 802.3ab.
3. Network Communication
- a. Provide a fully functional IP stack and interface that is both standards compliant and consistent with established practices. IP stack must include TCP (per RFC 793), UDP (per RFC 768), IGMPv2 (per RFC 2236), ARP (per RFC 826), ICMP (per RFC 792), SNMP (per RFC 1157), and unicast/broadcast/multicast support.
 - b. Provide statically configurable IP address, subnet netmask, and default gateway.
 - c. Provide support for managing the following network communication parameters via the Local Management functionality required herein.
 - IP Address
 - Subnet Mask
 - Default Gateway
4. Video Decoding and Streaming
- a. For each video output, decode video streams that are compliant to all of the following ISO/IEC 14496-2:2004/Amd.2:2005 MPEG-4 Part 2 profiles:
 - Simple Profile Level 0 (QCIF)
 - Simple Profile Level 1 (QCIF)
 - Simple Profile Level 2 (CIF)
 - Simple Profile Level 3 (CIF)
 - Simple Profile Level 5 (D1)
 - Advanced Simple Profile Level 0 (QCIF)
 - Advanced Simple Profile Level 1 (QCIF)
 - Advanced Simple Profile Level 2 (CIF)
 - Advanced Simple Profile Level 3 (CIF)
 - Advanced Simple Profile Level 4 (CIF)
 - Advanced Simple Profile Level 5 (D1)
 - b. Support streaming via RTP (per RFC 3550) to configurable unicast or multicast address and port.
 - c. Maintain 4:3 frame aspect ratio.
 - d. Support for the following resolutions, scaled to the proper aspect ratio:
 - D1 (720x480)
 - 4CIF (704x480)
 - CIF (352x240)
 - QCIF (176x120, 176x112, 160x120, 160x112)
 - e. Support the following simultaneous capabilities on the decoder output:
 - 30 frames-per-second frame rate
 - I-to-P (group of pictures) ratio from 1:1 to 1:30
 - Up to 4Mbps encoding bit rate
 - Automatic adjustment to stream format changes

- Switch between RTP streams on different addresses and port numbers and resynchronize with the new stream within 3 I-frames.
- f. Upon loss of video stream, output an indication in the video image that the video stream was lost.
 - g. Any on-screen text or title overlay features shall be configurable to be fully disabled.
 - h. Provide maximum decoding latency of 300 milliseconds with minimal transmission jitter and no video image degradation or transmission interruptions.
 - i. Decoded video must remain synchronized with the RTP packet stream with no noticeable drift for an interval of at least one (1) hour. RTP packet stream is derived from a 90 KHz clock reference.
 - j. Provide support for managing the following video streaming parameters via the Remote Management functionality required herein.
 - Unicast or multicast stream selection
 - Target address (for multicast sources)
 - Target port
5. Management
- a. Local Management
 - 1) Provide a command-line interface on the console port.
 - 2) Support configuration via the local management interface of the parameter groups detailed in the following sections:
 - Network Communication
 - Administrative Security
 - b. Remote Management
 - 1) Configuration
 - a) Support remote configuration using either the SNMP Agent required herein or a documented and programmatically parsible file accessible for upload and download via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or HTTP server.
 - b) No manufacturer-sourced configuration utilities, applications, or drivers shall be required to configure the decoder.
 - c) Support interactive remote management interface using one or more of the following:
 - Command-line interface via TELNET and/or SSH
 - Embedded HTTP server
 - d) Support configuration of all settings in the following parameter groups via the remote management interface(s).
 - Video Decoding and Streaming
 - SNMP Agent
 - SNMP Traps
 - 2) SNMP Agent
 - a) Provide an SNMPv1 agent accessible on UDP port 161 over the network interface per RFC 1157.
 - b) Support separate configurable read-only and read-write community strings.
 - c) Provide the standard MIB-II objects per RFC 1213.
 - d) Provide the following data in MIB-II object "sysDescr":
 - Manufacturer name

- Manufacturer model number
 - Manufacturer part number
 - Version identifiers for hardware and firmware components
- e) Furnish list of all industry standard MIBs that are supported.
- f) Furnish properly formatted MIB files detailing all vendor-specific objects supported. All MIB files should conform to RFC 1155 and RFC 1212.
- g) Provide support for managing the following SNMP Agent parameters via both the Local and Remote Management interfaces required herein.
- Read-only and read-write community strings
- 3) SNMP Traps
- a) Provide support for transmitting SNMPv1 traps over the network interface to UDP port 162 on configured receivers per RFC 1157 and RFC 1215.
- b) Support a minimum of four (4) configurable trap receivers with corresponding IP addresses and community strings.
- c) Provide traps reporting changes in the state of the video input sync (i.e. video input sync lost, video input sync restored).
- d) Furnish list of all industry standard traps that are supported.
- e) Furnish properly formatted MIB files detailing all vendor-specific trap objects supported. All MIB files should conform to RFC 1155 and RFC 1212.
- f) Provide support for managing the following SNMP Trap parameters via both the Local Management and Remote Management interfaces required herein.
- Trap receiver IP addresses and corresponding community strings.
- c. Firmware Updates
- 1) Provide firmware update mechanism via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or HTTP server.
- 2) No manufacturer-sourced firmware update utilities, applications, or drivers shall be required to perform firmware updates.
- 3) Provide password protection for firmware update mechanism or support for enabling and disabling the mechanism if the protocol doesn't support authentication (i.e. embedded TFTP server).
- 4) Provide support for managing the following firmware update parameters via both the Local Management and Remote Management interfaces required herein.
- Enable/disable insecure firmware update mechanism
- d. Administrative Security
- 1) Provide administrative access control via a configurable password.
- 2) Provide support for managing the following administrative security parameters via both the Local Management and Remote Management interfaces required herein.
- Administrative password
- e. Factory Reset
- 1) Provide mechanism of resetting the device to a known and documented factory default configuration.
- 2) Prior knowledge of the current administrative password or current network configuration shall not be necessary to reset the unit to the factory default configuration.

- 3) Opening the decoder case or enclosure shall not be necessary to reset the unit to the factory default configuration.
- f. LED Indicators
- Provide separate LED indicators on the exterior of the unit indicating:
- Power
 - Video stream status (video stream detected or not detected)
 - Network link status and activity

B. Video Decoder, Type C

Video Decoder, Type C is a high density decoder unit to decode multiple RTP video streams and display them on analog video outputs, with one output per video stream, suitable for control center use.

1. General

a. Chassis

- 1) Furnish rack-mountable units.
- 2) Rack-mountable units shall include integrated brackets for mounting in standard EIA 19-inch rack rack-mountings, and shall be no more than five (5) rack units (8.75 inches (223 mm)) high and 13 in. (330 mm) deep.
- 3) High density rack-mountable units are either self-contained, or a card/module-based chassis cage with individual decoders.
- 4) Furnish a high-density modular chassis cage when card/module-based decoder units are used.
- 5) High density rack-mountable units shall hold a minimum of twelve (12) individual decoders.

b. Labeling and Identification

- 1) Provide external silk-screened markings for all connectors, indicators, switches, and replaceable components.
- 2) Provide external labeling on the front or rear enclosure face for the manufacturer's name, product, model and part numbers, revision numbers, serial number, and MAC address(es).

c. Environmental

- 1) Operating temperature of 32 degrees F (0 C) to 113 degrees F (45 C) with relative humidity between 20% to 80% non-condensing.

d. Power

- 1) Nominal power input voltage of 120 VAC.
- 2) If external power supplies are used, they shall fit into the allotted space for the high density unit, and shall meet the same operating temperature and relative humidity requirements.
- 3) High density unit shall be powered from a single power connection.

e. Connectors

- 1) Video Outputs: Multiple BNC connectors with gold-plated center sockets.
- 2) Network: Single or multiple network connection(s), RJ-45 jack(s)
- 3) Console: Single or multiple console ports using female 9-pin D-subminiature (DE-9F) connector for RS-232 DCE (data circuit equipment) console interface compliant with TIA-574. If encoder housing has a connector interface other than DE-9F, furnish an adapter cable (no greater than 1m in length) with the required DE-9F connector for each encoder and labeled "CONSOLE".
- 4) Power: Single power connection, NEMA 5-15 plug

2. Interfaces

- a. Video Outputs: 1 output for each video signal, color NTSC signal, 1 volt peak-to-peak.
 - b. Console: RS-232 operation for PC communications.
 - c. Ethernet
 - 1) IEEE 802.3/802.3u 10/100Mbps Ethernet.
 - 2) Auto-negotiation of speed/duplex operation according to IEEE 802.3ab.
3. Network Communication
- a. Provide a fully functional IP stack and interface, on a per decoder unit or per high density unit basis, that is both standards compliant and consistent with established practices. IP stack must include TCP (per RFC 793), UDP (per RFC 768), IGMPv2 (per RFC 2236), ARP (per RFC 826), ICMP (per RFC 792), SNMP (per RFC 1157), and unicast/broadcast/multicast support.
 - b. Provide statically configurable IP address, subnet netmask, and default gateway.
 - c. Provide support for managing the following network communication parameters via the Local Management functionality required herein.
 - IP Address
 - Subnet Mask
 - Default Gateway
4. Video Decoding and Streaming
- a. For each video output, decode video streams that are compliant to all of the following ISO/IEC 14496-2:2004/Amd.2:2005 MPEG-4 Part 2 profiles:
 - Simple Profile Level 0 (QCIF)
 - Simple Profile Level 1 (QCIF)
 - Simple Profile Level 2 (CIF)
 - Simple Profile Level 3 (CIF)
 - Simple Profile Level 5 (D1)
 - Advanced Simple Profile Level 0 (QCIF)
 - Advanced Simple Profile Level 1 (QCIF)
 - Advanced Simple Profile Level 2 (CIF)
 - Advanced Simple Profile Level 3 (CIF)
 - Advanced Simple Profile Level 4 (CIF)
 - Advanced Simple Profile Level 5 (D1)
 - b. Support RTP (per RFC 3550) stream decoding from configurable unicast port, or multicast address and port.
 - c. Maintain 4:3 frame aspect ratio.
 - d. Support for the following resolutions, scaled to the proper aspect ratio:
 - D1 (720x480)
 - 4CIF (704x480)
 - CIF (352x240)
 - QCIF (176x120, 176x112, 160x120, 160x112)
 - e. Support the following simultaneous capabilities on all decoder outputs:
 - Up to 30 frames-per-second frame rate
 - I-to-P (group of pictures) ratio from 1:1 to 1:30

- Up to 4Mbps encoding bit rate
 - Automatic adjustment to stream format changes
 - Switch between RTP streams on different addresses and port numbers and resynchronize with the new stream within 3 I-frames.
- f. Upon loss of video stream, output an indication in the video image that the video stream was lost.
- g. Any on-screen text or title overlay features shall be configurable to be fully disabled.
- h. Provide maximum decoding latency of 300 milliseconds with minimal transmission jitter and no video image degradation or transmission interruptions.
- i. Decoded video must remain synchronized with the RTP packet stream with no noticeable drift for an interval of at least one (1) hour. RTP packet stream is derived from a 90KHz clock reference.
- j. Provide support for managing the following video streaming parameters via the Remote Management functionality required herein.
- Unicast or multicast stream selection
 - Target address (for multicast sources)
 - Target port
- k. Video parameters for each decoder shall be individually configurable.
5. Management
- a. Local Management
- 1) Provide a command-line interface on the console port.
 - 2) Support configuration via the local management interface of the parameter groups detailed in the following sections:
 - Network Communication
 - Administrative Security
- b. Remote Management
- 1) Configuration
 - a) Support remote configuration using either the SNMP Agent required herein or a documented and programmatically parsible file accessible for upload and download via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or HTTP server.
 - b) No manufacturer-sourced configuration utilities, applications, or drivers shall be required to configure the decoders.
 - c) Support interactive remote management interface using one or more of the following:
 - Command-line interface via TELNET and/or SSH
 - Embedded HTTP server
 - d) Support configuration of all settings in the following parameter groups via the remote management interface(s).
 - Video Decoding and Streaming
 - SNMP Agent
 - SNMP Traps
 - 2) SNMP Agent
 - a) Provide an SNMPv1 agent accessible on UDP port 161 over the network interface per RFC 1157.
 - b) Support separate configurable read-only and read-write community strings.

- c) Provide the standard MIB-II objects per RFC 1213.
 - d) Provide the following data in MIB-II object "sysDescr":
 - Manufacturer name
 - Manufacturer model number
 - Manufacturer part number
 - Version identifiers for hardware and firmware components
 - e) Furnish list of all industry standard MIBs that are supported.
 - f) Furnish properly formatted MIB files detailing all vendor-specific objects supported. All MIB files should conform to RFC 1155 and RFC 1212.
 - g) Provide support for managing the following SNMP Agent parameters via both the Local and Remote Management interfaces required herein.
 - Read-only and read-write community strings
- 3) SNMP Traps
- a) Provide support for transmitting SNMPv1 traps over the network interface to UDP port 162 on configured receivers per RFC 1157 and RFC 1215.
 - b) Support a minimum of four (4) configurable trap receivers with corresponding IP addresses and community strings.
 - c) Provide traps reporting changes in the state of the video input sync (i.e. video input sync lost, video input sync restored).
 - d) Furnish list of all industry standard traps that are supported.
 - e) Furnish properly formatted MIB files detailing all vendor-specific trap objects supported. All MIB files should conform to RFC 1155 and RFC 1212.
 - f) Provide support for managing the following SNMP Trap parameters via both the Local Management and Remote Management interfaces required herein.
 - Trap receiver IP addresses and corresponding community strings.
- c. Firmware Updates
- 1) Provide firmware update mechanism via embedded FTP or TFTP client, TFTP server, SSH/SCP server, or HTTP server.
 - 2) No manufacturer-sourced firmware update utilities, applications, or drivers shall be required to perform firmware updates.
 - 3) Provide password protection for firmware update mechanism or support for enabling and disabling the mechanism if the protocol doesn't support authentication (i.e. embedded TFTP server).
 - 4) Provide support for managing the following firmware update parameters via both the Local Management and Remote Management interfaces required herein.
 - Enable/disable insecure firmware update mechanism
- d. Administrative Security
- 1) Provide administrative access control via a configurable password.
 - 2) Provide support for managing the following administrative security parameters via both the Local Management and Remote Management interfaces required herein.
 - Administrative password
- e. Factory Reset
- 1) Provide mechanism of resetting the device to a known and documented factory default configuration.

- 2) Prior knowledge of the current administrative password or current network configuration shall not be necessary to reset the unit to the factory default configuration.
 - 3) Opening the encoder case or enclosure shall not be necessary to reset the unit to the factory default configuration.
- f. LED Indicators

Provide separate LED indicators on the exterior of the unit indicating:

- Power
- Video stream status (video stream detected or not detected)
- Network link status and activity

939.2.11 Equipment Rack

Provide equipment racks as applicable and required within the equipment cabinets as specified herein.

939.2.12 Equipment Frame

Provide equipment frames meeting the following requirements:

- Overall dimensions of approximately 84" (210 mm) high by 20.25" (514.4 mm) wide and meeting EIA standards for mounting 19" (480 mm) equipment.
- Equipment frame upright channels fabricated from 6061-T6 aluminum extrusions with minimum depth of 5.75" (146 mm), flange thickness of 0.19" (4.8 mm) and web thickness of 0.16" (4.1 mm).
- Fully assembled frames, with all mounting and accessories as required herein, that comply with Telcordia GR-63-CORE Network Equipment Building System Seismic Zone Rating 4..
- Equipment frame upright channels manufactured with threaded #12-24 mounting holes of entire channel length front and rear with standard EIA spacing. Do not use non-threaded clearance holes with separate "clip nuts".
- Provide front and rear mounting base angles fabricated from 6061-T6 aluminum extrusions with minimum 6" (150 mm) footing extension. Secure base angles to floor with a minimum of four 0.625 threaded expansion anchor bolts with steel or brass expansion sleeves. Do not use any other type of anchor.
- Provide front and rear top angles fabricated from 6061-T6 aluminum extrusions with minimum 1.5" (38 mm) by 2.0" (51 mm) web.
- Provide a front-mounted lower guard-rail fabricated from minimum 0.25" (6.4 mm) by 2.0" (51 mm) bar stock with 6.0" (150 mm) to 7.0" (180 mm) standoff from the upright channel.

Provide vertical cable management ducts in between all equipment frames and at each end of a row of equipment frames. Provide a vertical cable management duct on each side of a single equipment frame. Use vertical cable management ducts that reach from the bottom of the equipment frame fully to the top of the frame and that connect with the cable (fiber optic jumper) management ducts installed in the hub's cable runways. Use ducts that are double-sided, opening to the front and rear of the equipment frames, with each side having the minimum inside dimensions of 3.5" (89 mm) wide by 6.25" (159 mm) deep. Provide plastic or rubber grommets openings, between the two sides of the duct, with a minimum opening of 2" (50 mm) and a maximum spacing of 12" (300 mm). On the front-opening of each side of the duct, provide positive cable restraint through opening latches or removable covers.

- For all assembly or fastening hardware use zinc-plated steel, nickel-plated brass, or stainless steel unless otherwise specified.
- Use a black color finish on upright channels, top and base angles, and lower guard rails.
- With each equipment frame provide a minimum of 50 #12-24 x 0.75" (19 mm) (minimum) cuphead phillips-slot mounting screws with pilot points and nylon washers. Use zinc-plated steel, nickel-plated brass, or stainless steel screws. Provide more screws if necessary to properly mount all equipment as shown in the Plans.

- Provide a rear-mounted, 20-amp, 10-receptacle power strip secured with a minimum of four rigid standoff brackets. Do not use threaded bolts or rods as standoff brackets.
- Provide a sliding drawer that is an aluminum storage compartment mounted in each frame with the approximate following dimensions: 1.75 in (44.4 mm) (H) x 16 in (410 mm) (W) x 14 in (360 mm) (D). Ensure the compartment has telescoping drawer guides to allow full extension from the equipment frame upright channels. When extended, the storage compartment shall open to provide storage space for documentation and other miscellaneous items. The sliding drawer/storage compartment shall be of adequate construction to support a weight of 25 lb (11 kg) when extended. The top of the storage compartment shall have a non-slip plastic laminate attached which covers a minimum of 90% of the surface area of the top.
- Perform all assembly and installation in accordance with the equipment frame manufacturer's recommendations.

939.2.13 Dial-up Modem

As required, furnish and ensure that the dial-up modems are stand-alone modems that support programmable communication rates of 0-56,000 bps and provide fully automatic communications rate selection. Provide modems meeting the following minimum specifications:

- Modulation: V.34, V.90, V.32
- Protocol: Asynchronous and synchronous supported
- Error control: V.42
- Hayes standard AT command set
- Automatic speed buffering
- Flow control
- (2) Modular RJ-11 telephone line connectors
- Modular DB-25 RS-232C serial interface connector
- LED indicators for TX, RX, RTS, DCD, PWR

A. Equipment Cabinet Assembly

Ensure that all cabinets exhibit a smooth, uniform natural aluminum finish.

