CITY OF DUBUQUE
ENGINEERING DIVISION

2019
STREET LIGHTS &TRAFFIC SIGNAL SPECIFICATIONS

CITY OF DUBUQUE

50 WEST 13TH STREET
DUBUQUE, IOWA 52001

ENGINEERING DIVISION: (563) 589-4270

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ABBREVIATIONS

AASHTO - **American Association of State Highway and Transportation Officials**
ASA - American Standards Association
ASP - Advance Simple Profile
ASTM - American Society for Testing Materials
CC - Contact Closure
CTAD - tracking advance detector
ETA - estimated time of arrival
FDP - fiber distribution points
HH - Handhole
IMSA - International Municipal Signal Association
IPDVMS - Integrated Digital Video Management System
IVAS - Intelligent Video Analysis System
LED - Light Emitting Diode
LQI - Line Quality Indicator
MH - Manhole
MUTCD - Manual on Uniform Traffic Control Devices
NA -Numerical Apertures
NC - normally closed
NEC - National Electrical Code
NEMA - National Electrical Manufacturers Association
NO - normally open
OTDR - optical time domain reflectometer
RPD - radar presence detector
RSSI - Received Signal Strength Indicator)
RVSD - vehicle sensing devices
SP - Simple Profile
TCHH - Traffic Signal Tub
TMC - Traffic Management Center
UL - Underwriters Laboratory

1. GENERAL

1.1 This part of the specifications includes the furnishing of all material and equipment necessary to complete, in place and operational, a traffic control signal(s) as described in the project plans.

1.2 The installation of the traffic control signals and appurtenances shall be in conformance with the current edition of the Manual On Uniform Traffic Control Devices.

2. EQUIPMENT AND MATERIALS

2.1 Fabrication or assembly process materials shall comply with the applicable parts of Section 2523 "Highway Lighting" of the "1992 Standard Specifications" with the additions as stated herein.

2.2 Equipment and materials shall be of new stock unless the plans provide for the relocation of or the use of fixtures furnished by others. New equipment and materials shall be the product of reputable manufacturers of electrical equipment, and shall meet Engineer approval.

2.3 One (1) copy of catalog cuts and manufacturer's specifications shall be furnished for all standard "off-the-shelf" items shall be emailed to the City of Dubuque.

Engineer review of shop drawings and catalog cuts shall not relieve the Contractor of any responsibility under the Contract documents.

2.4 All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), and all material and work shall conform to the requirements of the National Electrical Code (NEC), the Standards of the American Society for Testing Materials (ASTM), the American Standards Association (ASA), and local ordinances. Miscellaneous electrical equipment and materials shall be UL approved.

Wherever reference is made in these specifications or in the standard provisions to the code, the safety orders, the general order, or the standards mentioned above, the reference shall be construed to mean the code, order, or standard that is in effect at the date of advertising of these Specifications.

2.5 Certification from the manufacturers of all electrical equipment, signal supports, conduit and cable shall be supplied by the Contractor stating said material complies with these Specifications.

2.6 Any existing traffic signal equipment designated to be removed on the project shall remain the property of the City of Dubuque, unless Dave Ness or Duane Richter, City of Dubuque, 563-589-4270, indicates the Contractor shall retain ownership. The Contractor shall deliver any removed equipment to the City of Dubuque Public Works Department at the address given by the City Project Engineer. The Contractor shall take all reasonable precautions in protecting existing equipment. If any equipment is damaged, the Contractor shall be liable for replacement. The existing signal shall remain in operation until the new system is ready for service. The Contractor shall notify the City Project Engineer and Police Dispatcher prior to any operational shutdown of the traffic signals, either existing or new.

3. SCHEDULE OF UNIT PRICES

3.1 Complete and forward to the Owner a copy of a list of unit costs for each item listed on the Schedule of Unit Prices attached to the Specifications by the preconstruction meeting. The sum of the costs for each item shall equal the total Contract Lump Sum price for the traffic signal installation(s). Monthly estimates of the work performed on the project will be made by the Owner and the unit costs will be used to prepare progress payments to the Contractor. The unit costs will also be used to establish the total cost for any Extra Work Orders related to traffic signal installation work items unless otherwise negotiated.