All bolts, nuts, washers, screws, hinges and hinge pins shall be stainless steel.

Manufacture the exterior mounting bracket and fixtures of aluminum or galvanized steel, and manufacture all fastening and mounting hardware of stainless steel. Verify that the bottom of the pole-mounted cabinet is fully enclosed. Where base-mounting of equipment cabinets is specified, the cabinet bottom shall be open.

Verify that all electrical cables between the cabinet and the device are UL-listed tray cable with #18 AWG 16-strand copper conductors with PVC/nylon insulation and a UV-resistant PVC outer jacket rated for 600V, 190 F (90 C) dry, 170 F (75 C) wet and wet/dry direct burial use. Conductor color-coding shall be in accordance with ICFE Table K.2/Method 1.

1. General

a. Standard Cabinet Housing

- 1) General Requirements: Unless otherwise specified, furnish cabinet housings that conform to the Cabinet Housing Details as defined in Chapter 6, Sections 2, 3 and 5 and the Cabinet Housing Details of the Caltrans Traffic Signal Control Equipment Specification, latest version (TSCES). The police panel and associated wiring circuits are not required as part of this cabinet assembly. All cabinets shall have hooks, welded to the inside of the front cabinet door, for hanging the plastic documentation pouch.
- 2) Unless otherwise specified in these Special Provisions or in the Plans, configure all equipment cabinet assemblies for pole mounting. The holes for pole mounting shall be properly reinforced with metal plates of adequate size and strength welded longitudinally across the inside depth of the cabinet. Where base-

mounting of equipment cabinets is specified, make the cabinet bottom open and provide an approved base mounting adapter, in accordance with the Department's Standard Specification for Traffic Signal Equipment.

- b. Type A Standard Cabinet Housing – Not Applicable
- c. Type B Standard Cabinet Housing – Not Applicable
- d. Type C Standard Cabinet Housing:
 - 1) The Type C cabinet housing (see Detail Drawings) is a standard Model 332 housing with approximate exterior dimensions of 64 in. (1.6 m) (H) x 24 in. (0.61 m) (W) x 30 in. (0.76 m) (D).
 - 2) Equip all Type C cabinet housings with the standard EIA 19-inch rack cabinet cage as described in Section 3 of the Caltrans specification. Install side panels within the two sides of the cabinet cage as shown on the Detail Drawings in this section. Each side panel shall be fabricated from 5052 sheet aluminum alloy with a minimum thickness of 0.125 in (3.175 mm).
 - 3) Equip Type C cabinet housings with a cabinet sliding drawer. Follow the drawer specifications given in Subsection 939.2.B.5.
 - 4) Provide a ground fault interrupt 15A duplex receptacle (NEMA 5-15R) in the cabinet as an accessory outlet. Install two (2) non-ground fault protected 15A equipment outlet strips, each with ten (10) receptacles. Mount the strip outlets vertically near the top of the cabinet as shown in the Detail Drawings in this section.
- e. Type D Standard Cabinet Housing:
 - 1) The Type D cabinet housing shall be a standard Model 336 stretch (336S) housing with approximate exterior dimensions of 46 in. (1.2 m) (H) x 24 in. (0.61 m) (W) x 23 in. (0.58 m) (D). The minimum door opening dimensions shall be 40.5 in. (1.03 m) (H) x 22 in. (0.56 m) (W).
 - 2) Equip all Type D cabinet housings with the standard EIA 19-inch rack cabinet cage as described in Section 3 of the Caltrans specifications and mounting panels as shown on the Detail Drawings in this section. The
 - 3) minimum clear vertical inside dimension of the rack for equipment mounting shall be 39.5 in. (1.00 m). Install side panels within the two sides of the cabinet cage. Use side panels fabricated from 5052 sheet aluminum alloy with a minimum thickness of 0.125 in (3.175 mm).
 - 4) Equip the Type D cabinet housing with a cabinet-sliding drawer. Follow the drawer specifications given in Subsection 939.2.B.5.
 - 5) Provide a ground fault interrupt 15A duplex receptacle (NEMA 5-15R) in the cabinet as an accessory outlet. Provide rack mounted power strip outlets near the top of the cabinet as shown in the Detail Drawings in this section. The power strip shall incorporate eight (8) NEMA 5-15R receptacles. The power strip receptacle shall face the back of the cabinet and shall be recessed within the cabinet rack to provide a minimum spacing of three (3) inches between the outlet's face and the cabinet door when the door is closed.
- f. Type F Standard Cabinet Housing:
 - 1) The Type F cabinet housing shall be a standard ITS Cabinet Housing #3 with approximate exterior dimensions of 67 in. (1.7 m) (H) x 44 in. (1.2 m) (W) x 26 in. (0.66 m) (D) as specified in the Caltrans Transportation Electrical Equipment Specifications, latest version and all addenda (TEES). The minimum door opening dimensions shall be 56 in. (1.4 m) (H) x 20 in. (0.51 m) (W).
 - 2) Equip all Type F cabinet housings with two standard EIA 19-inch rack cabinet cages as described in the Caltrans TEES. Equip all Type F cabinet housing with four (4) side mounting panels in the rack cabinet cages; side mounting panels shall mount from inside the rack cabinet cage only. The minimum clear vertical inside dimension of the rack for equipment mounting shall be 54.5 in. (1.4 m). Use side panels fabricated from 5052 sheet aluminum alloy with a minimum thickness of 0.125 in (3.175 mm) with minimum dimensions of 50 in (1.3 m) (H) x 21 in. (0.53 m) (W).
 - 3) Provide a minimum of four (4) wiring pass-through holes on the inside mounting panels to permit patch cords to pass between the two cabinet sides. Each pass-through hole shall be 5 in. (127 mm) in diameter

and shall be fully grommetted for patch cord protection, with the holes positioned with two (2) in the cabinet front and two (2) in the cabinet rear and aligning horizontally between the two side panels.

- 4) Provide a minimum of 16 plastic- or rubber-coated J-hooks or D-rings, minimum 1 in. (25 mm) depth and height, on the inside rails of the rack cabinet cages, to organize patch cords passing between the two cabinet sides. Install the J-hooks in horizontally-aligned pairs on the inside rails, with four (4) pairs in the cabinet front and four (4) pairs in the cabinet rear.
- 5) Equip the Type F cabinet housing with two cabinet-sliding drawers. Follow the drawer specifications given in Subsection 939.2.B.5.
- 6) Provide a ground fault interrupt 15A duplex receptacle (NEMA 5-15R) in the cabinet as an accessory outlet. Provide rack mounted power strip outlets near the top of the cabinet as shown in the Detail Drawings in this section. The power strip shall incorporate eight (8) NEMA 5-15R receptacles. The power strip receptacle shall face the back of the cabinet and shall be recessed within the cabinet rack to provide a minimum spacing of 3 in. (76 mm) between the outlet's face and the cabinet door when the door is closed.

2. Internal Cabinet Assembly Components

- a. Unless otherwise specified in the Plans or approved by the Engineer, construct all cabinet assemblies in conformance with this Subsection 939.2.B including all Detail Drawings, all applicable provisions of the Georgia DOT Standard Specifications for Traffic Signal Equipment, and applicable provisions of the Caltrans TSCES or TEES. Do not include with the cabinet assembly the power supply assembly, power distribution assembly, input file, output file, monitor unit assembly, field terminal hookup blocks, modular/serial/control bus, AC/DC power assembly and extension, and related wiring assemblies as described in the Caltrans TSCES or TEES.
- b. Provide a plastic documentation pouch to store the cabinet and equipment documentation. Use a pouch that is side-opening, resealable, opaque, and of a heavy-duty plastic material. Use a pouch that has metal or

hard-plastic reinforced holes for hanging from hooks included on the cabinet door. The pouch shall be of the size and strength to easily hold all wiring diagrams, equipment documentation and the maintenance logbook

3. Wiring, Conductors and Terminal Blocks

All 120VAC service entrance, power distribution, grounding and protection shall be provided by components mounted on 35mm DIN standard rails. Devices include, terminal blocks, circuit breakers and surge protection devices. All DIN rail mounted components will be certified to meet or exceed UL-94, UL-467, UL-489, UL-1449, IEC-947-7-1, IEC-60947-2, CSA-22.2 or as specified in the Details or special provisions.

DIN rail mounted power distribution devices supplied shall be configured as shown in the Details and shall meet or exceed the specifications and certifications listed below.

a. Mounting Rail

Use DIN rail fabricated from galvanized passivated steel with prepunched holes for mounting and certified to meet EN 50022, EN 60715 and DIN 46277-3. DIN mounting rail shall be 35mm wide, 7.5 mm high, 1 mm thick, perforated for flexible mounting and cut to length as show in the Details. Rail will cut between mounting holes to allow mounting at both ends of the rail section. Rail shall be provided burr free with no sharp edges or deformation from the standard profile. The portion of the rail at the mounting bolt holes shall be cleaned of any coating to expose the underlying steel. The area under the bolt hole and the aluminum power panel mounting point shall be covered with an anti corrosion paste to provide a solid and long lasting electrical connection between the DIN Rail and the power panel. DIN Rail shall be attached to the power panel by nut and bolt with star washers to provide a low resistance electrical connection between the rail and the power panel.

b. Terminal Blocks

Use DIN terminal blocks with voltage and current ratings greater than the voltage and current ratings of the wires that are terminated on the blocks. Metallic terminal block connection hardware and components shall be non-ferrous copper or nickel/tin-plated copper alloy or equivalent. All terminal blocks and wire shall be supplied in the colors listed below (see Detail Drawings).

- Black – Line
- White – Neutral

- Green or Green/Yellow – Ground
- c. Service Entrance Terminal Blocks
- Make the terminal block for the 120VAC cabinet service entrance (SE) a 10 mm single level screw type device. The terminal block shall accommodate #20 - 6 AWG wiring and shall be provided in colors as specified herein. The Ground terminal shall be the same size and pitch as the power terminals and shall provide positive electrical and mechanical connection to the mounting rail. Ground terminals may be provided in the color green or the international green and yellow style. Provide the quantity of terminals as shown in the Details.
- d. Distribution Terminal Blocks
- Terminal blocks for distribution of 120 VAC (TB2) and ground located on the protected side of the power distribution assembly shall be a 6 mm single level screw type device. The terminal block shall accommodate #24-8 AWG wiring and shall be provided in colors as specified herein. The Ground terminal shall be the same size and pitch as the power terminals and shall provide positive electrical and mechanical connection to the mounting rail. Ground terminals may be provided in the color green or the international green and yellow style. Provide the quantity of terminals as shown in the Details.
- e. Cross Connection Bridge
- Cross connection bridge strips shall be provided to connect a number of terminal blocks to create the specified power distribution design. The bridge strips shall match the pitch and construction of the terminals to be connected and shall be certified by the terminal block manufacturer to be compatible with the connected terminal blocks. Cross connection bridge strips shall be fully insulated to prevent operator contact. Connected terminal blocks of any number shall be connected by a single cross connection bridge strip.
- f. Circuit Breaker
- Provide circuit breakers as shown in the Detail Drawings in this section. Use only circuit breakers that are UL-489 and CSA 22.2 approved and plainly marked with trip, frame sizes and ampere rating. All circuit breakers shall be quick-make, quick-break on either automatic or manual operation. Ensure that contacts are silver alloy and enclosed in an arc-quenching chamber. Overload tripping shall not be influenced by an ambient air temperature range from -18 degrees C to 50 degrees C. Minimum interrupting capacity shall be 5,000 amperes RMS. Use only circuit breakers that are 35 mm DIN rail mounted.
- g. End Brackets
- Provide screw-clamped end brackets to positively lock all DIN rail mounted devices to the rail.
- h. Spacer
- Spacers or dividers shall be placed between terminal blocks and other components as shown in the Details for visual separation. Spacers shall snap on to DIN rail be approximately 5-18 mm thick and match the size of the terminals they separate.
- i. Safety Cover
- A safety covers shall be provided on terminal blocks to prevent contact with exposed conductors or any metallic components. This cover will provide electrical and visual separation between terminal blocks and other rail mounted devices. Covers shall be approximately 2mm thick and sized to match the terminal blocks they protect or separate.
- j. Surge Suppressor
- Provide a DIN rail mounted TVSS (Transient Voltage Surge Suppressor) with RFI/EMI filtering for AC power service to the cabinet housing. The TVSS shall provide protection from all conductors to ground and meet or exceed the following requirements and levels of protection.
- Nominal operating Voltage 120 V
 - Max. Continuous Operating Voltage 150V
 - Max. Surge Current Rating 20 kA
 - Nominal Surge Current Rating for 8x20µs surge 20 kA
 - Internal Thermal Fuses
 - Failure/ replacement indication

- Operating Temperature: -40C to 80C
- Meet UL1449 2nd Ed.,
- VDE0675-6, CSA-22.2, and CE marked

k. Wiring

Use a minimum #12 AWG grounding of each surge suppression device, or larger if recommended by the surge suppression device manufacturer or indicated in the Details. Use insulated green wire and connect the ground wire directly to the ground terminals. Do not “daisy chain” with the grounding wires of other devices including other surge suppressors. Terminate all ground wiring between cabinet surge suppressor devices on the DIN rail mounted ground terminal blocks. Dress and route grounding wires separately from all other cabinet wiring. Install grounding wires with the absolute minimum length possible between the suppressor and the ground terminals. Label all surge suppressors with silk-screened lettering on the mounting panel. Use minimum #12 AWG insulated THHN-THWN conductors between the surge suppression device and the power distribution terminal.

4. Sliding Drawer

Install drawer that is an aluminum storage compartment mounted in the rack assembly with the approximate following dimensions: 1.75 in (44.4 mm) (H) x 16 in (410 mm) (W) x 14 in (360 mm) (D). Ensure the compartment has telescoping drawer guides to allow full extension from the rack assembly. When extended, the storage compartment shall open to provide storage space for cabinet documentation and other miscellaneous items. Install a storage compartment that is of adequate construction to support a weight of 25 lb (11 kg) when extended. The top of the storage compartment shall have a non-slip plastic laminate attached which covers a minimum of 90% of the surface area of the top.

939.2.02 Delivery, Storage and Handling - Not applicable

939.3 Construction Requirements

939.3.01 Personnel

Have trained personnel available for troubleshooting and problem solving until all equipment is fully functional and ready to start the acceptance phase.

939.3.02 Equipment - Not applicable

939.3.03 Preparation

A. Network Equipment Programming

Perform network equipment programming and testing in accordance with the Network Equipment Programming Procedure below and as directed by the Engineer. Network equipment is defined as any traffic control and monitoring equipment with an Ethernet interface and includes equipment from the following GDOT Specifications and Special Provisions:

- Section 631—Changeable Message Signs
- Section 925—Traffic Signal Equipment
- Section 937—Video Detection System
- Section 938—Detection
- Section 939—Communications & Electronic Equipment

The Contractor is responsible for all steps, work and activities in the procedure below except when Department responsibility is expressly indicated. At all times, the Contractor is responsible for all equipment and materials, including while being programmed by the Department, and including operation, warranties, and technical support.

Coordinate all aspects of the procedure through the Engineer.

Perform all network equipment programming for a complete project at one time. The Contractor may request in writing for a staged equipment programming; provide a plan with schedule for the complete project that details all of the proposed stages and identifies all network equipment and field sites for each stage. If approved by the Department, the

procedure below applies independently and fully to each individual stage. Field sites will always be programmed concurrently for all of the equipment at that site.

Materials submittal reviews for all network equipment, and related equipment, shall be successfully completed prior to beginning the Network Equipment Programming Procedure.

Step 1

Request in writing for GDOT to prepare and provide the basic equipment programming data. The request shall clearly identify the project. If the Contractor desires a staged equipment programming, that request must be identified at this time and the staging plan must be submitted.

Step 2

Once the Contractor's request is complete, the Department will provide the basic equipment programming data within 45 days from the Department's acceptance of the Contractor's request. Basic equipment programming data will include the IP address, subnet, and gateway for each network device. The programming data will be provided in spreadsheet form.

Step 3

Complete installation of all field equipment, including but not limited to support poles, equipment cabinets, power service, field and network devices, and fiber communications infrastructure. Complete all basic equipment programming. Furnish Network Switch GBICs to GDOT. Furnish all fiber patch cords in the hub(s) but make no connections to the Network Switch. Provide in spreadsheet form the equipment model numbers, serial numbers, MAC addresses, and firmware revision numbers for each network equipment device in its installed location. Complete all field testing required prior to the Interim Field Subnet (IFS) test, and conduct an IFS test dry-run.

Step 4

Request in writing to begin the IFS test a minimum of 30 days in advance of the desired start date. Conduct IFS test in the presence of the Engineer. If the IFS test fails, identify the defects and make corrections, provide a written report on the diagnosis and corrections made, and request in writing an IFS retest a minimum of 14 days in advance of the desired start date.

Step 5

Upon successful and accepted completion of IFS testing, the Department will have 45 days to complete all network and system programming and NaviGator integration of the field devices and hub equipment. Continue with all remaining field construction that has no impact on any equipment or communications infrastructure associated with the network programming. Any disruption of the equipment or communications infrastructure shall result in stopping the 45 day period for Department programming.

Step 6

The Department will notify the Contractor when network programming is successfully completed, at which time the Network Equipment Programming Procedure will be considered completed. Continue with all remaining project activities, including remaining acceptance testing.

939.3.04 Fabrication

A. Cabinet Equipment and Components

Install in Types A, B, C, and D cabinet assembly one (1) fluorescent lighting fixture mounted inside the top front portion of the cabinet. Include with the fixture a cool white lamp, covered and operated by a normal power factor UL listed ballast. Install an RC network noise suppression filter in the light circuit. Install door actuated switches installed to turn on the cabinet light when either door is opened.

Install in Type F cabinet assembly four (4) fluorescent lighting fixtures mounted inside the top portions of the each cabinet side. Include with the fixture a cool white lamp, covered and operated by a normal power factor UL listed ballast. Install an RC network noise suppression filter in the light circuit. Install door actuated switches, front and rear of each door, installed to turn on all cabinet lights when any door is opened.

B. Cabinet Wiring, Conductors, and Terminal Blocks

Use two conductors per DIN terminal block (one conductor per terminal. Wire shall be stripped no longer than is necessary to provide a solid connection to the terminal block. No un-insulated wire shall be exposed at the terminal block. Number all terminal blocks, terminal strips, circuit breakers and have each item and each terminal position numbered and named according to function as shown in the "quoted labels" in the Detail Drawings. Label terminal blocks, terminal strips, and circuit breakers with silk-screened lettering on the mounting panel.

939.3.05 Construction

A. Equipment

1. Installation

- a. Install all equipment in new and/or existing equipment racks and equipment frames in accordance with the equipment manufacturer's recommendations, including mounting, interconnection wiring, and electrical service. Furnish and install all mounting hardware and incidental materials, including fasteners and auxiliary supporting frames/brackets, as recommended by the manufacturer. Furnish and install all miscellaneous hardware, materials, wiring/cabling, configuration, and any other incidental items necessary for fully operational components and subsystems shown in the Contract Documents and Section 940 of the Special Provisions, except when specifically identified as existing or as work to be performed by the Department.
- b. Work in this project may require access to various Department buildings and Hubs requiring coordination of all work activities in these locations with the Engineer before access is needed. Work in this project requires system configuration tasks to be performed by the Department before some Contractor-installed items can be brought online and completely system tested. Coordinate all work activities needing system configuration with the Engineer a minimum of 14 days prior to any testing.
- c. Install all Hub and control center equipment in the presence of the Engineer. Locate new equipment in new or existing equipment racks or equipment frames as shown in the Plans.
- d. Provide proper electrical service, including grounding and current rating, in the equipment racks and equipment frames for all hardware installed under this project. This requirement includes existing and new equipment racks and equipment frames. Obtain Engineer approval prior to installation of all electrical service for hardware in control centers. Furnish and install additional power outlet strips in new and existing equipment racks and equipment frames if needed for the new equipment.
- e. For any equipment that is not rack mountable with "rack ears", provide perforated shelves and secure all shelf-mounted equipment with rack mounting hardware.
- f. Label all wiring and cabling, including building entrance cables, jumper and patch cords, and power supply cables, using cable identification numbers as shown in the Plans or provided by the Engineer. Apply cable labels at each end and in the center of the cable. Cable labels shall consist of permanent ink printed or legibly written on self-laminating and over-wrapping label material.
- g. Protect cable ends at all times with acceptable end caps. Never subject any coaxial cable to a bend radius of less than six (6) inches. Provide grommets, guides and/or strain relief material where necessary to avoid abrasion of or excess tension on wire and cable.

2. Serial Data Terminal Server

For Hubs, install the Serial Data Terminal Servers, 16 Port, in equipment frames as shown in the Plans and in accordance with the Manufacturer's recommendations. For equipment cabinets and as required, install the Serial Data Terminal Servers, Type B, as shown in the Plans and in accordance with the Manufacturer's recommendations. Furnish and install all interconnection wiring and power service connections.

3. Patch Cords

a. General Requirements:

- 1) Use patch cords only within control center buildings, communication Hubs, and equipment cabinets.
- 2) Label all patch cords using cable identification numbers as shown in the Plans or provided by the Engineer. Apply cable labels at each end and in the center of the cable. Use printer-generated adhesive overlapping cable labels.

- 3) Neatly route, dress and secure patch cords in the equipment racks or frames and at both ends. Use all available cable management devices and/or trays. Route patch cords only vertically on the sides of the equipment racks and frames or horizontally across the bottom or top of the racks and frames; no diagonal routing is permitted. Follow all manufacturer's recommendations including bend radius requirements during all patch cord installation.
 - b. Fiber Optic Patch Cords: Furnish and install fiber optic patch cords in accordance with Section 935 and this section.
 - c. Coaxial Video Patch Cords: Where an equipment or termination facility has a connector other than BNC (such as an RCA), furnish and install a BNC adapter to connect the patch cord to the equipment or termination facility.
 - d. Data Patch Cords: Use data patch cords to connect all local area network and RS-standard (e.g., RS-232, RS-422/485) serial data termination facilities and equipment.
 - 1) Where an equipment or termination facility has a connector other than an RJ45 outlet (such as a "D-shell" connector), furnish and install RJ45 adapters between the connectors and the network/data patch cords as approved by the Department. For any type of RJ45 adapter, provide the proper pin-out of the adapter as part of the documentation.
 - e. Network Switch / Field Switch Patch Cables: Furnish and install Category-6 unshielded twisted pair (UTP)/shielded twisted pair (STP) patch cables that comply with EIA/TIA-568-A standards for all network to device interconnects (device to switch).
 - f. Voice/Telephone Patch Cords: Use voice/telephone patch cords to connect all voice or telephone communications facilities and equipment. Furnish and install the voice/telephone patch cords with the necessary pair sizing and connector for the equipment being connected.
4. Network Switch, Layer 3 Gig-E

For Hubs, furnish and install Network Switches, Layer 3 GigE that are compatible with the existing NaviGator Ethernet network as shown in the Plans, as applicable. The existing network consists of Nortel Networks 8600 Layer 3 GigE switches.

Furnish and install the network switch and all fiber optic jumper cabling necessary to connect to the fiber optic cable FDC as shown in the Plans.

5. Hub Uninterruptible Power Supply

Furnish and install a dedicated electrical service branch circuit from the Hub main service panel for the UPS system. Ensure that the UPS system branch circuit is in accordance with all recommendation of the UPS manufacturer, including the provision of a locking plug/receptacle connection. Make all electrical conduit and fittings rigid EMT or approved equivalent. Locate the branch circuit receptacle as close as possible to the UPS mounting position to minimize the UPS input line cord and to minimize tripping hazards.

Configure the electrical service inputs for all network switches, serial data terminal servers, video encoders/decoders, and video switches to be supplied by the UPS. Furnish and install line cords, power strips, and all incidental materials to configure the UPS service to the above equipment.

B. Communications Subsystem

1. General

- a. Use Network Switches, Layer 3 Gig-E, Field Switches, Serial Data Terminal Servers, and Video Encoders/Decoders, as necessary or required to establish:
 - 1) For Traffic Signals, digital data communications between local controllers and system masters and to and from Hubs and control centers
 - 2) For Ramp Meters, digital data communications to and from equipment cabinets/Hubs/control centers
 - 3) Digital camera video and control data communications to and from equipment cabinets/Hubs/control centers
 - 4) Digital CMS control data communications to and from equipment cabinets/Hubs/control centers
 - 5) Digital detector data communications to and from equipment cabinets/Hubs/control centers

- 6) Digital VDS processor control data communications to and from equipment cabinets/Hubs/control centers
- b. Furnish and install Network Switches, Layer 3 Gig-E, Field Switches, Serial Data Terminal Servers, and Video Encoders/Decoders, as necessary or required as specified in the Plans to ensure proper communications.

2. Installation Requirements

Install all communications equipment and materials necessary for a complete communications path from the field site to the control center or communications Hub as shown in the Plans. Furnish and install all mounting and interconnection materials, including but not limited to card cages, mounting panels and rack hardware, fiber, patch/jumper cables, and power supply cables. Mount card cages and mounting panels as shown in the Plans and Detail Drawings in this section. Furnish and install the type and quantity of equipment shown in the Plans. Where the Plans show that new Field Switches, Video Encoders, VDS System Processors, Modems, and/or other devices are to be placed in existing cabinet space, furnish and install compatible mounting hardware, as required.

Label all wiring and cabling, including entrance cables, jumper and patch cords, and power supply cables. Cable labels shall consist of permanent ink printed or legibly written on self-laminating and over-wrapping label material.

- a. Equipment Cabinet Mounting: All field equipment shall be mounted in a manner as to not restrict the replacement of other components in the cabinet housing.
- b. Hub/Control Center Mounting: Where data is transmitted to a receiving end such as a Hub, TCC or TMC, permanently mount the equipment as required within an equipment rack, frame.

3. Radar Dial-up Modem

Furnish and install all cabling required to connect the radar dial-up modems to the telephone lines and the radar workstation.

4. CMS Dial-up Modem

Furnish and install all cabling required to connect the CMS dial-up modems to the telephone lines and the CMS workstation.

C. Equipment Cabinet Assembly

1. General Requirements

Furnish and install the equipment cabinet assembly to include all devices/components, assembly, wiring and materials required in this Subsection 939.3.05.C and in Subsection 939.2.B.

The equipment cabinet assembly, as described below, shall conform to all applicable sections of the Caltrans specifications and Georgia DOT Standard Specifications.

2. Classification of Types

Furnish and install equipment cabinet assemblies as called for in the Plans in accordance with the following requirements for each type.

- a. Type A Cabinet – Not Applicable.
- b. Type B Cabinet – Not Applicable.
- c. Type C Cabinet: Furnish and install a Type C Cabinet that conforms with all materials and installation requirements of this Subsection 939.3.05.C and Subsection 939.2.B using a Type C Standard Cabinet Housing (see Detail Drawing in this section).
- d. Type D Cabinet: Furnish and install a Type D cabinet assembly that conforms with all materials and installation requirements of this Subsection 939.3.05.C and Subsection 939.2.B using a Type D Standard Cabinet Housing (see Detail Drawing in this section).
- e. Type F Cabinet: Furnish and install a Type F cabinet assembly that conforms with all materials and installation requirements of this Subsection 939.3.05.C and Subsection 939.2.B using a Type F Standard Cabinet Housing (see Detail Drawing in this section).

3. Identification and Documentation

Include the manufacturer's name only on the inside of the front cabinet door along with the cabinet model number, serial number, schematic wiring diagram number, and month/year of manufacture. Provide this information on a waterproof, permanently affixed label.

Identify all components of the cabinet assembly, which are mounted on panels. Make identification on the panels with permanent silk-screen or other printed labels. These components include but are not limited to terminal blocks (with all positions numbered and labeled), panel and socket mounted surge suppressors, circuit breakers, accessory and equipment outlets, and communications transmitters/transceivers.

Provide complete documentation with each cabinet. Identify all cabinet documentation, including the maintenance logbook, by field site name and system ID. Make all cabinet documentation (except that documentation contained in the maintenance logbook below) on ledger size non-fading xerographic black-on-white 20# or greater bond paper. Supply four (4) sets of schematic wiring diagrams with complete parts lists with each cabinet. Draft the diagrams in neat, workmanlike manner. The diagrams shall be completely legible at the specified paper sizes and be non-proprietary. Identify in the diagrams all circuits in a manner as to be readily interpreted. Include in the diagrams a cabinet drawing showing the equipment layout in a front and rear elevation view and front views of each of the side panels. Label all equipment on the drawings with the same identifiers as labeled on the panels themselves. Identify all cabinet electrical components and equipment and the ventilation filter on parts lists on the wiring diagrams or in the maintenance logbook. The parts lists shall include manufacturer and complete model number. Store the diagrams in the documentation pouch on the door.

Include in the cabinet documentation an equipment list and maintenance logbook. This maintenance logbook shall contain a list of all major removable equipment items in the cabinet and all major items installed outside of the cabinet including but not limited to Field Switch, Video Encoders, VDS System Processors, Modems, CCR, camera, lens, housing, and pan/tilt unit, along with manufacturer name, model, and serial numbers. Include in the equipment list in the logbook spaces to enter the communications address, system identifier, and other site-specific configuration information. The maintenance logbook shall include a minimum of five (5) blank forms for documenting site visits, including the date, time, technician name, and work performed. The maintenance logbook pages shall be standard letter size 3-hole 20# or greater white paper bound in a plastic report cover.

4. Internal Cabinet Assembly Components and Wiring

a. Cabinet Assembly Installation

- 1) Install the cabinet assembly as shown in the Plans. Provide the cabinet assembly with a grounding system in accordance with the Department's Standard Specification for Traffic Signal Equipment grounding. Measure the resistance to ground in the presence of the Engineer. Resistance to the ground cannot exceed ten (10) ohms. Do not splice the ground conductor between the cabinet grounding terminal and the ground rod. Isolate and insulate the ground conductor from any utility grounding equipment. Completely isolate the cabinet assembly grounding system from any other grounding system, including the support pole grounding system, such that there is no electrical bond between any equipment (cabinet, conduit, camera support bracket, etc.) and any other grounding system. In the case of steel support poles, it is not necessary to insulate equipment strapped to the pole.
- 2) Mount all pole mounted cabinet assemblies to the support pole at a height of 4 ft +/- 3 in (1.2 m +/- 76 mm) from ground level to the centerline of the cabinet housing. Where the Plans show base-mounted cabinets, install the cabinets in accordance with the Department's Standard Specification for Traffic Signal Equipment installations.
- 3) Enclose all cabling and wiring entering the cabinet housing in conduit. Securely and neatly dress all cabling and wiring inside the cabinet, including field wiring. Provide sufficient slack (minimum 2 ft. (600 mm)) for cabinet equipment maintenance and re-termination of the field wiring. Route fiber drop cables into the cabinet to provide as much physical protection as possible. Secure the drop cables through the cabinet, and strain-relieve them within the fiber termination unit.

b. Wiring, Conductors and Terminal Blocks:

- 1) Use stranded copper for all conductors, including those in jacketed cables, except for earth ground conductors, which may be solid copper. Neatly arrange all wiring, firmly lace or bundle it, and mechanically secure the wiring without the use of adhesive fasteners.
- 2) Route and secure all wiring and cabling to avoid sharp edges and to avoid conflicts with other equipment or cabling. Route camera control wiring, and 120VAC power wiring separately. Terminate all wiring on the DIN rail terminals. Use a minimum #12 AWG THHN-THWN for all conductors of 120VAC circuits. Install all wiring as shown in the Detail Drawings.

c. Surge Suppression:

- 1) Protect all copper wiring and cabling entering the cabinet housing, except for the earth ground conductor, by surge suppression devices as specified.
 - 2) Terminate all power supply wiring between cabinet devices and the transient surge suppressors on DIN terminal block. Use a minimum #12 AWG grounding of each surge suppression device, or larger if recommended by the surge suppression device manufacturer. Use insulated green wire and connect the ground wire directly to the ground terminal block.
 - 3) Do not "daisy chain" with the grounding wires of other devices including other surge suppressors. Dress and route grounding wires separately from all other cabinet wiring. Install grounding wires with the absolute minimum length possible between the suppressor and the ground terminal block. Label all surge suppressors with silk-screened lettering on the mounting panel.
- d. Component Installation:
- 1) All components/devices of the cabinet assembly are to be rack mounted with Phillips-head machine screws. Install screws into tapped and threaded holes in the panels. These components/devices include but are not limited to DIN rails, terminal blocks, accessory and equipment outlets, DC power supply chassis, video encoders, video processors, and field switches.
 - 2) Fasten all other cabinet components with hex-head or phillips-head machine screws installed with nuts (with locking washer or insert) or into tapped and threaded holes. These other components include but are not limited to door switches, fans, lights, thermostats, , and door lock mechanisms. Fasten stud-mounted components to a mounting bracket providing complete access to the studs and mounting nuts. All fastener heads and nuts (when used) shall be fully accessible with a complete cabinet assembly, and any component/device shall be removable without requiring removal of other components, panels, or mounting rails. Do not use self-tapping or self-threading fasteners.
5. Cables, Conduit and Power Service

Furnish and install electrical cables, conduit and power service necessary to make the system fully operational.

a. Electrical Cables:

- 1) Furnish and install electrical cables for providing electrical power service to the site and for providing telephone and/or /DSL service and/or cable service from the telephone company demarcation point to the equipment cabinet.
- 2) Furnish and install electrical cables used for power service, including grounding, in accordance with the Standard Specifications for electrical, lighting and traffic signal equipment.
- 3) Furnish and install electrical cables used for power supply as shown in the Detail Drawings. Do not splice any cable, shield or conductor used for power supply. Identify all conductors of all cables by color and number. Identify the conductor function in as-built documentation included in the cabinet documentation.
- 4) Electrical cables installed for telephone service from the telephone company demarcation point to the equipment cabinet shall be minimum #22 AWG twisted pair, UV-resistant shielded cable rated for wet/dry direct burial use. Install telephone service cable directly to or into the equipment cabinet in accordance with telephone company procedures. Install telephone service cable from the telephone company demarcation point to the equipment cabinet. Unless otherwise shown in the Plans or directed by the Engineer, install the telephone cable underground in conduit of minimum 1 in. (25 mm) diameter. Make all necessary connections at the telephone interface box and inside the equipment cabinet for proper operation of the video, control signaling and communications signaling. Neatly coil a minimum of 2 ft. (0.6 m) of telephone service cable in the bottom of the cabinet.

b. Electrical Conduit:

- 1) Install electrical conduit to provide enclosures for electrical cables at or terminating at the site. Furnish and install electrical conduit in accordance with the Standard Specifications for electrical, lighting and traffic signal equipment, and as required below.
- 2) Make all aboveground electrical conduit and conduit bodies rigid metal except as noted below. Terminate all aboveground conduit in either a weather head or in a cabinet. All conduits entering a pole-mounted equipment cabinet shall enter through the bottom with at least one conduit body with a sealable, removable cover for pulling access. All conduits entering in a base-mounted cabinet shall enter through the foundation and the base-mount adapter.

- 3) Install electrical conduits for electrical power service drops to the cabinet in the diameter indicated in the Plans. Conduits used as risers from a cabinet shall be minimum 2 in. (50 mm) diameter. Make nipples, welded collars, conduit bodies (e.g., LB condulets) and weather heads in hollow metal or concrete poles at the device mounting locations and at the cabinet mounting locations a minimum 2.5 in. (63 mm) diameter.
- c. Electrical Power Service:
- 1) Furnish and install materials and equipment to bring electrical power service to the cabinet from the source shown in the Plans. Furnish and install electrical power service in accordance with the Standard Specifications for electrical, lighting and traffic signal equipment, and as required below.
 - 2) Provide and terminate electrical power service equipment at the power service source as shown in the Plans. If the power service source is shown as a new power service drop, then furnish and install an electrical power service assembly at the new service drop location in accordance with the Standard Specifications. Include, as a minimum, with the electrical power service equipment at a new drop a service disconnect, surge arrester, grounding electrode and conductor, and all necessary conduit, wiring and hardware. Provide a ground conductor, other than the electrical service conduit, between the electrical service disconnect ground buss and the equipment cabinet service entrance terminal block SE. Furnish and install a service metering base where required by the local utility or electrical codes or where shown in the Plans. Include a minimum 30 ampere circuit breaker with electrical service disconnects. Mount the electrical surge arrester on the disconnect housing. The arrester shall be rated for a maximum permissible line to ground voltage of 175RMS, and shall be in conformance with NEMA standards for surge arrestors. Electrical service conduit shall be minimum 2 in. (25 mm) diameter. Separate electrical service conduit from all other conduit. This conduit cannot contain any other wiring. Dedicate electrical service conduit from the electric utility drop point through the meter base and disconnect and to the cabinet, where the electrical service conduit shall enter the cabinet through the cabinet bottom.
 - 3) If the power service source is an existing service drop, then furnish and install the necessary materials and equipment to supply service to the cabinet from the existing service drop. Unless otherwise shown in the Plans, service the cabinet from a dedicated branch circuit with circuit breaker. Make all electrical service installation from the existing drop point as specified for new power service drops above.
 - 4) Furnish and install surge suppression at all electrical power service sources. Ground all electrical power service sources and bond the AC neutral and ground at the power service source only.
 - 5) The contractor will establish accounts with the appropriate utility provider. After all accounts are established, the contractor will submit the utility transfer form to the appropriate DOT Utility office through the Engineer for transfer. The Engineer will provide the utility transfer form to the contractor.