4. TESTING AND MAINTENANCE OF SIGNAL EQUIPMENT

4.1 Notify the Engineer the date the signal or signal system will be ready for testing once the project is open to traffic.

4.2 Upon authorization of the Engineer, place the signal or signal system in operation for a consecutive 30-day test period. The signal(s) shall not be placed into operation without prior notification and authorization of the Engineer. Any failure or malfunction of the equipment furnished by the Contractor, exclusive of minor malfunctions (such as lamp burnouts) occurring during the test period, shall be corrected at the Contractor's expense and the signal or system tested for an additional 30 consecutive day period. This procedure shall be repeated until the signal equipment has operated satisfactorily for 30 consecutive days.

4.3 A representative from the manufacturer and/or supplier of the signal controller shall be at the project site when the signal controller(s) are ready to be turned on, to provide technical assistance including, as a minimum, programming of all necessary input data. All required signal timing data shall be provided by the Engineer.

4.4 After signal turn on and prior to final acceptance of the completed traffic signal system, the Contractor shall respond, within 24 hours, to perform maintenance or repair of any failure or malfunction reported.

5. GUARANTEE

5.1 In addition to warranties or guarantees on specific traffic signal equipment listed elsewhere in these specifications, the Contractor shall fully guarantee the traffic control signal installation furnished as part of the contract against defective equipment, materials and workmanship for 24 months. Should any defect develop under normal and proper operating conditions within these specified periods after acceptance of the completed installation by the Owner, this malfunction shall be corrected by, and at the expense of the Contractor, including all labor, materials, and associated costs.

5.2 This guarantee shall be provided in writing on company or corporation letterhead stationery by the Contractor to the Owner prior to final acceptance. The Contractor shall transfer all required equipment warranties on the date of final acceptance to the Owner.

6. HANDHOLES/VAULTS

6.1 Handholes/Vaults shall be installed at the locations shown on the plans, and at such additional points as the Contractor, at his own expense, may desire to facilitate the work.

Furnish precast concrete handhole or fiber vault, or fiberglass handhole, each with cast iron ring and cover or heavy duty fiberglass cover as specified in plans.

6.2 **24" Round Handhole HH 24-36**

The 24" round handhole shall be a 3" thick concrete 24" diameter by 36" in depth with a 22.25" cast iron manhole cover with the legend "Traffic Signal" set flush to the ground. Each HH 24-36 handhole shall have a 5/8" by 10' ground rod driven into the center of the handhole (for later use if not needed immediately). Each HH 24-36 shall include a drainage system as shown in the plans. The body of the pre-cast handhole shall meet the requirements for Class 1500D concrete pipe insofar as applicable. Cast iron ring and shall be rated heavy duty for traffic areas (320 pounds minimum) where shown on the plans. Deviations in weights shall not exceed plus or minus five percent. The cover shall have the words "TRAFFIC SIGNAL" cast on the top of the cover. Cable hooks - Four (4) cable hooks shall be provided in all handholes as detailed on the plans. Cable hooks shall be galvanized steel with a minimum diameter of 3/8" and a minimum length of 5" and anchored in the wall of the handhole utilizing appropriate anchoring devices.

6.3 **Fiber Vault, Square FVS48-48**

Fiber Optics Junction Vault shall be a Square 48" x 48" outside dimension, 36" x 36" inside dimension fiber vault manhole. Vault shall be 48" deep (inside dimension). Each vault shall include a drainage system (where applicable) as shown on in the plans. The vault will have 4 – ¾" drain holes in the sump pit for water to drain. The fiber vault shall include the following:

A minimum of 4 cable hooks will be installed in each vault to support fiber optic cables. Maintain 18" of clean stone beneath and around the structure.

Fiber optic square hand holes will be installed at the locations specified on the construction documents (Typically 1000' apart feet or less).