939.3.06 Quality Acceptance

The Engineer, based on justification of public interest, may order any completed or partially completed portions of the project placed in service. Such action is not an acceptance of the project in whole or in part, nor is it a waiver by the Engineer of any provision of the specifications. Assume no right to additional compensation or extension of time for completion of the work or any other concession because of the use of the project or any part thereof prior to final acceptance of the completed project. Fully maintain all equipment prior to final acceptance, which includes but is not limited to equipment configuration and communication systems.

Perform all acceptance testing in the presence of the Engineer. Notify the Engineer of a desired acceptance test schedule no less than fourteen calendar days prior to beginning the testing except for testing using the NaviGator software and existing NaviGator control center and communications equipment. For acceptance testing using the NaviGator software and existing NaviGator control center and communications equipment, coordinate the testing schedule with the Engineer no less than 30 days prior to the start of this testing. Do not conduct any testing during any State or Federal holiday.

A. Equipment

1. General

Coordinate all work activities needing system configuration with the Engineer a minimum of 14 days prior to any testing.

Work in this project includes furnishing specific equipment to the Department for configuration and use by the Department during the course of the project. Operate this equipment and maintain the proper configuration until

final acceptance of the project, including throughout the project duration after the Department has started using the equipment.

2. Start-up Testing

Provide start-up testing for the various devices supplied as described herein and as further detailed in the respective equipment specification section.

The Contractor shall provide a test plan and procedures for review and approval by the Engineer prior to any testing. The Contractor shall conduct a pre-test prior to contacting the Engineer prior to final inspection. Pretest shall be defined as all tests that are performed for the Engineer during inspection. The Contractor shall provide all test equipment and software necessary to perform the tests. Perform all tests in the presence of the Engineer unless otherwise specified.

Include in the test plan and procedures, as a minimum, the following tests:

- Device or system power-on self test
- Conduct visual inspection of device or system to confirm presence of all components and features specified by the Contract specifications and otherwise customarily provided by the manufacturer
- Test using the built-in manufacturer's product or system diagnostics to confirm proper performance
- Test all input and output ports
- Demonstrate that all functional features of the device or system are operational
- An operational test demonstrating equipment performs as intended and as prescribed by the manufacturer and meets the requirements of the Contract specifications.

Configure the components of the device, make necessary settings or adjustments, and power-on according to the manufacturer's instructions.

3. Serial Data Terminal Server

Prior to acceptance of any Serial Data Terminal Servers (all Types), the following shall be performed:

- Connect with serial cable to Serial Data Terminal Server with PC or laptop using HyperTerminal.
- Ensure that the Serial Data Terminal Server recognizes all ports and attached expansion modules.
- Input addressing for Serial Data Terminal Server and reset.
- Determine successful Ethernet connectivity (link light at Hub/switch).
- Successfully telnet from PC or laptop to Serial Data Terminal Server through Hub/switch.
- Print to screen configuration information that is consistent with addressing data previously entered into Serial Data Terminal Server.

4. Field Switches

Prior to acceptance of any Field Switch (all Types), the following shall be performed:

a. Stand-alone Acceptance Test (SAT)

- 1) The Contractor shall provide the test plan and procedures for review and approval by the Department prior to any SAT activities. The test procedures shall provide comprehensive tests to verify and demonstrate full compliance with these specifications and device functionality. Pass and fail criteria shall be identified for each tests for review and approval by the Department.
- 2) The Contractor shall provide all test equipment and software necessary to perform the tests.
- 3) The Department will perform the SAT in a test area provided by the Department. A Contractor representative shall be present during the SAT.
- 4) The Field Switch will be assembled and connected to power in a stand-alone configuration.
- 5) The Field Switch will be powered up and allowed to initialize, boot and run self-diagnostic tests as defined in the Department-approved test procedures.
- 6) After the Field Switch has started and initialized, test procedures will be executed.

- 7) After the test procedures have been executed, the Field Switch will be allowed to run, uninterrupted, for a burn-in period of seventy-two (72) hours.
- 8) At the end of the burn-in period, the unit will be re-started and configuration verified.

Upon completion of all test procedures, the Contractor will be notified of SAT Field Switch acceptance or failure. If the unit fails the test, the Contractor shall replace it at no additional cost to the Department and the test procedure shall be re-started.

b. Operational Test

- 1) The Contractor shall provide the test plan and procedures for review and approval by the Department prior to any Operational Test activities. The test procedures shall provide comprehensive tests to verify and demonstrate full compliance with these specifications in regards to device or subsystem network performance. Pass and fail criteria shall be identified for each tests for review and approval by the Department.
- 2) The Contractor shall provide all test equipment and software necessary to perform the tests.
- 3) After successful completion of the SAT, the Department will configure and connect the Field Switch to the GDOT Network.
- 4) Verify communications and network control from the Field Switch to/from the Hub and TMC.
- 5) Verify system integrity through comprehensive diagnostics.
- 6) Verify 10/100Base-T/TX interfaces and operations.
- 7) Verify 1000Base-X interfaces and operations.

Upon completion of all the tests, the Contractor will be notified of Operational Field Switch acceptance or failure. If the unit fails the test, the Contractor shall replace the unit at no additional cost to the Department and the test procedure shall be restarted.

5. Video Encoders & Decoders (All Types)

Prior to acceptance of any Video Encoder and Decoder, (All types), the following shall be performed:

a. Stand-alone Acceptance Test (SAT)

- 1) The Contractor shall provide the test plan and procedures for review and approval by the Department prior to any SAT activities. The test procedures shall provide comprehensive tests to verify and demonstrate full compliance with these specifications and device functionality. Pass and fail criteria shall be identified for each tests for review and approval by the Department.
- 2) The Contractor shall provide all test equipment and software necessary to perform the tests.
- 3) Using the Department approved Contractor-supplied test plan and procedures, the Department will perform SAT in a test area provided by the Department. A Contractor representative shall be present during the SAT.
- 4) The Video Encoder/Decoder will be assembled and connected to power in a stand-alone configuration.
- 5) The Video Encoder/Decoder will be powered up and allowed to initialize, boot and run self-diagnostic tests as defined in the Department-approved test procedures.
- 6) After the Video Encoder/Decoder has started and initialized, the test procedures will be executed.
- 7) After the test procedures have been executed, the Video Encoder/Decoder will be allowed to run, uninterrupted, for a burn-in period of seventy-two (72) hours.
- 8) At the end of the burn-in period, the unit will be restarted and configuration verified.

Upon completion of all test procedures, the Contractor will be notified of SAT acceptance or failure. If the unit fails the test, the Contractor shall replace the unit and/or update the firmware as required at no additional cost to the Department and the test procedure shall be restarted.

b. Operational Test

- 1) The Contractor shall provide the test plan and procedures for review and approval by the Department prior to any Operational Test activities. The test procedures shall provide comprehensive tests to verify and demonstrate full compliance with these specifications in regards to device or subsystem network performance. Pass and fail criteria shall be identified for each tests for review and approval by the Department.
- 2) After successful completion of the SAT, the Contractor shall configure and connect the Video Encoder to the field switch and GDOT network.
- 3) Along with the Video Encoder, the Contractor shall provide a Video Decoder unit (as specified herein), a video monitor, a laptop, and camera control application provided by the Department. The Contractor shall be responsible to provide all test equipment and software necessary to perform the tests.
- 4) Verify MPEG video performance over the GDOT network.
- 5) Verify serial data channel performance using NaviGAtor PTZ control commands.
- 6) Verify and demonstrate user programmable paramcters and functions.
- 7) Verify and demonstrate network management and remote configuration.

Upon completion of all the tests, the Contractor will be notified of Operational Test acceptance or failure. If the unit fails the test, the Contractor shall replace the unit and/or update the firmware as required at no additional cost to the Department and the test procedures shall be re-started.

6. Interim Field Subnet Test

Prior to acceptance of any network communications equipment or field device connected to the communications network, perform and successfully complete an Interim Field Subnet (IFS) test. All Start-Up and Standalone testing shall be successfully completed on all devices before an IFS test can begin. Include in the IFS test all network communications devices in the project, including but not limited to all field switches, video encoders and decoders, VDS processors, CMS controllers, microwave radar detectors, serial data terminal servers, ramp meter signal controllers, and traffic signal controllers.

- a. Provide the test plan and procedures for review and approval by the Department prior to any IFS activities. The test procedures shall provide comprehensive tests to verify and demonstrate full compliance with these specifications and device functionality. Pass and fail criteria shall be identified for each test for review and approval by the Department. The test procedures shall identify all field sites and devices in the project, as well as the field subnets the sites are attached to.
- b. Furnish all test equipment and software necessary to perform the tests, including but not limited to laptop PC with web browser and network analysis software, temporary field switch or other compatible media converter, and all necessary patch cords.
- c. Prior to conducting a scheduled IFS test, conduct a dry-run test to ensure all preparations for the IFS test are complete. The Engineer reserves the right to attend the dry-run test.
- d. An IFS test shall be conducted for each field subnet, which is typically a group of field sites connected to a fiber pair ring between two hubs. The test shall be conducted from one of the hubs. During the test, every network device shall be pinged, probed by SNMP or equivalent status queries, logged into, and connected to by other methods as needed to demonstrate that the equipment is functional, contains the proper base programming data, and is in the proper location.

939.3.07 Contractor Warranty and Maintenance

Provide a Manufacturer's support (usual and customary warranties) period for all equipment and materials furnished and installed as part of the Communications and Electronic Equipment System. Include in warranty and support all Contractor or Manufacturer activities related to maintenance, removal and replacement of parts and materials during the period of support. Begin the Manufacturer warranty support period upon successful completion of equipment cabling and component testing as outlined in Subsection 939.3.06. All Manufacturer warranties shall be continuous throughout the period and state that they are subject to transfer to the Department.

939.3.08 Training

Provide training as required herein. Include with training all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training. Furnish a training notebook in a labeled 3-ring binder to each trainee. Include in the cost of training all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training.

Provide installation, operations, and maintenance training on the equipment at a site near the project area. Personnel trained by the various equipment manufacturers and authorized by said manufacturers shall perform the training. Provide installation, operations and maintenance training for up to twelve (12) people. Include in this training both classroom training and hands-on training. Limit in-shop and in-field training to group sizes of four (4) people at a time. Conduct all training in half-day sessions. Two half-day sessions may be held on the same day. The total of the training shall consist of at least six (6) clock hours of training for each participant. Provide a course content of, at a minimum, the following:

Field Switches

- Unit set-up and configuration
- Diagnostic and maintenance
- Performance tuning
- Hands-on use of Field Switches for each trainee

Video Encoders and Decoders

- Installation of all digital video compression system equipment
- Explanation of MPEG-4 digitized video
- Maintenance of all digital video encoder and decoder system components including software
- Measurement of digital video signals
- Hands-on use of digital video transport system equipment for each trainee

If CCTV training is also required in the project, digital video transport system training shall be provided in conjunction with the CCTV training specified herein. If so, the total of the CCTV and digital video transport system training shall consist of at least eight (8) clock hours of training for each participant. Meet all CCTV training requirements of Subsection 936.3.08.

939.4 Measurement

B. Equipment

For each equipment unit listed below, furnish and install all mounting and interconnection materials, including but not limited to card cages, mounting hardware, all patch cords of all types, and power strips and power supply cables at no separate cost to the Department. If software device drivers/communication protocols not currently incorporated into NaviGator software are needed, provide and integrate them at no separate cost to the Department.

1. Serial Data Terminal Server:

Serial Data Terminal Servers (16 Port and all Types) are measured for payment by the number actually installed, complete, functional and accepted. For each unit provided, furnish and install any required Serial Data Terminal Servers and serial port concentrators as specified in Subsection 939.2.A.2 and in the Plans at no separate cost to the Department.

2. Hub Uninterruptible Power Supply:

Hub Uninterruptible Power Supplies are measured for payment by the number actually installed, complete, functional and accepted.

3. Network Switch, Layer 3 Gig-E:

Network Switches, Layer 3 GigE (all Types) are measured for payment by the number actually installed, complete, functional and accepted. For each unit provided, furnish and install any required switching Hubs, router and switching chassis as specified in Subsection 939.2.A.5 and in the Plans at no separate cost to the Department.

4. GBIC Routing Switch Module:

GBIC Routing Switching Modules (all Types) are measured for payment by the number actually installed, complete, functional and accepted

5. GBICs:

GBICs (all Types) are measured for payment by the number actually installed, complete, functional and accepted.

6. Field Switches:

Field Switches (all Types) with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

7. Video Encoders, Type B:

Video Encoders, Type B, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

8. Video Encoders, Type C:

Video Encoders, Type C, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

9. Video Decoders, Type B:

Video Decoders, Type B, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

10. Video Decoders, Type C:

Video Decoders, Type C, with rack mounting hardware are measured for payment by the number actually installed, complete, functional and accepted.

11. Equipment Frame:

Equipment frames are measured for payment by the number actually installed, complete, functional and accepted.

12. Dial-Up Modems:

As required, dial-up modems are measured for payment by the number actually installed, complete, functional and accepted. For each unit installed, furnish and install all mounting and interconnection materials, including but not limited to card cages, shelves, hardware, fiber, jumper cables, RS-232/422/485 converters and power supply cables at no separate cost to the Department.

C. Equipment Cabinet Assembly

Equipment cabinet assemblies are measured for payment by the number actually installed, complete, functional and accepted. For each unit installed, furnish all required items, including but not limited to identification and documentation, lighting, contact switch, fan, contact-closure sensor, patch cords, and cables at no separate cost to the Department.

D. Electrical Power Service Assembly

Electrical power service assemblies are measured for payment by the number actually installed, complete, functional, and accepted. For each assembly installed, furnish all required items, including but not limited to conduit; riser; wiring; hardware; disconnect; meter base; and Class 3, 30 ft. (9 m) timber pole at no separate cost to the Department. Exceptions to the previous sentence include horizontal conduit, wiring, Type 2 pull boxes, electrical junction boxes, and directional bores between the electrical service pole to the equipment cabinet requiring power service which will be measured for payment as conduit, nonmetal, type 2 – power service as per Section 682.

E. Testing

Testing is measured as a lump sum for full delivery of testing and acceptance requirements.

F. Training

Training is measured as a lump sum for all supplies, equipment, materials, handouts, travel, and subsistence necessary to conduct the training.

939.4.02 Limits - Not applicable

939.5 Payment

Payment is full compensation for furnishing and installing the items complete in place according to this Specification. Payment for all items is as follows:

Item No. 939	Serial Data Terminal Server, 16 Port and Type _	Per Each
Item No. 939	Type _ Cabinet	Per Each
Item No. 939	Electrical Power Service Assembly (type)	Per Each
Item No. 939	Network Switch, Layer 3 Gig-E, Type _	Per Each
Item No. 939	GBIC Routing Switch Module, Type _	Per Each
Item No. 939	GBIC, Type _	Per Each
Item No. 939	Field Switch, Type _	Per Each
Item No. 939	Video Encoder, Type _	Per Each
Item No. 939	Video Decoder, Type _	Per Each
Item No. 939	Hub Uninterruptible Power Supply	Per Each
Item No. 939	Equipment Frame	Per Each
Item No. 939	Testing	Lump Sum
Item No. 939	Training	Lump Sum

939.5.01 Adjustments

Not applicable

DEPARTMENT OF TRANSPORTATION

STATE OF GEORGIA

P.I. NUMBER 0013163

SIGMAN RD WIDENING

ROCKDALE COUNTY

SUPPLEMENTAL SPECIFICATION

Section 647—Traffic Signal Installation

Delete Section 647 and substitute the following:

647.1 General Description

This work consists of furnishing materials and erecting a traffic signal installation including all traffic signal equipment, poles, bases, wires and miscellaneous materials required for completion of the installation. Ramp Meters are defined as a form of traffic signalization and all general provisions for traffic signalization are applicable unless otherwise noted in the Plans and Specifications.

It also includes all test periods, warranties and guarantees as designated in subsequent sections, and response to maintenance and operational issues as described in subsequent sections.

Apply for, obtain and pay for all utility services, communications services to, and pole attachment permits required by all utility owners that are necessary for the signal installation and operation required in the Plans. The Contractor will be responsible for establishing utility services and ongoing monthly costs related to utility services until final acceptance of the signal project.

Upon completion of a successful "burn in" or operational testing period for the signal installation, the Contractor will be responsible for an orderly and uninterrupted transfer of these services and permits to the local government or other jurisdiction that will be responsible for subsequent maintenance and operation.

647.1.01 Definitions

General Provisions 101 through 150.

647.1.02 Related References

A. Standard Specifications

Section 106—Control of Materials

Section 107—Legal Regulations and Responsibility to the Public

Section 108 —Prosecution and Progress

Section 150 —Traffic Control

Section 500—Concrete Structures

Section 501—Steel Structures

Section 535—Painting Structures

Section 615—Jacking or Boring Pipe

Section 631—Changeable Message Signs

Section 636 – Highway Signs

Section 639—Strain Poles for Overhead Sign and Signal Assemblies

Section 645—Repair of Galvanized Coatings

Section 680—Highway Lighting

Section 681—Lighting Standards and Luminaires

Section 682—Electrical Wire, Cable, and Conduit

Section 700—Grassing

Section 755—Electrical Work

Section 800—Coarse Aggregate

Section 801—Fine Aggregate

Section 832—Curing Agents

Section 833—Joint Fillers and Sealers

Section 850—Aluminum Alloy Materials

Section 852—Miscellaneous Steel Materials

Section 853—Reinforcement and Tensioning Steel

Section 854—Castings and Forgings

Section 861—Piling and Round Timber

Section 870—Paint

Section 886—Epoxy Resin Adhesives

Section 910—Sign Fabrication

Section 911—Steel Sign Posts

Section 912—Sign Blanks and Panels

Section 913—Reflectorizing Materials
Section 915—Mast Arm Assemblies
Section 922—Electrical Wire and Cable
Section 923—Electrical Conduit
Section 924—Miscellaneous Electrical Materials
Section 925—Traffic Signal Equipment
Section 926 – Wireless Communication Equipment
Section 927 – Wireless Communication Installation
Section 935—Fiber Optic System
Section 936—CCTV System
Section 937—Video Detection System
Section 939—Communications & Electronic Equipment
Section 940—Navigator Integration

B. Referenced Documents

National Electrical Manufacturers Association (NEMA) Traffic Control Systems Standards No. TS 1
NEMA Traffic Control Systems Standards No. TS 2
AASHTO Roadside Design Guide
The Manual on Uniform Traffic Control Devices (MUTCD), current edition
National Electrical Code
National Electrical Safety Code (NESC)
GDT 7 Determining Maximum Density of Soils
GDT 24a Determining the Theoretical Minimum Dry Density of Soils or Soil Aggregates containing > 45% Retained on the No. 10 Sieve
GDT 24b Determining the Theoretical Minimum Dry Density of Soils or Soil Aggregates containing > 5% Retained on 2-Inch Sieve using a 5.5 Pound Rammer and a 12 Inch Drop
GDT 67 Family of Curves Method for Determining Maximum Density of Soils

647.1.03 Submittals

Use only equipment and materials that are on the Department's Qualified Products List (QPL

These products have been evaluated by the Office of Traffic Operations and have proven their capability of meeting the appropriate Georgia Department of Transportation Specification. Any of these products may be used without sampling or pre-testing. The Contractor shall submit a letter to the Field Engineer, stating which QPL items they will use. Submittal letter shall include QPL number-and product description.. The Field

Engineer and/or department designee must ascertain that the construction item is the same material identified on the appropriate QPL and will acknowledge receipt of these items in the project diary or as required by the Construction manual.

Written approval is required from the State Traffic Engineer or District Engineer prior to beginning any work on the traffic signal installation and /or installing the proposed on the work site.

A. Review

For all traffic signal material submittals, the Engineer's review of the material should be completed within forty five (45) days from the date of receipt of the submission unless otherwise specified. The State Traffic Engineer or District Engineer will advise in writing, as to the acceptability of the material submitted.

The State Traffic Engineer or District Engineer may determine that submitted equipment is approved, in which no further action is required. In the event, materials submitted for use are rejected the Contractor is required to re-submit materials, within fifteen (15) days of notification of material failure or rejection. Resubmittal of subsequent materials for review will be considered the start point of a new approval cycle as described.

The Department reserves the right to be reimbursed by the Contractor for reviewing any equipment and/or component submittals after a second submittal of equipment proposed for use on the project.

B. Submittal Costs

No separate measurement or payment will be made for submittal costs. All costs associated with reproduction of submittal material documents, samples and mailing expensed will be the responsibility of the Contractor and are not subject to reimbursement by the Department. All submittal material becomes the property of the Department and will not be returned to the Contractor.

C. Steel Strain Pole, Concrete Strain Pole or Steel Pole Certification

Instruct the supplier or manufacturer of the strain poles or steel poles with traffic signal mast arms to submit a certification, including mill certificates to:

Department of Transportation
Office of Materials and Research
15 Kennedy Drive
Forest Park, Georgia 30297

Include the following in the certification:

- A statement that the items were manufactured according to the Specifications, including the Specification Subsection number
- Project number and P.I. number

Instruct the supplier or manufacturer to send copies of the transmittal letter to the Engineer.

Prepare Shop Drawings and related signal strain pole design calculations with the following criteria, 5% sag and 18 foot signal head height. Provide "bending moment at yield" to determine the foundation size

according to the signal strain pole foundation drawings. Submit all Shop Drawings and related signal strain pole design calculations to the Traffic Engineer. The Traffic Engineer will forward to the State Bridge and Structural Design Engineer for review and approval. Obtain written approval prior to pole fabrication and installation. Upon acceptance of the pole certification provide one copy of the design calculations and shop drawings to the agency responsible for maintaining the traffic signal installation.

All pole drawings shall include roadway and pole elevations.

Show all dimensions and material designations of the designs on the Drawings. See Subsection 501.1.03 for the certification procedure for poles and anchor bolts.

D. Signal Item Certification

Only Equipment and/or material on QPL shall be submitted for certification. All others will be rejected. Submit four (4) copies of material catalog product numbers and descriptions to the Engineer. One copy of all submittals is to be provided to the maintaining agency. Reference the project number, P.I. number, and QPL number, for the following traffic signal items:

- Signal heads
- LED Signal Modules
- Mounting hardware
- Controllers
- Cabinet assemblies
- Battery Backup System (BBS)
- Detectors
- Monitors (conflict/IVDS)
- Cable
- Load switches
- Blank-out signs
- Lane use signals
- Preformed cabinet bases
- Other related signal equipment (including but not limited to Conduit, Pull boxes, Ground Rods, Enforcement Indications, etc.)

E. Test Results Submittal

Submit the results of the testing of the following items to the Engineer. A copy of the test result submittals shall be provided to the maintaining agency.

- Loop Detector Testing
- Signal Cable Testing
- Interconnect Cable Testing
- Pre-emption Testing

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- Controller and Cabinet Testing from Manufacturer (Including conflict monitor)
 - Traffic Signal Monitor
 - Any other operational testing required by the Engineer

F. Mast Arm Pole Chart

For locations with mast arm pole installations, submit a "Mast Arm Pole Chart" for review and approval by the State Bridge and Structural Design Engineer. The "Mast Arm Pole Chart" shall also include a sketch on an 8 ½ inch x 11 inch (216 mm x 279 mm) sheet of paper showing the following:

- Curb lines
- Location of mast arm pole based on utility information and field location verified by Contractor. (Final location of mast arm pole must meet the criteria for setback from the road as specified in the Roadside Design Guide by AASHTO and in the Standard Detail Drawings.
- Distance from both adjacent curbs to mast arm pole
- Distance along mast arm from pole to curb and from curb to each proposed signal head
- Directional arrow
- Street names
- Position of Luminaries

Label the sketched distances. Once this pole chart is approved, the Contractor shall use the distances measured to the proposed signal head locations when ordering the mast arm to ensure that the mast arm is fabricated with holes for signal head wiring in the correct locations.

647.2 Materials

647.2.01 Delivery, Storage, and Handling

A. State-supplied Equipment

For projects where traffic signal equipment is to be supplied by the Georgia Department of Transportation, obtain State-supplied traffic signal equipment from the Traffic Signal Electrical Facility (TSEF):

1. Contact the Engineer by phone or correspondence within one week after receiving the Notice to Proceed and arrange for a date, time and location to pick up the signal equipment and materials from the Traffic Signal and Electrical Facilities (TSEF).
2. Sign GDOT's Warehouse Issue Request Form 592 to accept delivery of the State-supplied equipment from GDOT's Traffic Signal Equipment Warehouse. Initial Form 592 if equipment is received from a GDOT District Field Office.
3. Inspect the equipment to ensure that it is operating properly and perform any operational tests within ten (10) calendar days after receiving the equipment.
4. Before installation, and within ten (10) calendar days, certify to the Engineer in writing that the State-supplied equipment was received in good condition.
5. Notify the Engineer in writing if the State-supplied equipment is defective. The State Signal Engineer will replace the defective State-supplied equipment.

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6. If no written dissent is received after ten (10) calendar days or if equipment is installed in the field, the Engineer will consider this equipment to be satisfactory and accepted.
 7. The Contractor shall supply new in like and kind State approved equipment to replace State-supplied equipment that is damaged or lost.

B. Signal Equipment

See Section 925 for signal equipment specifications.

The signal equipment, components, supplies, or materials used in traffic signal installation may be sampled and tested if not previously approved by the Department.

Test according to the Specifications and the Sampling, Testing, and Inspection Manual using one or more of the following methods:

- Have the Department use their own facilities.
- Have the supplier or manufacturer use their facilities with an authorized Department representative to witness the testing.
- Provide independent laboratory test results indicating compliance with Department Specifications referenced in Subsection 647.1.02, "Related References", of this document.
- When testing by the Department is required, supply the item to the Department. Acceptance of materials tested does not exclude further testing or waive warranties and guarantees required by the Specifications.

C. Cable

Use cable conforming to Section 680, Section 922, and Section 925 and the appropriate IMSA, NEMA, or UL Specifications for the wire or cable.

Obtain pole attachment permits required by local utility companies or pole owners to allow joint use for signal cable, hardware, or other auxiliary devices.

D. Interconnect Communications Cable

- 1 Use fiber optic interconnect cable or spread spectrum radio for all new interconnected signal systems. See Section 935 for fiber optic cable or spread spectrum information, specifications, marking and installation and testing techniques.
- 2 Use copper cable only as directed by the Engineer or where specifically shown in the Plans. Refer to Subsection 647.3.05, "Construction", of this document for installation.

E. Conduit on Structures

Use galvanized rigid steel materials for all exposed conduit for cabling. Use galvanized rigid steel (GRS) conduit on the exterior of signal poles and other structures and to house signal conductors for the entire length from the weather head on the pole to the interior of the cabinet or to the pull box and ground conduit using an approved grounding bushing.(see Subsection 647.3.05V).

647.3 Construction Requirements

Refer to Subsection 107.07 of the Specifications regarding proper conduct of The Work.

647.3.01 Personnel

For the definition of a qualified electrician, see Subsection 755.1.01.

647.3.02 Equipment

Use machinery such as trucks, derricks, bucket vehicles, saws, trenchers, and other equipment necessary for the work and approved by the Engineer prior to installation operations.

647.3.03 Preparation

Utility Permits

A. Application

Apply for, obtain, and pay for utility services and pole attachment permits for signal operation, traffic signal communications including standard telephone service and signal communications as required in the Plans.

B. Maintenance

The Contractor will be responsible for establishing utility services and ongoing monthly costs related to utility services until Final Acceptance of the signal(s) installation, or in the event of multiple installations, the Contractor will be responsible for utility costs until overall project acceptance. After Final Acceptance, the Contractor will provide an orderly transfer these services and permits to the local government or jurisdiction responsible for maintenance and operation. Ensure that the transfer does not interrupt service.

C. Utility Location**1. Adjustment**

Prior to ordering signal poles, locate utilities and adjust the location of poles, where necessary, to minimize utility conflicts. Obtain approval from the District Traffic Engineer for any deviation from the Plans.

Determine the final length of mast arms based on any field adjusted pole locations. Final location shall be approved by the District Traffic Engineer.

2. Clearance

When installing aerial cable of any type, it is the Contractor's responsibility to ensure that overhead clearance and separation requirements conform to local utility company standards, the NEC and the NESC. Refer to the Standard Details Drawings for further information on utility clearances.

3. Pre-emption

When traffic signal pre-emption is used, coordinate with the railroad, fire department or any other agency that uses pre-emption to obtain pre-emption output and route output cable to the signal controller operating the intersection to be pre-empted. It is the Contractor's responsibility to obtain all permits and approval for crossing at grade or grade separated railroad facilities.

647.3.04 Fabrication

General Provisions 101 through 150.

647.3.05 Construction

A. Acquiring and Disposing of Equipment

Do not modify the signal equipment, design, and operation without the District Traffic Operations Engineer's written approval.

All traffic signal equipment removed or replaced shall be returned to District Traffic Signal Shops unless otherwise noted in the Plans or as directed by the Engineer or District Signal Engineer. Provide an inventory list and arrange a mutually agreeable delivery time with the District Signal Engineer twenty-four (24) hours in advance. All materials not returned to the District Signal shop shall be the responsibility of the Contractor to remove and dispose.

B. Traffic Signal Equipment Modification and Removal

Upon the Department issuance of Notice to Proceed any existing traffic signal equipment, responsibilities for maintenance, operations and response to traffic signal malfunction become the responsibility of the Contractor and provisions of Subsection 647.3.07, "Contractor Warranty and Maintenance", apply.

1. Remove existing signal equipment that is not used in the final installation when the new signal equipment is operational.

Carefully remove equipment to minimize damage and retain it in its original form. This equipment may include:

- Strain poles including the foundation down to 3 feet (900 mm) below ground level finished grade
- Timber poles
- Traffic signal cabinets including contents, cabinet base and work pads
- Original signal heads including span wire support
- Other equipment not retained in the final installation

Ensure that unused equipment is secured and disposed of in accordance with all Environmental Protection Agency regulations and Department instructions.

2. Replace traffic signal equipment that the District Signal Engineer determines has been damaged or destroyed during installation, modification, or removal of the traffic signal, at no expense to the Department. Replace with new material.
3. If the Engineer finds that the existing material shown in the Plans to be relocated is unsatisfactory, replace with new material. The costs will be paid for as Extra Work.
4. Remove old signal heads by the end of the day that the new signal equipment is placed in operation. Remove all other signal equipment within seven (7) days after operations of the newly installed equipment.

C. Auxiliary Cabinet Equipment

Provide auxiliary cabinet equipment or special purpose equipment with connecting harnesses, if necessary, or as shown in the Plans or Standard Detail Drawings.

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1. Install the equipment in its associated cabinet. Extraneous wiring may be necessary to install the equipment. Additional cabling shall be enclosed in NEMA enclosure and neatly secured.
 2. Connect the auxiliary equipment to its cable harness, or insert it in premounted racks or sockets.

D. Signal Controllers

Furnish and install approved microprocessor controllers at the locations shown in the Plans or as directed by the Engineer. All equipment furnished shall comply with Section 925, "Traffic Signal Equipment".

1. Identify the controller and other auxiliary equipment by model and revision numbers. These numbers shall agree with previously approved catalog submittals.
2. Assemble the controller, cabinet, and auxiliary equipment to provide the operational sequence shown in the Plans and future operations specified. Ensure the controller functions as a unit with the cabinet assembly.
3. Ensure controller and auxiliary equipment are provided AC power from receptacles marked for controller power.
4. The Department will provide controller firmware. The Contractor shall provide the controller to the Department. The Department will load the firmware into the controller and notify the Contractor that the controller is ready to be picked up. If the controller is purchased with applications firmware, ensure that the firmware provided is the current Department licensed version of firmware including "boot code". Current firmware version shall be at the date of application "turn on".
5. Unless otherwise specified in the Plans or directed by the Engineer, thirty days prior to installation of equipment the Contractor shall deliver the controllers to and pick up the controller from the Traffic Signal Electrical Facility (TSEF) Atlanta office. The Department shall have 30 work days to load the controller firmware starting from the date the Contractor delivered the controllers to the Department.
6. For 2070 signal controllers used for Ramp Metering ensure the Watchdog Timer "Muzzle Jumper" is selected on the field input/output module. This is required for operating with a 208 monitor.

E. Cabinet Assembly

1. Location

The cabinet should be located in accordance with the Plan location, however if the cabinet location needs to be moved, choose a location that:

- a. Protects maintenance personnel from vehicles when servicing the equipment
- b. Allows the front panel door of the controller to open away from the intersection for view of signal indications while servicing or performing cabinet work.
- c. Does not block a sidewalk or passageway and complies with Federal regulations for Americans with Disabilities Act (ADA) clearance requirements.
- d. Is located away from the roadway or curb line to prevent vehicular damage to the cabinet.
- e. Is not located within drainage areas or installed in areas likely to collect and hold surface water.
- f. Relocate the cabinet to avoid conflicts from proposed reconstruction projects, commercial driveways, etc. within the right-of-way at the Engineer's discretion.

2. Erection

Install and level traffic signal controller cabinets at locations shown in the Plans and/or as directed by the Engineer.

- a. Install cabinets to conform to the Standard Detail Drawings. Install pole or base-mounted as indicated in the Plans. Cabinet base shall not extend more than 9 inches above final grade.
- b. Seal base-mounted cabinets to their base using silicone based sealer. Pliable sealant used shall not melt or run at temperatures as high as 212 °F (100 °C).
- c. Use prefabricated bases and work pads
- d. Install technician pad in front and rear of the controller cabinet door and if applicable in front of battery backup cabinet door. See Standard Details for pad information.
- e. Close all unused conduit in the controller base with a PVC cap sized appropriately. Do not permanently affix the conduit cap to the conduit. Seal those conduits used for signal cable with a pliable sealant to prevent moisture and insects from entering the cabinet via the conduit.

3. Field Cabinet Wiring

All wiring shall be neat and secured and comply with NEC, NEMA, and Table 647-1, Table 647-2, Table 647-3 Table 647-4, Table 647-5, and Table 647-6 of this Specification.

- a. Cut field cabinet wiring to the proper length and organize it in the cabinet. Wire lengths should be slack (minimum 10 feet) allowing for future modifications.
 - Use at least No. 6 AWG wire for the conductors between service drop and AC+ and the AC-terminals.
- b. Do not mount electrical meter to the cabinet. Submit "power pedestal" or other method of providing location for mounting to the Engineer.
- c. Label all field terminals and conductors so as to identify the specific field input.
- d. Crimp terminal connections to conductors with a ratchet-type crimping tool that will not release until the crimping operation is completed.
- e. Do not use splices inside the controller cabinet, base, or conduit.
- f. Do not use solid wire, except grounding wire.
- g. Supply the cabinets with cabinet wiring diagrams, schematic drawings, pin assignment charts, and manuals for circuits and components. Store these documents in the cabinet in a resealable, weatherproof container.

F. Signal Monitors

Furnish signal monitor equipment as follows,

1. Mount signal monitors in a rack with appropriate connectors to attach to the wiring harness.
2. Program the monitor according to the signal operation indicated in the Signal Plans before placing the installation in flash or stop-and-go operation. Provide any signal monitoring programming tools required to program the monitor to the maintaining agency.
3. Configure and equip the signal monitor to monitor all red signal indications. Ensure that the red output for unused or vacant load bays or output slots is jumpered to 120 V AC+.

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4. For ITS Cabinets configure the CMU and AMU.
 5. For Ramp Metering Cabinets mount model 208 monitor in rack and provide the necessary programming required for the Ramp Meter operation as shown in the Plans.

G. Power Disconnect

Install a power disconnect box at each intersection as shown in the Standard Detail Sheets. Ensure the power disconnect is installed at the top of the cabinet pole or as indicated on plans. Install service cables from disconnect box and terminate as specified on the controller cabinet-wiring or battery backup diagram.

H. Flashing Beacon

Furnish and install the flashing beacon controller at the locations shown in the Plans and/or as directed by the Engineer. Install it as a complete unit (solid state flasher and cabinet with time clock, if applicable) and ensure that it conforms to this Specification.

I. Loop Detector Systems

Install and test loop detector systems according to NEMA Standards Publication TS 1-1983, Section 15, Inductive Loop Detectors, subsequent revisions (except as shown in the Plans), Details, notes, and this Specification.

Ensure that loop detectors are complete and fully operational before placing the signal in stop-and-go operation.

1. General Installation Requirements

Each loop must consist of at least two turns of conductor, unless otherwise shown in the Plans or this Specification. Do not place a portion of the loop within 3 feet (1 m) of a conductive material in the pavement such as manhole covers, water valves, grates, etc.

- a. Install pull boxes, condulets, and conduits before beginning loop installation.
- b. Ensure that the ambient pavement surface temperature in the shade is at least 40 °F (5 °C) before cutting roadway and placing sealant into saw cuts.

2. Loop Saw Cuts

- a. Outline the loop on the pavement to conform to the specified configuration.
- b. Ensure each loop has a separate saw cut with a minimum distance between saw cuts of 6 inches.
- c. Install the detector loop in a sawed slot in the roadway surface deep enough to provide at least 3 inches (76 mm) of sealant cover.
- d. Ensure that the slot is at least 0.25 inches (6 mm) wide for stranded No. 14 AWG loop wire, THWN, XHHW, or XLPE, and at least 0.31 inches (7 mm) wide for polyethylene or PVC encased No. 14 AWG loop wire.
 - 1) At the intersection of the slots, drill a 2 inch (51 mm) diameter hole or make miter saw cuts in the pavement. Overlap miter saw cuts at the intersection of saw cuts so that the slots have a full-depth and smooth bottom.
 - 2) Prevent the wire from bending sharply.

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- 3) Do not install detector loop wire unless sawed slots are completely dry and free of debris. Pressure wash the slot to guarantee adhesion of the loop sealant. Use compressed air to thoroughly dry the sawed slot.
 - 4) Install the loop wire starting at the nearest pull box or conduit, around the loop for the specified number of turns, and back to the pull box or conduit.