Vaults shall be installed in a neat and workmanlike manner. Damaged vaults will not be accepted. All conduits shall enter the vault at a depth of 18" to 30" from the bottom of the vault. Any deviations from this requirement shall be approved by the Engineer. All holes cut into vaults for conduit entry/exit shall be core drilled from the inside out or shall use manufactured knock-outs of appropriate size. All penetrations shall be sealed as indicated in conduit section of the specifications. The ends of all conduit leading into the handhole shall fit approximately 4" beyond the inside wall. If primary conduit leading into vault contain 4 smaller conduits, a quadplex plug is to be installed on the conduit. Any empty conduits should also be plugged as detailed in the conduit section of the specifications. A coarse aggregate drain conforming to the dimensions shown on the plan details shall be provided when applicable. Cast iron rings and covers for handholes shall be set flush with the sidewalk or pavement and 1" above the surface of the ground when installed in an earth shoulder away from the pavement edge. Any backfilling necessary under a pavement or paved sidewalk or within 2' of the pavement edge shall be made with stone screening.

Installation of the fiber vault shall include all transportation, labor, material, connections, excavation, backfilling, and compaction necessary to completely install the Fiber Optics Junction Vault at the locations specified on the plan.

6.4 **Fiber Vault, Round FVR 48-48**

Use the FVR48-48 which is an internal 48" diameter x 48" deep fiber vault manhole. This vault will have a 4" or larger opening in the bottom sump area with 4 – ¾" drain holes in the sump pit for water to drain; 8 knockout locations, each measuring 2'-2" x 6" x 2 ¼ every 45 degrees in angle;

and a 48" lid with a 24" cast iron cover marked "Fiber Optics" as shown on the details in the plans. A minimum of 4 cable hooks will be installed in each vault to support fiber optic cables. All components are to be plastic, aluminum, or stainless steel to avoid rusting. Each vault shall have a 5/8" by 10' ground rod driven into the ground near the sump pit opening. This ground and the tracer wires shall be wired together and (if applicable) into the locator station. Each vault shall include a drainage system as shown on in the plans (Where applicable).

Vaults shall be installed in a neat and workmanlike manner. Damaged vaults will not be accepted. All conduits shall enter the vault at a depth of 18" to 30" from the bottom of the vault. Any deviations from this requirement shall be approved by the Engineer. All holes cut into vaults for conduit entry/exit shall be core drilled from the inside out or shall use manufactured knock-outs of appropriate size. All penetrations shall be sealed as detailed in the conduit section of the specifications. The ends of all conduit leading into the handhole shall fit approximately 4" beyond the inside wall. If primary conduit leading into vault contain 4 smaller conduits, a quadplex plug is to be installed on the conduit. Any empty conduits should also be plugged as detailed in the conduit section of the specifications. A coarse aggregate drain conforming to the dimensions shown on the plan details shall be provided. Cast iron rings and covers for handholes shall be set flush with the sidewalk or pavement and 1" above the surface of the ground when installed in an earth shoulder away from the pavement edge. Any backfilling necessary under a pavement or paved sidewalk or within 2' of the pavement edge shall be made with stone screening.

Installation of the fiber vault shall include all transportation, labor, material, connections, excavation, backfilling, and compaction necessary to completely install the Fiber Optics Junction Vault at the locations specified on the plan.

6.5 **Traffic Signal Tub, (Indicated as "TCHH" and located adjacent to the Control Cabinet**

Tubs shall be as shown on plan details. Construction shall be a 36"x36"x24" precast concrete with cast iron lid (R-6689) with the legend "Traffic Signal" on the lid. A minimum of four (4) cable hooks will be installed in each hand-hole to support the signal cables. Hand-holes shall be constructed with a open bottom. Covers shall support an 8,000 pound load over a 10" square with a minimum test load of 12,000 pounds. Covers subject to heavy loads shall support a 15,000 pound load over a 10" square with a minimum test load of 22,568 pounds. A coarse aggregate drain shall be provided. The ground rod assembly at this location shall conform to the Grounding and Bonding at a cabinet location standard.

6.6 Handholes/Vaults in the immediate intersection shall conform to the Grounding and Bonding section of the specifications.

6.7 Handholes/Vaults shall be installed in a neat and workmanlike manner. When the use of forms is required they shall be set level and of sufficient thickness to prevent warping or other deflections from the specified pattern. A means shall be provided for holding conduit runs rigidly in place while the concrete is placed. All conduits shall enter the handhole at a depth of 12 inches from the bottom of the handhole unless otherwise specified. Any deviations from this requirement shall be approved by the Engineer. The ends of all conduit leading into the handhole shall fit approximately 2 inches beyond the inside wall. A coarse aggregate drain conforming to the dimensions shown on the plan details shall be provided. Cast iron rings and covers for handholes shall be set flush with the sidewalk or pavement and one inch (1") above the surface of the ground when installed in an earth shoulder away from the pavement edge. Any backfilling necessary under a pavement or paved sidewalk or within two feet (2') of the pavement edge shall be made with stone screening. Damaged handholes/vaults or covers will not be accepted. Damaged handholes/vaults will need to be replaced prior to acceptance. Handholes/vaults are not to be installed in the flow lines of a ditch.