NOTE: Loop wire from the street is to be spliced in condulets or pull boxes only.

- 5) Refer to table 647-9 for the number of turns for Quadrupole loops. Refer to table 647-8 for the number of turns for Bipole loops. Bipole loops require at least three (3) turns.
 - e. Press the wire in the slot without using sharp objects that may damage the jacket.
 - f. Hold the loop in place every 5 feet (1.5 m) with 1 inch (25 mm) strips of rubber, neoprene, flexible tubing, or foam backer rod as approved by the Engineer.
 - g. Leave the hold down strips in place when filling the slot with loop sealant.
 - h. Where encased loop wire is used, apply a waterproof seal to the ends of the polyethylene tubing that encase the wire to prevent moisture from entering the tube.
 - i. Where the loop wires cross pavement joints and cracks, protect the loop wires using the method specified in "Traffic Signal Details" in the Plans. When crossing expansion joints drill a 2 inch diameter hole minimum 3 inches deep, or to bottom of saw cut. Do not install loop wires in an expansion joint.
 - j. Twist Loop Lead-in 3 turns per foot.

3. Loop Sealing

After successfully testing each loop, fill the slots with sealant to fully encase the conductors.

- a. Seal the slot within one hour of cutting slot.
- b. Ensure that the sealant is at least 3 inches (75 mm) thick above the top conductor in the saw cut.
- c. Apply the sealant so that subsequent expansion does not extend the sealant material above the pavement surface.
- d. In case of accidental spill, before the sealant sets, remove surplus sealant from the adjacent road surfaces without using solvents or epoxy sealants.
- e. When the Engineer determines that the loop sealant can accommodate traffic but the surface is tacky, dust the sealer on the pavement surface with cement dust before opening the roadway to traffic.
- f. Dispose of the solvents used to clean loop installation equipment according to the manufacturer's specifications and local, State, and Federal regulations.

4. Loop Connections

Connect loop conductors to a shielded lead-in cable that runs from the pull box adjacent the pavement edge or conduit to the detector hook-up panel in the controller cabinet, unless otherwise specified in the Plans.

- a. Use continuous (no splices) shielded lead-in cable from the pull box or conduit to the cabinet input file terminal. Do not ground the shield in the loop lead-in cable at the cabinet.

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- b. Connect each loop to an individual detector channel as specified in the Plans.
 - c. If the Plans specify that two or more loops will be operated on the same detector channel or detector amplifier unit, wire them in series to their loop lead-in at the pull box or conduit.
 - d. Use series-parallel connections when series connections do not meet the manufacturer's specified operating range for the detector amplifier unit.
 - e. Make weather-tight and waterproof splices as detailed on the Plan Standard Detail Sheets. Make loop splices to loop lead-in cable only after the detector system has been tested and demonstrated under traffic conditions to the Engineer's satisfaction.

5. Loop Maintenance

Locate all existing loops, determine the operational status of all loop assemblies, and notify the Engineer prior to commencing loop construction activities at the intersection.

Maintain all existing, operational loops, unless otherwise notified by the Engineer. Repair of an existing loop that is non-operational prior to beginning work will be considered as extra work.

Locate points of conflict between new loops and existing loops, and install all new loops and saw cuts so as not to cut existing loop lead-ins and loop wires that are to be retained.

If an existing operational loop that is not scheduled for replacement fails during the construction time frame, notify the Engineer and complete the replacement of the damaged loops immediately.

The Engineer may grant a twenty-four (24) hour period to repair the loops if their operation is not critical. All costs associated with the replacement of the loops damaged during construction shall be charged and paid for by the Contractor.

J. Pedestrian Push Button

Install the push button with a pedestrian instruction sign as illustrated on the Department's Standard Detail Sheets and according to the Plans.

1. Place the pedestrian buttons as shown on the Signal Plan Sheet and within 10 inches (254 mm) of sidewalk or concrete landing pad. Position the pedestrian button to correspond to the appropriate signal phase. Locate pedestrian buttons perpendicular to the appropriate signal indication and signal phase, and as field conditions require.
2. Place the center of the buttons between 38 inches (0.965 m) and 42 inches (1.05 m) above the sidewalk or ground level.
3. Seal all openings to prevent moisture from entering the pushbutton.

K. Cable

Install and connect electrical cable to the proper equipment to produce an operating traffic signal system. Use stranded copper cable conforming to Section 925.

Install wiring in accordance with IMSA, NEMA, UL, and the Department's Traffic Signal Wiring Standards, shown in Tables 647-1, 647-2, 647-3, 647-4, 647-5, and 647-6 of this Specification.

In addition to the information provided below, see Section 682, Section 922, and Section 925 for cable equipment and installation specifications.

Table 647-1 Vehicular Signals Georgia DOT Wiring Standards

Signal Indications	Four Conductor Cable		Seven Conductor Cable		Ten Conductor Cable	
	Phases 2, 4, 6, & 8	Phases 1, 3, 5, & 7	Phases 2, 4, 6, & 8	Phases 1, 3, 5, & 7	Phases 2, 4, 6, & 8	Phases 1, 3, 5, & 7
Red	Red Wire		Red Wire		Red Wire	
Yellow	Black Wire		Orange Wire		Orange Wire	
Green	Green Wire		Green Wire		Green Wire	
Red Arrow		Red Wire		White Wire with Black Tracker		Red Wire with Black Tracker
Yellow Arrow		Black Wire		Black Wire		Orange Wire with Black Tracker
Flashing Yellow Arrow		Green Wire		Orange Wire		Blue Wire
Green Arrow		Green Wire		Blue Wire		Green Wire with Black Tracker
Auxiliary					Black Wire	Black Wire
Neutral	White Wire	White Wire	White Wire	White Wire	White Wire	White Wire
Spare					White Wire with Black Tracker	White Wire with Black Tracker

Table 647-2 Vehicular Loop Detectors Georgia DOT Wiring Standards

Detectors	Phases 3, 4, 7, and 8 Presence Loops		Phases 2 and 6 Setback Pulse Loops and Phases 1 and 5 Presence Loops	
	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair
Right Curb Lane	Red Wire	Red/Black Pair (1)	Red Wire	Red/Black Pair (1)
Second Lane	Green Wire	Green Black Pair (1)	Green Wire	Green Black Pair (1)
Third Lane	White Wire	White/Black Pair (1)	White Wire	White/Black Pair (1)
Fourth Lane	Red Wire	Red/Black Pair (2)	Red Wire	Red/Black Pair (2)
Fifth Lane	Green Wire	Green/Black Pair (2)	Green Wire	Green/Black Pair (2)
Sixth Lane	White Wire	White/Black Pair (2)		
First Left-Turn Lane			Red Wire	Red/Black Pair (3)
Second Left-Turn Lane			Green Wire	Green/Black Pair (3)

Table 647-3 Pedestrian Signals Georgia DOT Wiring Standards

Signal Indications	Four Conductor Cable		Seven and Ten Conductor Cable	
	Phases 2 and 6	Phases 4 and 8	Phases 2 and 6	Phases 4 and 8
Don't Walk	Red Wire	Red Wire	Red Wire	Orange Wire
Walk	Green Wire	Green Wire	Green Wire	Blue Wire
Neutral	White Wire	White Wire	White Wire	White Wire

Table 647-4 Pedestrian Detectors Georgia DOT Wiring Standards

Push Buttons	3 Pair Shielded Cable	
	Phase 2 and 6	Phase 4 and 8
Call	Green and Black Pair	Red and Black Pair

NOTE: Do not use aluminum cable.

Table 647-5 Ramp Meter Signals Georgia DOT Wiring Standards	
Signal Indications	3-Section Signal Heads Seven Conductor Cable L1,L2,L3
Red	Red Wire
Yellow	Orange Wire
Green	Blue Wire
Neutral	White Wire

Table 647-6 Ramp Meter Loop Detectors Georgia DOT Wiring Standards				
	Demand Detector Loops		Queue Detector Loops	
	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair
Lane 1	Red Wire	Red/Black Pair (2)	Red Wire	Red/Black Pair (1)
Lane 2	Green/Wire	Green Black Pair (2)	Green Wire	Green/Black Pair (1)
Lane 3	White Wire	White/Black Pair (2)	White Wire	White/Black Pair (1)
	Passage Detector Loops		Mainline Detector Loops (if used)	
	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair	Loop Wires	Shielded Loop Lead-in Cable, 3 Pair
Lane 1	Red Wire	Red/Black Pair (3)	Red Wire	Red/Black Pair (4)
Lane 2	Green Wire	Green/Black Pair (3)	Green Wire	Green/Black Pair (4)
Lane 3	White Wire	White/Black Pair (3)	White Wire	White/Black Pair (4)

L. Signal Cable for Vehicular Signal Heads and Pedestrian Heads

Install cable for signal heads and pedestrian heads as follows:

1. For vehicle signal heads, install one 7-conductor signal cable for each intersection approach from the controller cabinet to the through-signal head on each approach as directed by the Engineer. From this leftmost signal head, install a 7-conductor signal cable to each of the other signal heads on the same approach in sequence.
2. For pedestrian signal heads, install one 7-conductor signal cable from the controller cabinet to each pedestrian head installation location to operate either one or two pedestrian heads.
3. Make a minimum 1 foot (300 mm) diameter 3 turn weather drip loop as shown in the Standard Detail Drawings in the Plans at the entrance to each signal head.
4. Neatly tie signal cables leaving a structure or weatherhead to enter a signal fixture. Tie the cables to the messenger cable as illustrated in the Standard Detail Drawings.
5. For Ramp Meter signal heads install one 7-conductor signal cable for each lane of the Ramp Meter operation from the controller cabinet.

M. Interconnect Communications Cable

Use fiber optic interconnect cable as specified in the Plans for all new interconnected signal systems. See Section 935 for fiber optic cable information, specifications and installation and testing techniques, and all other signal interconnect methods. Install interconnect communications cable as follows:

1. Provide support for the interconnect cable on new or existing utility poles or signal poles; install underground in conduit.
2. Use fiber optic standoff brackets as needed to prevent damage from poles, trees and other structures.
3. Pull cables with a cable grip that firmly holds the exterior covering of the cable.
4. Pull the cables without dragging them on the ground, pavement or over or around obstructions. The Engineer will inspect and approve the cable prior to installation. Use powdered soapstone, talc, or other approved inert lubricants to pull the cable through the conduit.
5. When using a separate messenger cable, spirally wrap the communications cable with a lashing machine according to the IMSA-20-2 Specifications.
6. Do not splice outside the signal cabinet except at the end of full reels of 5,000 feet (1500 m).
7. Ensure that splice points are near support poles and accessible without closing traffic lanes.
8. Unless drop cable assemblies for communications are used, loop the cable in and out of the control cabinets. Coil and tie 10 feet (3 m) of cable in the controller cabinet foundation. Tape the cable ends to keep moisture out until the terminals are attached.
9. Prevent damage to the cable during storage and installation.

NOTE: Do not allow anyone to step on or run over any cable with vehicles or equipment.

N. Loop Detector Lead-in Cable

Use 3-pair shielded lead-in cable in compliance with Section 925 and manufacturer's recommendations for Detector loop lead-in installed for loop detectors. Ensure the three pair has 3 separate distinguishing colors. Use a shielded lead-in cable connecting the loop to the detector hook-up panel in the controller cabinet, unless otherwise specified in the Plans. Provide a separate 3- pair for each phase or future phase.

1. Splice the loop detector wire to a shielded loop detector lead-in cable in a pull box adjacent to the loop detector installation.
2. Use continuous (no splices) shielded lead-in cable from the pull box or conduit to the cabinet input file terminal. If induced voltage is present, the shield in the loop lead-in cable shall be grounded to cabinet per NEC. Otherwise do not ground the shield in the loop lead-in cable at the cabinet.
3. Connect each loop to an individual detector channel as specified in the Plans.
4. Each detection loop shall be connected to the control cabinet via separate lead-in pair.
5. Set back loops with aerial loop leads to the control cabinet shall be supported by ¼ inch messenger cable with no splices between the control cabinet and the initial point of aerial attachment.
6. Make weather tight and waterproof splices between lead-in and loop wire. Loop installation may be approved only after the detector system has been tested and demonstrated under traffic conditions to the Engineer's satisfaction, during the Operational Test Period.

O. Pedestrian Push Button Lead-in

Use 3-pair shielded lead-in cable compliant with Section 925 for pedestrian push buttons. Install one 3-pair shielded lead-in cable to each pedestrian push button station(s) location to operate either one or two push buttons. Do not ground the shield for the push button lead-in cable at the controller cabinet. Do not use the same 3 pair cable for loop and pedestrian detectors.

P. Messenger Cable, Stranded-Steel

The messenger is used to support signal cable indicated in the Plans as overhead cable. Use devices such as aluminum wrap, aluminum wire ties or lashings to attach the cable.

- Before erecting the messenger strand, determine the suspension strand length to span the distance between the poles.
- Run the messenger strand from structure to structure without splicing.
- The minimum allowable sag is two and one-half percent (2.5%) for timber poles, five (5%) for strain poles of the longest diagonal distance between the signal poles unless pole manufacturers specifications exceed 2.5%.
- Calculate attachment points for the messenger strand at the signal pole according to the Plan Detail Sheet.

Set messenger strands so that the height conforms to the clearances on the Standard Detail Drawings. Attach cables to messenger cable using lashing wire, aluminum ties, or lashing rods (Subsection 925.2.43). If lashing rods are used use lashing rods sized for the cables and messenger strand. Only use lashing rods that are of the same material as the messenger strand. Lashing wire shall only be used to support aerial loop lead-in and fiber optic.

1. Drill wood poles to receive the eye bolts so that the span wire and eyebolt at each connection form a straight angle.
2. Never pull or strain the messenger on the eye bolt to an angle of variance greater than ten degrees (10°).
3. Attach down guy wires to guy hooks. Use a minimum 3/8 inch messenger cable for down guys. Never attach them directly to the eye of an eyebolt.
4. Ensure that messenger strand clearances conform with local utility company Standards.
5. Make stranded messenger cable attachment points with the appropriate size strand vises or 3 bolt clamps. Stranded steel messenger cable is not paid for separately under this Specification.
6. Use minimum ¼ inch messenger cable.
7. Use standoff brackets as needed to prevent damage from poles, trees or other structures.

NOTE: Never splice messenger cable between structures or stand off brackets.

Q. Underground Cable for Signal Circuits

Underground cable for signal circuits includes cable, with conduit, as shown in the Plans. Install cable under existing pavement or surfaced shoulder, according to Subsection 680.3.05.

1. Cable in Conduit

Pull cable into conduits as follows:

- a. Pull cables into conduits without electrical or mechanical damage. Pull cables by hand only. The use of trucks or other equipment is not permitted, unless approved by the Engineer. If mechanical pulling is approved, do not exceed the manufacturer's tension rating for the cable.
- b. Pull cables with a cable grip that firmly holds the exterior covering of the cable.
- c. Use powdered soapstone, talc, or other inert lubricants to place conductors in conduit according to manufacturer's recommendations.
- d. Handle and install the conductors to prevent kinks, bends, or other distortion that may damage the conductor or outer covering.
- e. Pull all cables in a single conduit at the same time. When pulling cables through hand holes, pole shafts, etc., use a pad of firm rubber or other material between the cable and the opening edges to prevent cable damage.
- f. When installing cable in conduit with existing signal cable circuits remove all existing cables and pull them back into the conduit with the new cables.

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- g. The distance between pull boxes in a run of conduit shall not be greater than 100 feet (30 m), unless otherwise shown in the Plans or approved by the Engineer or District Signal Engineer, with the exception of fiber optic cable.
 - h. The distance between pull boxes in a run of conduit for fiber optic cable shall not exceed 750 feet (225 m), unless otherwise shown in the Plans or approved by the Engineer. Identification tape and tone detection wire shall be used for fiber optic cable in conduit. All unused conduit shall have a continuous pull cable installed between pull boxes.

2. Splices

Required splicing shall be performed according to the National Electric Code; use materials compatible with the sheath and insulation of the cable.

Insulate required splices with electrical insulation putty tape, plastic, pressure sensitive, all-weather 1.5 mil (0.038 mm) electrical tape in accordance to standard details.

- a. Make the spliced joints watertight.

Note: Splice detector wires to shielded loop detector lead-in at pull boxes located immediately after the loop wire leaves the roadway. No splices will be permitted in shielded loop detector lead-in cable from this point to the controller cabinet.

R. Conduit and Fittings

Install conduit by type (GRS, HDPE, PVC) as shown in the Plans and the Standard Detail Drawings. Refer to the NEC, for conduit full percentages.

Separate the power cable to the controller cabinet from all other cables in its own 1in (25 mm) galvanized rigid steel conduit except inside poles. Ensure that conduit conforms to Section 682, Section 923 and Section 925 with the following addition:

- Use flexible conduit only where shown in the Details or as directed to do so in writing by the District Signal Engineer.

Use the conduit size specified in the Plans, unless otherwise directed by the Engineer. Obtain written approval from the Engineer prior to installing conduit other than the size specified in the Plans.

All 2 inch (50 mm) conduit elbows shall be "sweep" type. The minimum radius for the elbow is 18 inches (450 mm), unless otherwise approved by the Engineer.

NOTE: Do not use multi-cell conduit.

Install conduit and fittings as follows:

1. Ensure that exposed conduit on poles are galvanized rigid steel (GRS) conduit.
2. Ream the ends of metallic conduit after cutting the threads. Ream other conduit as necessary.
3. Cut the ends square, and butt them solidly in the joints to form a smooth raceway for cables.
4. Make conduit joints to form a watertight seal.

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5. Coat metallic conduit threads with red- or white-lead pipe compound, thermoplastic or Teflon seal. Ensure that they are securely connected.
 6. Make plastic conduit joints with materials recommended by the conduit manufacturer.
 7. Install bushings in the conduit to protect the conductors. When conduit is installed for future use, properly thread and cap the ends of the metallic conduit runs.
 - a. Plug the ends of nonmetallic conduit runs to prevent water or other foreign matter from entering the conduit system.
 - b. Seal the exposed conduit ends with a permanently malleable material.
 - c. Ensure that empty conduit installed for future wire or cable has a nylon pull string or cord inside that is impervious to moisture and rot and can withstand a load of 50 pounds (23 kg) without breaking. Secure this pull cord at each open end and at each pull box.
 8. Ensure that conduit on pole exteriors are mounted with galvanized, two-hole straps or clamps. Place the clamps not more than 3 feet (1 m) from junction boxes, condulets, or weatherheads. Place it at 3 foot (0.9 m) intervals elsewhere.
 - a. Fasten the clamps to wood poles with galvanized screws or lag bolts.
 - b. Do not install conduit risers on concrete, steel, or mast arm poles unless approved by the Engineer.
 9. Install a weatherhead at the end of exterior conduit runs on a pole or other structure to prevent moisture or other matter from entering the conduit.
 10. After installation, ensure that the conduit or fitting placement has not warped or distorted any condulet, terminal, control or junction box.
 11. Ensure Conduit that is terminated at poles is grounded at the pull box.

S. Underground Conduit

Underground conduit includes encased or direct burial conduit.

1. Install the conduit in a trench excavated to the dimensions and lines specified in the Plans.
 - a. Provide at least 18 inches (450 mm) finished cover, unless otherwise specified.
 - b. Under pavement, excavate at least 36 inches (900 mm) below the bottom of the pavement.
2. Before excavation, the Contractor is responsible for determining the location of electrical lines, drainage, or utility facilities in the area to prevent damage.
 - a. Place the conduit where it will not conflict with proposed guardrail, sign posts, etc.
 - b. Change locations of conduit runs, pull boxes, etc., if obstructions are encountered during excavation. Changes are subject to the Engineer's approval.
 - c. Where possible, provide at least 12 inches (300 mm) between the finished lines of the conduit runs and utility facilities such as gas lines, water mains, and other underground facilities not associated with the electrical system.
3. When the conduit run is adjacent to concrete walls, piers, footings, etc. maintain at least 4 inches (100 mm) of undisturbed earth or firmly compacted soil between the conduit and adjacent concrete or, when

the conduit is encased, between the encasement and the adjacent concrete. Unless specified in the Plans, do not excavate trenches in existing pavement or surfaced shoulders to install conduit.

4. When placing conduit under an existing pavement, install the conduit by directional boring, or other approved means. See Section 682 for directional boring pipe specifications. Obtain the Engineer's approval prior to installing conduit by means of boring-method.
5. When the Plans allow trench excavation through an existing pavement or surfaced shoulder, restore the pavement shoulder surface, base, and subgrade according to the Specification.
6. Cut trenches for conduit on a slight grade (0.25 percent minimum) for drainage, unless otherwise specified. When the grade cannot be maintained all one way, grade the duct lines from the center, both directions, down to the ends.
7. Avoid moisture pockets or traps. Excavate vertical trench walls.
8. Tamp the bottom of the trench to produce a firm foundation for the conduit.
9. When necessary to prevent damage, sheet and brace the trenches and support pipe and other structures exposed in the trenches.
10. Conduit installed for fiber optic cable installation shall have identification tape and detectable tone wire installed for detection as specified and detailed in the Project Standard Detail Sheets.
11. Install direct burial conduit as shown in the Plans. Use rigid galvanized steel, or polyethylene conduit. Excavate at least 36 inches (900 mm) below the top of the finished ground or 36 inches (900 mm) below the bottom of the pavement.
12. When rock is in the bottom of the trench, install the conduit on a bed of compacted, fine-grain soil at least 4 inches (100 mm) thick.
13. Conduit installed for fiber optic cable installation shall have detectable tone wire installed for detection as specified in Section 682 and detailed in Standard Detail Sheets.

T. Encased Conduit

Place encased conduit in the locations shown in the Plans unless otherwise specified. Construct as follows:

1. Construct the encasement using Class A concrete that meets requirements in Section 500 .
2. Extend the encasement or conduit under roadway pavements or surfaces 6 inches (150 mm) past the outer edge of paved shoulders or sidewalks, or past curbs if no shoulder or sidewalk is present.
3. Extend the conduit at least 3 inches (75 mm) beyond the encasement.
4. Place 3 inches (75 mm) of concrete in the bottom of the trench and place the conduit on top of it.
5. Temporarily plug the ends of the conduit to prevent concrete or foreign materials from entering.
6. Cover the conduit with at least 3 inches (75 mm) of concrete. Wait to encase the conduit with concrete until the Engineer inspects and approves the conduit.
7. Cure the concrete encasement according to Subsection 500.3.05.Z, except curing may be reduced to twenty-four (24) hours. Use a precast encasement if approved by the Engineer.

U. Backfilling

Immediately backfill the conduit after the Engineer's inspection and approval, except for encased conduit, which must complete a twenty-four (24) hour cure period.

1. Backfill with approved material free of rocks or other foreign matter.
2. Backfill in layers no greater than 6 inches (150 mm) loose depth, up to the original ground level.
3. Compact each layer to one hundred percent (100%) of the maximum laboratory dry density as determined by GDT 7, GDT 24a, GDT 24b, or GDT 67 whichever applies.

V. Conduit on Structures

Install conduits, condulets, hangers, expansion fittings, and accessories on structures according to the Plans and, unless otherwise specified, the following:

1. Run the conduit parallel to beams, trusses, supports, pier caps, etc.
2. Install horizontal runs on a slight grade without forming low spots so they may drain properly.
3. Run conduits with smooth, easy bends. Hold the conduit ends in boxes with locknuts and bushings to protect the conductors.
4. When not specified in the Plans or Special Provisions, submit the type and method for attachment to structures to the Engineer for submission to the District Signal Engineer for approval.
5. Ground galvanized rigid steel conduit in pull boxes.

All exposed conduit shall be galvanized, rigid conduit unless otherwise specified.

W. Testing Conduit

After installing the conduit, test it in the presence of the Engineer.

1. Test conduit using a mandrel 2 inches (50 mm) long and 0.25 inches (6 mm) smaller in diameter than the conduit.
2. Repair conduit to the Engineer's satisfaction if the mandrel cannot pass through. If repairs are ineffective, remove and replace the conduit at no additional cost to the Department.
3. Thoroughly clean the conduits. When installing conduit but wiring at a later date:
 - a. Perform the mandrel test.
 - b. Ream the duct opening to remove burrs or foreign matter.
 - c. Thoroughly clean the duct.
 - d. Provide and install a weatherproof cap at each open end.
 - e. All installed conduit not used or containing cable shall have a continuous nylon pull string installed between junction boxes.

X. Grounding

Ground the cabinets, controller, poles, pull boxes, and conduit to reduce extraneous voltage to protect personnel or equipment.

NOTE: Grounding shall meet the minimum requirements of the NEC.
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Provide permanent and continuous grounding circuits with a current-carrying capacity high enough and an impedance low enough to limit the potential above the ground to a safe level.

Perform grounding as follows:

1. Bond the grounding circuits to nonferrous metal driven electrodes. Use electrodes that are at least 0.625 inches (15 mm) in diameter, 8 feet (2.4 m) long, and are driven straight into the ground.
2. Use the shortest possible ground lead that leads directly to a grounding source.
3. Ensure that the maximum resistance between the ground electrode and the earth ground is no greater than twenty five (25) ohms.
4. Connect the ground electrodes and the ground wire with an exothermic weld or ground rod clamp as approved by Signal Engineer.
5. Connect neutral conductors to the cabinet buss-bar and ground them at each terminal point.
6. Ground the cabinet with a No. 6 AWG solid copper wire between the buss-bar to the ground electrode. Bends shall not exceed 4 inch (100 mm) radius bends.
7. Permanently ground the poles by bonding the No. 6 AWG solid copper wire to a separate ground rod.
8. Ground pole-mounted accessories to the pole.
9. Underground metallic conduit or down guys are not acceptable ground electrodes. Do not use Snap-On connections.
10. For extended distances between Ramp Meter and IVDS additional grounding may be required by the manufacturer.

Y. Ground Rod

Install copper clad ground rods adjacent to the traffic signal pole bases, controller cabinet bases, and in pull boxes to shield and protect the grounding system.

When ground rods are not protected, bury them at least 2 inches (50 mm) below the finished ground level.

1. Use 0.625 inch (15 mm) diameter ground rods at least 8 feet (2.4 m) long. Use copper clad ground rods.
2. Drive single ground rods vertically until the top of the rod is no more than 2 inches (50 mm) above the finished ground.
3. Attach a length of No. 6 AWG solid copper wire to the top of the ground rod using an exothermic weld.
4. When controller cabinets are mounted on timber poles, ground them with No. 6 AWG solid copper wire attached to the ground rod. Run the wire inside a minimum 0.75 inch (19 mm) rigid conduit attached to the timber pole and to the chassis ground in the controller cabinet.
5. When ground penetration is not obtained:
 - a. Place a horizontal ground rod system of three (3) or more parallel ground rods at least 6 feet (1.8 m) center-to-center and 30 inches (720 mm) below the finished ground.
 - b. Ensure that this grounding system produces a resistance of 25 ohms or less.
 - c. Join the ground rods and connect them to the grounding buss of the traffic signal cabinet with No. 6 AWG solid copper wire.

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6. Install a ground wire on wood poles.
 - a. Use at least No. 6 AWG solid copper wire bonded to the grounding electrode and extending upward to a point perpendicular to the uppermost span.
 - b. Place wire staples no greater than 2 feet (0.6 m) apart to secure the ground wire to the pole.
 - c. Connect the span wire to the pole ground using copper split bolt connectors. Provide a separate ground rod for pole mount cabinets. Do not use the pole ground. Bond the pole ground to the pole cabinet ground rod.
 7. Ensure that grounding for signal strain poles conforms to the grounding assembly typical erection Detail Sheet in the Plans.
 8. Permanently ground cabinet and cabinet conduits to a multi-terminal main ground buss.
 - a. Use a No. 6 AWG solid copper wire bonded between the buss and grounding electrode.
 - b. Connect the power company neutral, conduit ground, and grounds of equipment housed in the cabinet to the buss-bar.
 - c. Do not ground to a permanent water system instead of the driven ground rod. Ensure that grounding devices conform to the requirements of the NEC and NEMA.
 9. When testing for resistance ensure the ground is dry. The Contractor is responsible for submitting the ground test results.

Z. Signal Poles

See Section 501 for signal pole materials certification and Subsection 925.2.27, Subsection 925.2.28, Subsection 925.2.29, Subsection 925.2.30 and Subsection 925.2.31 for traffic signal equipment. Refer to the Plans for pole locations.

Where necessary, adjust pole location to avoid utility conflicts. Provide minimum clearance distances between the signal pole and the roadway as specified in the Plans and on the Standard Detail Drawings.

1. Strain Poles

Provide signal strain poles that conform to Section 639.

Provide caissons or foundations that conform to the "Construction Detail for Strain Pole and Mast Arm Pole Foundations" in the Plans.

Determine the required foundation size based on the manufacturer's specified "bending moment at yield" for each pole.

Provide strain poles with manufacturer-installed holes for pedestrian heads and push buttons. Seal unused holes with water tight plugs that match the pole finish provided by the manufacturer of the pole. All steel strain pole holes that are used shall have a rubber grommet or weather head.

Rake the poles during installation to provide a pole that is plumb once the load is applied.

2. Metal Poles

Install metal poles as follows:

- a. Ensure that anchor bolts, reinforcing bars, and ground rods conform to Section 639 and Section 852 and are placed in the excavation.

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- b. Support the anchor bolts with a template to provide the proper bolt circle for the pedestal or pole to be installed. Anchor bolts shall be installed without any modifications. Refer to signal details for proper installation.
 - c. Wire the reinforcing bars together or to the anchor bolts.
 - d. Wire the conduits in the base to the reinforcing bars for support. Ensure that they are accessible above and beyond the foundation.
 - e. Before pouring the foundation concrete, determine that the anchor bolt orientation is correct so that the tensile load is divided between at least two anchor bolts. Pour and vibrate the concrete with the Engineer present.
 - f. Ensure that the pole foundations and pedestals with the anchor-type base conform to Section 500 and Section 639. Do not install or locate poles without the Engineer's approval. Ensure the foundation meets AASHTO guidelines.
 - 1) The Engineer may take a concrete test cylinder as it is being poured.
 - 2) Cure the cylinder and submit it for testing to the Office of Materials and Research.
 - g. If the concrete foundation fails to meet the requirements of the Specifications and is not accepted, replace the foundation upon notification of failure.
 - h. After installing poles and applying the load of the signal span, inspect them for plumb and for the proper horizontal position of the mast arm, when applicable. Make sure all threads of the nut are threaded onto the anchor bolt.
 - i. Correct deficiencies by using the leveling nuts on the anchor bolts or by adjusting the mast arm.
 - j. The Engineer will examine the pedestals and poles for damaged paint or galvanizing. Restore the finish coating where necessary.
 - k. After the Engineer approves the pole installation, provide an acceptable method of protecting the area between the pole base and the top of the foundation to prevent the accumulation of debris. If the finish or galvanized steel materials is scratched, chipped, or damaged, the material will be rejected. The finish may be replaced as specified under Section 645, with the Engineer's approval.
 - l. For poles or arms that need galvanization, thoroughly clean the steel poles and arms and touch up non-galvanized parts with i-d red or original-type primer.
 - m.

NOTE: Never add holes or openings to the metal pole or mast arm without approval from the Office of Bridge and Structural Design.
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 - n. Install a service bracket and insulator on one pole at each intersection to attach power service wire as specified in the Plan Details. Install a disconnect box on the cabinet pole at each intersection to attach power service where the power service is provided overhead.
 - o. Install poles to which controller cabinets are attached with mounting plates, bolts, nipples, and at least two, 2.5 inch (64 mm) threaded openings at the top and at least two (2) 2 inch (50 mm) at the bottom of the pole.
 - p. Attach the fittings to the poles as specified by the manufacturer in the Plans or as the Engineer directs. The fittings may include:

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- Cast aluminum cap
 - Pole clamp hardware for span wire attachment
 - Weatherhead with chase nipples and couplings
 - Galvanized elbow with bushing installed by cutting the pole and welding in place around the entire circumference
- q. The Office of Materials and Research will inspect the anchor bolts. If approved, the Office of Materials and Research will display the inspector's hammer stamp mark on the top of the bolt.
3. Concrete Strain Poles
- a. Ensure that concrete strain poles meet the requirements of Section 639 and detailed construction drawings.
 - b. Install concrete strain poles so that the angle of variance between the eye bolt on the pole and the span wire is less than ten degrees (10°).
 - c. Verify pole hole orientations for pedestrian heads, pedestrian push button stations, luminaries arms, etc., with the Engineer prior to proceeding with traffic signal installation. For poles at cabinet location provide at least two 2.5 inch (64 mm) openings at the top of pole and at least two 2.0 inch (50 mm) threaded openings at the bottom.
 - d. Plug all unused holes. Use Grout or threaded fittings. Match the finish of the pole.

4. Mast Arms

Install mast arms that can accommodate traffic signal mounting hardware and that adhere to the manufacturer's recommended procedures and Section 925 and Section 915. Do not add holes.

- a. Seal the openings in the mast arms to prevent pests from entering.
- b. Align the mast arm to allow the signal heads to hang plumb at the correct height without using extensions.
- c. All Mast arms are to be galvanized unless indicated otherwise in the Plans.

NOTE: The Contractor shall submit a "Mast Arm Pole Chart" to the Engineer and the Office of Bridge and Structural Design for review and approval as described in Subsection 647.1.03.F of this Specification.

Verify pole hole orientations for pedestrian heads, pedestrian push button stations, luminaries arms, etc., with the Engineer prior to proceeding with traffic signal installation.

5. Aluminum Pedestrian Pedestals Poles

Install aluminum pedestal poles, which adhere to Section 850 on breakaway aluminum bases that meet the requirements for breakaway construction. See Section 925 for breakaway base requirements. See the Standard Detail Drawings for Pole and Foundation Details.

- a. Secure at least four anchor bolts in a concrete foundation as shown in the construction Detail.
- b. As an alternate to a concrete foundation install a Pedestal Foundation Anchor Assembly (Subsection 925.2.29). Install the foundation until the top of the base plate is level with the ground. Slide bolt

heads through the keyhole and under the base plate against the bolt head keepers with threads up. Bolt the pole base to the foundation. Adhere to the manufacturers instructions for installation.

- 1) Use a Universal Driving Tool with the correct kelly bar adaptor and bolts supplied with the tool.
 - 2) Attach driving tool assembly to the foundation base plate using the bolts provided with each foundation. Be sure to align the tool so the holes in the tool line up with the proper bolt circle on the foundation.
 - 3) Stand the foundation, with the attached drive tool assembly, upright and attach the drive-tool-foundation to the kelly bar.
 - 4) Raise the kelly bar until the foundation swings free of the ground. Maneuver the kelly bar until the point of the foundation is over the marked installation location.
 - 5) Lower the kelly bar until the point of the foundation is forced into the ground and the helix is flush with the ground surface.
 - 6) Ensure the shaft of the foundation is plumb by checking the shaft with a level on two sides that are at least 90 degrees from each other. Recheck the shaft to be sure it is plumb when the foundation has penetrated 1 foot into the ground.
 - 7) When the base plate of the foundation is 1 (25 mm) to 2 (50 mm) inches above the ground line remove driving tool.
- c. Contain the wiring inside the pole or in approved hardware. Do not allow conduit outside the pole.
 - d. Position the pedestal pole plumb and high enough to clear the pedestrian's head as shown in the Plans. Ensure that the bottom of the pedestrian signal housing including brackets is not less than 10 feet (3 m) from the ground line. If using a vehicle signal housing ensure pole is adequate to give signal head a height of 12 feet (3.6 m)
 - e. Instruct the supplier to furnish a mill certificate that shows the alloy and physical properties of the steel used in fabricating the anchor bolts. The bolts may be subjected to a tensile and shear strength test.

6. Timber Poles

Timber poles do not require the use of concrete for filling the cavity around the pole base.

Use timber poles that meet the requirements of Section 861 and Section 639. Use Class II for all signal support poles. Use Class IV for aerial loop lead-in or communication cable if approved by the Engineer. Poles shall be inspected and include AWW stamp.

Drill wood poles to receive the eye bolt so that the angle of variance between the eye bolt and span wire at each connection is less than ten degrees (10°). See the Standard Detail Drawings for additional information.

Guy timber poles use single or double guy wires as shown in the Plans and as directed by the Engineer. Guy helper cables with separate guy wires when helper signal span cables are indicated in the Plans.

NOTE: Never attach down guy wires to eye bolts. Attach down guy wires to angle guy attachment only and install insulating rods on all down guy installations as detailed on Standard Detail Sheets

AA. Pull Boxes

Ensure that pull boxes conform to the Standard Detail Drawings or Plan Detail Sheet. Install pull boxes as required by the Specifications and Plans.

1. Include provisions for drains in pull box excavations as specified.
2. Do not place the aggregate for the drain until the Engineer approves the excavation.
3. Do not set the pull box until the aggregate is in place.
4. Set the pull boxes in place, level, and install conduits as required. Conduit entrance shall be through the open bottom in Types 1, 2, 3, 4S and 5S. Conduit entrance shall be directly through cored holes in the side walls in Types 4 and 5. Conduit entrance shall be through the conduit terminators in Types 6 and 7.

Adjust the location of the pull box if necessary to avoid obstacles.

Where conduit entrance will be through the side wall in Types 4 and 5, or for conduit other than the terminator size provided in Types 6 and 7, use field cored conduit entrance holes in the side wall of the box. All field coring shall be made with a diamond-tipped masonry hole saw and according to the pull box manufacturer's recommendations.

Use an approved HDPE to EPVC coupling or an underground-type conduit adhesive where joining conduit or conduit bodies of dissimilar materials, such as HDPE-to-EPVC sweeps into pull boxes or installing into pull box conduit terminators.