7. CONDUIT SYSTEM

7.1 The number, type, and size of conduit shall be as shown on the plans. Conduit shall meet the requirements of Sections 2523.10 and 4185.10 of the Iowa DOT Standard Specifications.

7.1.1 Conduit shown on the plans as rigid steel shall be galvanized steel meeting the requirements of ANSI Standard Specification C80.1, latest revision.

7.1.2 Conduit shown on the plans as polyvinyl chloride (PVC) conduit shall meet the requirements of NEMA TC-2, Type 2, and applicable UL Standards. HDPE conduit with an SDR of 13.5 will be allowed to be used in place of PVC conduit.

7.1.3 Conduit for interconnect runs shall be Inner duct as shown on the plans. Inner duct conduit shall be schedule SDR 13.5 high density polyethylene. Conduit shall provide nominal duct size as indicated on the plans, shall be orange in color unless otherwise specified, and be longitudinally ribbed on the inside wall.

7.1.4 Conduit attached to structures shall be nonmetallic, similar in color to the structure, and rigid enough not to sag under its own weight plus the weight of its contents between brackets.

7.2 Conduit shall be placed as shown on the plans. All locations subject to minor changes pending City of Dubuque Engineering. Change in direction of conduit shall be accomplished by bending such that the conduit will not be injured or its internal diameter changed. Bends shall be of uniform curvature and the inside radius of curvature of any bend shall not be less than six (6) times the internal diameter of the conduit.

7.3 When it is necessary to cut and thread steel conduit, no exposed threads will be permitted. All couplings shall be tightened until the ends of conduits are brought together so that an electrical connection will be made throughout the entire length of the conduit run. All conduit and fittings shall be free from burrs and rough places and all conduit runs shall be cleaned, swabbed and reamed before cables are installed. Nipples shall be used to eliminate cutting and threading where short lengths of conduit are required. Damaged galvanized finish on conduit shall be painted with zinc rich paint. All fittings used with rigid steel conduit shall be galvanized steel only.

7.4 Approved conduit bushings shall be installed on the exposed ends of rigid steel conduit. Bell end fittings shall be installed on the exposed ends of PVC conduit. In all bases, conduit shall extend a minimum of 4 inches above the finished surface.

7.5 Whenever converting from PE to PVC or PE to PE or PVC to PVC conduits splicing shall be accomplished as follows:

7.5.1 If splicing from PE to PE a fusion splice is required. Fusion splicing shall not cause significant interior deformation or ridges. If deformation or ridges are present the conduit needs to be cut and refused.

7.5.2 If splicing from PE to PVC the approved coupling is a Shurlock II system as manufactured by AD Technologies or approved equal for the appropriate size conduit.

7.5.3 If splicing from PVC to PVC, an approved PVC primer must be applied along with an approved PVC glue to seal the connection.

7.5.4 If existing splices are in place and need to be repaired, or coupling is needed for conduits with existing infrastructure, the approved coupling is the MOR Clamp or approved equal.

The MOR Clamp is manufactured by AD Technologies. The MOR Clamp shall only be used with the approval of the engineer.

7.6 Conduit buried in open trenches shall be placed a minimum of 24 inches deep unless otherwise directed by the Engineer. Open trench methods of placing conduit will be permitted except where the conduit is to be placed under existing pavement. If conduit is installed in an open trench, the conduit must be placed on backfill for support. Conduit in pavement areas shall be placed to a minimum depth of 24 inches below the finished pavement surface or as directed by the Engineer.

7.7 Inner duct and conduit containing fiber optic cable shall be buried a minimum of 42 inches.

7.7.1 Generally 4 -1½" 13.5 HDPE 4 color (Red, Blue, Green, Yellow) conduits will be installed between vaults. One exception to this rule is when there is not a receiving vault at the end of this conduit, in which case the conduit shall be capped with a tracer wire installed

7.7.2 2"HDPE SDR 13.5 fiber conduit from the fiber vault to the traffic control cabinet shall make a direct path between the two structures and should be kept separate from any intersection wiring conductors and handholes. This fiber conduit shall terminate in the back left side of the traffic control cabinet.

7.7.3 In areas where fiber inner duct it is open trenched, it shall also contain 3" non-detectable underground tape: "CAUTION BURIED FIBER OPTIC LINE BELOW" (Orange) at approximately 18" to 24" in depth.

7.7.4 Tracer wire will be tied together at all fiber vault locations. The tracer wire shall be pulled alongside of the bored or trenched conduit. Tracer wire for open-trench installation shall be a 10 AWG solid, PRO-TRACE® HF-CCS PE30 with orange insulation color. Conductor shall be soft-drawn, 21% IACS, copper clad steel, utilizing a AISI 1006 low carbon steel core (required to meet break load and flexibility), with break load of 448 lbs (55,000 psi). Conductor shall be extruded with a 30 mil, high density polyethylene, and meet the APWA color code of the buried utility line. Tracer wire shall be rated for direct burial use at 30 volts and RoHS compliant. Tracer wire shall be PRO-TRACE ® HF-CCS PE30 as manufactured by Pro-Line Safety Products.

7.7.5 Existing conduit may consist of a 4" fiber conduit between vaults which will contain 4 – 1" HDPE inner-ducts as detailed below. One exception to this rule is when there is not a receiving vault at the end of this conduit, in which case the conduit shall be capped with a tracer wire installed. Installation of 1" conduits shall be with a pulley system at the same horizontal level as the conduit. This is to prevent tearing, or crushing of the 4" conduit.

7.7.6 All larger conduits that contain smaller 1" conduits shall have a Quadplex type seal installed between the larger conduit and the 4 smaller conduits. An Orange 10-gauge tracer wire shall also be pulled along with the 4 - 1" conduits. This tracer shall follow along one of the smaller conduits as the Quadplex seal is installed. These 4 smaller conduits shall be the following colors: RED, GREEN, BLUE, and YELLOW. These 4 smaller conduits shall not extend more than 3 inches nor less than 1 inch past the end of the larger conduit. Follow manufacturer's specifications for PE and allow for the proper amount of shrinkage after the inner-duct is pulled. The tracer wire shall not be installed inside any of the 1" inner ducts.

7.8 The backfill material in open trenches shall be deposited in layers not to exceed 6 inches in depth and each layer shall be thoroughly compacted before the next layer is placed. Backfill material

shall be free of cinders, broken concrete, or other hard or abrasive materials. All surplus material shall be removed from the public right-of-way.

7.9 Whenever excavation is made across parkways, driveways or sodded areas, the sod, topsoil, crushed stone or gravel shall be replaced or restored as nearly as possible to its original condition and the whole area involved shall be left in a neat and presentable condition. Concrete sidewalks, pavements, base courses and bituminous surfaces shall be replaced with new materials. Surface restoration in grass areas shall be considered incidental to the bid items of the project and will not be paid for separately unless a bid item has been provided for the surface replacement.

7.10 "Pushed" conduit shall be placed by jacking, pushing, boring or any other means necessary to place the conduit without cutting, removing, or disturbing existing pavement. The size of a bored hole shall not exceed the outside diameter of the conduit that is to be placed. Tunneling under the pavement or water jetting will not be permitted. Pits for boring shall not be closer than two (2) feet to the back of curb unless otherwise directed by the Engineer.

7.11 All conduit openings in the controller cabinet, handholes, and bases shall be sealed with an approved polyurethane expansion joint sealing compound such as BASF Sonolastic NP1, Bostik Chem-Calk 915, Tremco Vulkem 116 or approved equal. This compound shall be readily workable soft plastic. It shall be workable at temperatures as low as 30° F, and shall not melt or run at temperatures as high as 300° F.

7.12 All empty conduits to have flat polyester pull-tape (1,250 lbs. tensile) with footing markings, including each of the 4 - 1½" and 4 – 1" inner ducts when connecting to existing conduit. This pull-tape is to be attached to the expandable plug and sealed within conduit with a minimum of 48" of slack in the pull-tape on each end (96" total).