- Do not locate pull boxes on the curb side of the signal pole in the intersection radius return
 - Install pull boxes so that the long dimension is parallel to the adjacent roadway
 - Install the pull box at a location that is level with the surrounding ground or pavement. Do not place a pull box in a ditch or depression. Unless otherwise shown in the Plans, when installed either in a sidewalk or in the ground, the top of the pull box shall be level with the sidewalk or ground surface.
5. Obtain the Engineer's approval, and begin backfilling and installing the frame and cover. Ground metal lids or covers.

BB. Span Wire and Span Wire Assemblies

Use span wire to support signal heads, cable, and other hardware only. Use messenger cable to support the aerial cable plant. Install span wire and messenger wire where specified in the Plans and in accordance with the Standard Detail Drawings. See Section 925 for information on span wire and messenger cable.

1. Install signal span wire not to exceed the sag specified by the pole manufacturer. Span wire used with timber pole installation shall have a minimum 2.5% sag. Span wire used with strain pole installation shall have a minimum 5% sag.
2. Use helper cables where specified in the Plans and on the Standard Detail Drawings.
3. For construction of a box or modified box span, use bullrings. Be consistent throughout the intersection in use of bull rings or strandvises. If bull rings are not used, standvises shall be interlocked.
4. Install 12 inch (300 mm) diameter drip loop wrapped three times at the cable entrance to signal heads. Arrange cable so that it enters the structure from the bottom of the drip loop. Use a 24 inch (600 mm)

diameter drip loop where cables enter a weatherhead and use 24 inch (600 mm) sag at corners of a span.

5. Use aluminum ties, lashing rods, or aluminum wrap to attach cables to span wire. When using aluminum wrap or aluminum ties spaced at 6 inch (150 mm) increments. Aluminum wrap shall have at least three turns of wrap. Do not use lashing wire on span wire.
6. Ground all span wire and down guy assemblies as shown on Standard Detail Sheets. Bond all span wire together and bond to ground at every pole.

CC. Traffic Signal Heads

Place traffic signal heads according to the signal design and Plan Detail Drawings. Deviation from the Plans must be according to the MUTCD, current edition and at the Engineer's approval. Ensure all Traffic Signal Heads at an installation have the same appearance for the signal heads and the LED Modules. The Ramp Metering enforcement device shall be mounted on the back of one signal per lane and wired to the red display. The enforcement device shall be able to be viewed from downstream on the ramp.

1. Install traffic signal heads at least 17 feet (5.1 m), but no greater than 19 feet (5.7 m) over the roadway. All vertically attached signal head assemblies shall have a metal support plate installed within the top section (RED) indication of the signal head for additional support and stability. Install Ramp Metering traffic signal heads as shown on the Plans Detail Drawings.
2. Adjust signal heads on the same approach to have the same vertical clearance.
 - a. Measure the clearance from the pavement to the lowest part of the assembly, including brackets and back plates.
 - b. Mount traffic signals on poles with a clearance of at least 12 feet (3.6 m) but no more than 19 feet (5.8m) above the sidewalk or pavement grade of the center of the highway, whichever grade is higher.
 - c. Mount and adjust Ramp Metering traffic signals as per the Plan Detail Drawings.
 - d. Mount and adjust Ramp Meter enforcement device (head) as per the Plan Detail Drawings.
3. Connect the signal cable to the wire in each signal head to provide the correct signal indication when the cables are connected to the controller cabinet back panels. Do not splice cables. Use wire nuts to make the connections to the LED signal modules leadin. Make all connections in the top section. Ensure that the black jacket is pulled into the signal head 6 inches (150 mm).
4. Install optically programmable (OP) signal heads as shown in the Plans and Standard Detail Sheet and as directed by the manufacturer.
5. Mount OP heads securely or tether them to limit movement.
6. Mask the OP lamp for directing visibility under the Engineer's supervision.
7. Tether signal heads that have tunnel visors longer than 12 inches (300 mm), at the discretion of the Engineer.
8. Attach signal heads to mast arms using rigid mounting brackets. See Section 925 for equipment information. Adjust signal heads on mast arms so that all red indications on the same mast arm are at the same elevation.

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9. Install lane control heads for reversible lane systems and Ramp Metering heads as shown in the Plans and the Standard Detail Drawings. Center each signal over the lane or lanes under signal control.
 10. Leave a vertical clearance for blank-out signs as shown on the Standard Detail Drawings. Use a spirit level to ensure that the bottom edge of each sign is horizontal.
 11. All LED modules shall be labeled with their turn on date on the backside of the LED insert.

DD. Pedestrian Signal Heads

Install pedestrian signal heads on wood, concrete, steel strain poles, wood or steel auxiliary poles, or metal pedestal poles. Do not mix pole mount methods at the same intersection installation.

Install the pedestrian signal heads as shown on the Standard Detail Drawings and the intersection Plan Sheets and Drawings.

Leave a vertical clearance from the bottom of the head to the ground level of least 10 feet (3 m) unless specified by the Engineer.

1. Pedestal Mounts

Make pedestal mounts with a lower supporting assembly consisting of:

- a. A 4 inch (100 mm) slip-fitter bracket
- b. Hollow aluminum arms with a minimum inside cross-sectional area equal to a 1.5 inch (38 mm) pipe
Use serrated locking devices that firmly hold the signal heads in the required alignment.
- c. For Pedestal Mounts using side hinge "clamshell". Secure "clamshell" to pedestal using 0.75 inch (19 mm) wide and 0.30 inch (0.75 mm) thick stainless steel bands.

2. Pole Mounts (Side of Pole)

For Metal poles, use side hinge "clamshell" mounting hardware or hardware as described in Wood Pole, Metal Pole alternate, or pedestrian pole.

a. Side Hinge "Clamshell"

- Secure the hubs to metal or concrete poles using 0.75 inch (19 mm) wide and 0.030 inch (0.75 mm) thick stainless steel bands. Secure the hubs to wood poles using lag bolts.

b. Wood Pole or Metal Pole alternate:

Make pole mounts with the upper and lower assembly consisting of:

- A post arm with a minimum cross-sectional area equal to a 1.5 inch (38 mm) pipe
- A post hub plate that matches the outside pole contour
- Secure the hubs to metal or concrete poles using 0.75 inch (19 mm) wide and 0.030 inch (0.75 mm) thick stainless steel bands. Secure the hubs to wood poles using lag bolts, or banding.

Space the junctions so that each pedestrian signal head can be directed toward approaching traffic as needed.

Use serrated locking devices that hold the pedestrian signal heads in alignment.

EE. Blank-out Signs

Install blank-out signs as shown on Plans or as follows:

1. Securely fasten the signs to a stationary structure or to a messenger strand support system.
2. Center each sign over the lane or lanes under sign control, where applicable.
3. Leave a vertical clearance for blank-out signs as shown in the Plans or in Subsection 647.3.05.EE, "Traffic Signal Heads." Use a spirit level to ensure that the bottom edge of each sign is horizontal.
4. Use terminal strips to connect each sign electrically to the external control box or cabinet.

FF. Battery Backup System (BBS)

Install Battery Backup System (BBS) if indicated on the Plans. Install in accordance with the option as indicated on the Plans and as directed by the Engineer.

With the Battery Backup submittal provide calculations for determining the size of the inverter and batteries based on the actual power requirements for the intersection installation. Ensure that all auxiliary items are included in the calculations. Ensure the submittal specifies the model number and the firmware revision that is being supplied.

Ensure that the external cabinet supplied meets the Section 925 Specifications and is base mounted next to the 332A cabinet as specified. Do not attach the battery external cabinet to the 332A cabinet unless otherwise specified. The external cabinet option allows for 2 separate configurations. Ensure that the correct configuration is installed in accordance with the Plans. Make all connections to the 332A cabinet through the base of the cabinets.

Provide date of manufacture of all batteries provided.

Ensure the BBS functions as required by the specifications. Ensure the "ON BATTERY" relay provides an input into the controller Alarm 2. Install the two hour run time circuitry from the normally open contacts in the BBS controller to the AC+ and the mercury coil terminal in the traffic signal cabinet.

Ensure that the BBS is enabled to communicate via Ethernet connection.

Provide copy of all documentation (Operation and Maintenance Manual) for items supplied. Include with documentation any communications firmware and cable required to interrogate the unit for status, setup or logs.

GG. Power Meters

Install Power Meters per GDOT Standard Drawings and Utility Provider's Specifications.

647.3.06 Quality Acceptance

A. Testing Loop Detector Installation

Test each loop after installing the conductors in the slots cut in the pavement and before sealing.

- Perform a test where the loop wire is spliced to the shielded lead-in wire and where the shielded lead-in wire enters the controller cabinet

- If there are no splice points, such as in direct entry to the controller cabinet, only perform the tests at the controller
- Record the test results on the Loop Installation Data Sheet in Table 647-10, as shown in this section. Make copies of the data sheet as needed.
- Include the data sheets in the records, and place a copy in the controller cabinet.

Conduct the following five (5) tests to evaluate each loop installation for acceptance before sealing the loop in the pavement:

1. Induced AC Voltage Test

Read 0.05 V AC or less on a digital voltmeter or no deflection on the pointer of an analog meter.

2. Inductance

Inductance (I) is measured in microhenries (mH), and the total inductance is equal to the inductance of loop plus inductance of the loop lead-in.

Acceptable inductance is within 10 percent (10%) of the calculated value for a single loop with the design criteria listed in Table 647-8 and Table 647-9:

Table 647-8 Standard (Bi-Pole) Loops	
6 ft x 6 ft (3 turns) [1.8 m x 1.8 m (3 turns)]	I = 76 mH + 23 mH per 100 feet of loop lead-in cable I = 76 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 30 ft (2 turns) [1.8 m x 9 m (2 turns)]	I = 126 mH + 23 mH per 100 feet of loop lead-in cable I = 126 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 40 ft (2 turns) [1.8 m x 12 m (2 turns)]	I = 165 mH + 23 mH per 100 feet of loop lead-in cable I = 165 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 50 ft (2 turns) [1.8 m x 15 m (2 turns)]	I = 205 mH + 23 mH per 100 feet of loop lead-in cable I = 205 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 70 ft (2 turns) [1.8 m x 21 m (2 turns)]	I = 285 mH + 23 mH per 100 feet of loop lead-in cable I = 285 mH + 23 mH per 30 m of loop lead-in cable

6 ft x 30 ft (2, 4, 2 turns) [1.8 m x 9 m (2, 4, 2, turns)]	I = 269 mH + 23 mH per 100 feet of loop lead-in cable I = 269 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 40 ft (2, 4, 2 turns) [1.8 m x 12 m (2, 4, 2, turns)]	I = 349 mH + 23 mH per 100 feet of loop lead-in cable I = 349 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 50 ft (2, 4, 2 turns) [1.8 m x 15 m (2, 4, 2, turns)]	I = 429 mH + 23 mH per 100 feet of loop lead-in cable I = 429 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 60 ft (2, 4, 2 turns) [1.8 m x 18 m (2, 4, 2, turns)]	I = 509 mH + 23 mH per 100 feet of loop lead-in cable I = 509 mH + 23 mH per 30 m of loop lead-in cable
6 ft x 70 ft (2, 4, 2 turns) [1.8 m x 21 m (2, 4, 2, turns)]	I = 589 mH + 23 mH per 100 feet of loop lead-in cable I = 589 mH + 23 mH per 30 m of loop lead-in cable

3. Leakage Resistance to Ground

The resistance to ground shall be 5 Mohm or more.

4. Loop Resistance

The resistance reading on an ohmmeter is approximately within ten percent (10%) of the calculated value:

- Acceptable Resistance @ (dc @ 68 °F [20 °C]):ohms(μ)
- No. 18 AWG wire: R = 29.4 μ /mile (or) R = 5.5 x 10⁻³ μ /ft. Approximately 5.5 ohms per 1,000 feet of No. 18 AWG wire)[R = 18.3 μ /km (or) R=18.3 x 10⁻³ μ /m]
- No. 14 AWG wire: R = 13.32 μ /mile (or) R = 2.523 x 10⁻³ μ /ft. Approximately 2.52 ohms per 1,000 feet of No. 14 AWG wire)[R = 8.3 μ /km (or) R=8.3 x 10⁻³ μ /m]
- No. 12 AWG wire: R = 5.2 μ /mile (or) R = 9.85 x 10⁻⁴ μ /ft. Approximately 0.98 ohms per 1,000 feet of No. 12 AWG wire [R = 3.24 μ /km (or) R = 3.24 x 10⁻³ μ /m]

5. Loop Q

Q at 50 kHz is greater than 5.

Report to the Engineer an out-of-range reading on any of the above tests. If a test is found unacceptable, remove the loop, install new wire, and repeat the test procedure.

Include in the test results:

- Type and model number of the equipment used (must be ohmmeter having a high resistance scale of R x 10 KW or greater)
- The last calibration date of the equipment and the scale used

Check the loop using an impedance tester to determine the natural operating frequency and impedance. Ensure that the completed units detect all motor vehicles. If the loop detection system does not meet the above test requirements, payment will not be made for work on the signal installation until corrections are completed.

Table 647-10 Loop Installation Data Sheet	
Conditions	
Project Number:	
Date:	
Contractor:	
Weather:	
Temperature:	
Pavement Condition - Wet () or Dry ()	
Location	
City or County:	Phase:
Intersection Name or Number:	Function:
Route Number(s) or Name (s):	Lane Location:
Installation or Plan Sheet Number:	No. of Turns:
Size and Type of Loop:	Downstream/Upstream: Down () Up ()
Distance from Stop Bar:	Distance E.O.P./Curb to Lead-in:
Distance Lead-in Cable:	
Material	
Loop Wire Color/Insulation Type/Gauge:	
Loop Lead-In Wire Color/Insulation Type/Gauge:	
Splice Point:	
Conduit Length from Curb/E.O.P. to Splice Point:	
Conduit Length from Splice Point to Cabinet:	
Sealant Type and Part Number:	
Sealant Manufacturer and Lot No.:	
Interconnect Wire Type and Length:	
Loop Tests	
1. Induced Voltage _____ 2. Inductance _____ microhenries	
3. Leakage Resistance to Ground _____ megohms 4. Loop Resistance _____ ohms 5. Loop Q (Quality) _____ Q	
Comments	
Inspector's Name, and Title	

B. Field Tests

In addition to performing tests during installation and before turning on the equipment, perform the following tests on traffic signal circuits in the presence of the Engineer:

-
- Test each circuit for continuity

Test each circuit for grounds. If a test fails, repair the circuit immediately. New signals shall operate in the flash mode for three (3) days prior to beginning stop-and-go operation unless otherwise directed by the Traffic Engineer.

For Ramp Metering:

The Contractor shall submit to and obtain approval from the Engineer for Ramp Metering testing procedures for each specific Ramp Meter location. The testing procedure shall demonstrate that all components: hardware, cable, and connections furnished and installed by the Contractor operates correctly and that all functions are in conformance with the specifications.

At a minimum, the Contractor shall demonstrate to the Engineer:

- The IVDS and loop detectors at each location are functioning properly with expected accuracy as specified. IVDS burn-in period shall only be in conjunction with the Ramp Meter signal burn-in period of 30 days.
- The Ramp Meter signals function properly at all stages, including non-metering, startup, metering, and shutdown.
- In multi-lane configurations, the Ramp Meter can operate a simultaneous release of vehicles from all lanes and as well as an alternating or staggered release of vehicles from the two (or three) lanes.
- Queue detectors are functioning as specified, including both queue detection and queue override.
- The Ramp Meter functions properly for both local traffic responsive and time of day operations.
- The advance warning sign can be clearly seen and can be activated and deactivated properly.
- The Ramp Meter can communicate properly with the hub/TMC.
- The traffic enforcement heads are operating as per the Plans and can be seen by enforcement personnel.

The Contractor shall coordinate closely with Engineer for conducting Ramp Meter field operational tests.

Note: Pretest should be performed prior to calling the Engineer for formal field tests inspection. Pretest shall be defined as conducting all field tests in accordance with the Ramp Metering field testing procedures submitted and approved. Results of pretests shall be recorded and submitted to the Engineer. The Engineer may require the Contractor to address particular items noted in the pretest before beginning the actual field tests.

Operational test shall not begin until the field tests are accepted by the engineer-that will be performed during the Engineer's inspection. Begin operational tests after the Engineer is satisfied that all work has been completed. After the Ramp Meter has been placed in operation, the Contractor, in coordination with the system integrator, shall demonstrate that all equipment furnished and installed by the Contractor operates with all software and firmware as specified.

After successful completion of the test procedure, each Ramp Meter assembly shall go through a burn-in period for 30 consecutive days of normal Ramp Metering operations. During the burn-in period, the

Contractor shall ensure that all Contractor-supplied equipment operates without failures of any type. If any equipment component malfunctions or fails to provide the specified functionality during the 30-day burn-in period, the Contractor shall replace or repair the defective equipment within 48 hours of notification by the Engineer.

After the malfunctioning component(s) have been repaired or replaced to the satisfaction of the Engineer, the Contractor shall begin a new 30-day burn-in period. The new 30-day burn-in period shall apply only to equipment components supplied by the Contractor. In the event of a failure or malfunctioning of equipment furnished by others which prevents the 30-day burn-in test from continuing, the Engineer will suspend the burn-in test and resume when the other equipment failures are corrected.

C. Operational Tests and Equipment Activation

After the equipment is installed and the field tests are completed successfully the Contractor shall request an initial equipment inspection. The Engineer shall notify in writing the District Signal Engineer a minimum of 14 working days prior to the inspection. The District Signal Engineer shall provide an in depth inspection and provide a written punch list of items for the Contractor to correct. Within fourteen days of the notification the Contractor shall correct the items noted.

Prior to activating new equipment and before removal of any existing intersection control or equipment, test and ensure any communications equipment is functional.

In the event that programming of the controller application is not a pay item for the contract the Engineer will notify the District Signal Engineer a minimum of 14 working days prior to activating the equipment.

Prior to activating equipment all Inductance loop, video detection equipment and detection zones shall be functional and operational.

When defects are resolved, the District Signal Engineer will begin the Contractor's operational test period to demonstrate that every part of the system functions as specified. The operational test shall be concurrent for the entire project.

1. The operational test for the traffic signal and Ramp Metering projects shall be at least thirty (30) days of continuous, satisfactory operation.
2. If a component or system fails or shows unsatisfactory performance, the condition must be corrected and the test repeated until thirty (30) days of continuous satisfactory operation is obtained.
3. The District Traffic Engineer will send the Engineer and Construction Office a letter showing the start, termination, suspension, or successful completion of the operational test period.
4. The District Engineer may recommend payment only after the successful completion of the test period.
5. The Contractor shall obtain written acceptance of the signal installation from the District Traffic Operations Engineer before Final Acceptance.

Costs incurred during operational tests, including power consumption, shall be at the Contractor's expense and included in the price bid for Contract Items.