7.13 Conduits entering handholes or vaults shall enter with no more than 4" or less than 1" of exposed conduit inside of the handhole. All conduits shall contain an orange 10-gauge tracer wire and be plugged with an expandable rubber plug.

7.14 Trenches need to be excavated straight and true with bottom uniformly sloped to low points. Excavate trenches to a depth of 3" below invert of pipe, unless otherwise indicated. Backfill with porous backfill 2' over water lines and conduit followed by native material (no organic material or rocks larger the 1" or debris) in all areas where no pavement would be placed. Course sand backfill material with hydraulic compaction can be used in trenches that are too narrow to be compacted by mechanical compactors. Trenches under all paved surfaces will be backfilled with compacted limestone to sub-grade elevation. In lawn areas, any settling that occurs shall be repaired and re-graded before seeding is done.

7.15 The length measured for payment shall be the plan distance along a straight line measured between changes in direction and the center of terminal structures.

7.16 General Guidelines (unless otherwise specified)

7.16.1 Generally, a 4" PVC or HDPE (if bored) will be used between the traffic controller and signal base. A 2" PVC or HDPE will be used to connect to the upright pedestal signals. Conduit placed under the street will be assumed to be bored unless otherwise noted.

7.16.2 Street lighting conduit will be installed from the service pedestal into the hand-hole located next to the traffic controller. The metered service feed for the traffic controller will be fed directly into the front right side of the controller base. The metered service for the Fiber Hub cabinet will be fed directly from the meter pedestal to the right side of the fiber hub base.

7.16.2 All empty and used conduits at foundation locations shall be plugged. Empty conduits

shall be plugged with appropriate sized duct plugs. Conduits with conductors shall be plugged with duct seal.

8. WIRING

8.1 Where practical, color codes shall be followed so that the red insulated conductor connects to the red indication terminal, yellow to yellow, and green to green. Circuits shall be properly labeled at the controller by durable labels, or other appropriate methods, attached to the cables.

8.2 All cable runs shall be continuous from connections made in the handhole compartment of signal pole bases to the terminal compartment in the controller cabinet. Splicing will not be allowed in underground handholes unless specifically called for on the plans.

8.3 Power lead-in cable runs shall be continuous from the Power Company service point to the service pedestal and from the service pedestal to the controller cabinet.

8.4 Slack for each cable shall be provided by a four (4) foot length in each handhole and a two (2) foot length in each signal pole, pedestal and controller base (measured from the handhole compartment in the pole to the end of the cable). No coils for grounding and bonding wire will be permitted in the handholes.

8.5 Cables shall be pulled through conduit by means of a cable grip designed to provide a firm hold upon the exterior covering of the cable or cables, with a minimum of dragging on the ground or pavement. This shall be accomplished by means of reels mounted on jacks, frame mounted pulleys, or other suitable devices. Only vegetable lubricants may be used to facilitate the pulling of cable.

8.6 Conductor dimensions on construction plans are plan length between bases, contractor must adjust for any vertical runs.

9. ELECTRICAL CABLE

9.1 General

9.1.1 Electrical cable for intersection signalization shall be rated 600 volts minimum.

9.1.2 The number of conductors and size of all electrical cable shall be as shown on the plans.

9.1.3 All wire shall be plainly marked on the outside of the sheath with the manufacturer's name and identification of the type of the cable.

9.2 Power Lead-In Cable

9.2.1 Power lead-in cable shall be 600 volt, single conductor, stranded copper, Type XHHW, with UL approval and size as shown on plans. All underground cable shall be in conduit of the type and size shown on the plans and shall conform to the National Electric Code currently in effect. Unless otherwise specified, use a 3 conductor #8 gauge (Black, White, Ground) to feed between the traffic control pedestal and the meter pedestal.

9.3 Signal Cable

9.3.1 Signal cable shall be 600 volt, multi-conductor copper wire. Signal cable shall meet the requirements of the International Municipal Signal Association (IMSA) Specification 19-1 stranded, latest revision thereof for polyethylene insulated, polyvinyl chloride jacketed signal cable.

9.3.2 Unless otherwise specified in the plans:

9.3.2.1 All conductors shall be #14 AWG.

9.3.2.2 This cable should homerun from each corner quadrant to control cabinet as single 12 or 20 conductor A 7 conductor #14 gauge IMSA 19-1 wire to feed from each signal head to the transformer base at the bottom of each signal.

9.3.2.3 7 conductors will also feed from the transformer base to each “Walk/Don’t Walk, Countdown” combination pedestrian head.

9.3.3 Conductor color coding shall be provided by the use of base colored insulation in accordance with the above referenced specifications. Color coding by the use of words or numerals printed on the insulation will not be accepted.

5 Conductor (Standard Colors) reserved for pedestrian pushbuttons

1. Black
2. White
3. Red
4. Green
5. Orange

7 Conductor (Standard Colors)

1. Black
2. White
3. Red
4. Green
5. Orange
6. Blue
7. White with Black Stripe

12 Conductor (Standard Colors)

1. Black
2. White
3. Red
4. Green
5. Orange
6. Blue
7. White with Black Stripe
8. Red with Black Stripe
9. Green with Black Stripe
10. Orange with Black Stripe
11. Blue with Black Stripe
12. Black with White Stripe

20 Conductor (Standard Colors)

1. Black
2. White
3. Red
4. Green
5. Orange
6. Blue
7. White with Black Stripe
8. Red with Black Stripe
9. Green with Black Stripe
10. Orange with Black Stripe
11. Blue with Black Stripe
12. Black with White Stripe
13. Red with white stripe
14. Green with white stripe
15. Blue with white stripe
16. Black with red stripe
17. White with red stripe
18. Orange with red stripe
19. Blue with red stripe
20. Red with green stripe

Signal Head Color Code Legend

Red -	Red Ball
Orange -	Yellow/Amber Ball
Green -	Green Ball
Black -	Yellow/Amber Arrow
Blue -	Green Arrow
Blue with Black Stripe	Walk
Black with White Stripe	Don't Walk

Example of Conductor Usage
Double Head, Double Ped using a 12 conductor

One phase solids
One phase with black stripes

Solid Blue	Ped 1
Solid Black	Ped 1
Blue with Black Stripe	Ped 2
Black with White Stripe	Ped 2

Mastarm
7 conductor to/from each head to transformer base

Transformer base to controller - Whatever is needed to complete phases, typically a 12 or 20 conductor as specified on the plans.

Mastarm/Head Naming Convention

Mastarm closest to controller cabinet = Pole #1

Then Clockwise Pole #2, Pole #3, Pole #4 Etc.

Signal heads numbered from farthest end of mastarm (#1) to transformer base
Signal Head #1, #2, #3 etc.

Ped heads numbered from top to bottom starting with direction of mastarm, then in a clockwise direction. If no mastarm exists, then North is #1

All cables labeled Pole #1 Head #1, Pole #1 Head #2, Pole #1 Ped #1

Example
Pole #1 Head #1, Pole #1 Head #2, Pole #1 Head #3, Pole #1, Ped #1, Pole #1, Ped #2

Pole #2 Head #1, Pole #2 Head #2 Pole #2 Ped #1

9.4 Loop Detector Wire (With Plastic Tubing)

9.4.1 The loop wire shall meet the requirements of the International Municipal Signal Association (IMSA) Specification 51-5, latest revision thereof for polyvinyl chloride insulated, nylon jacketed, loosely encased in a polyvinyl chloride or a polyethylene tube loop detector wire. The conductor shall be #14 AWG unless otherwise specified on plans.

9.5 Detector Lead-In Cable

9.5.1 Detector lead-in cable shall meet the requirements of the International Municipal Signal Association (IMSA) Specification 50-2, latest revision thereof for polyethylene insulated, polyethylene jacketed loop detector lead-in cable. All conductors shall be #14 AWG unless otherwise specified on the plans.

9.6 Tracer Wire

9.6.1 A tracer wire shall be installed in all conduits with the exception of conduits running between detector loops in the pavement and the initial handhole.

9.6.2 Tracer wire shall be a 10 AWG solid, PRO-TRACE® HF-CCS PE30 with orange insulation color. Conductor shall be soft-drawn, 21% IACS, copper clad steel, utilizing a AISI 1006 low carbon steel core (required to meet break load and flexibility), with break load of 448 lbs (55,000 psi). Conductor shall be extruded with a 30 mil, high density polyethylene, and meet the APWA color code of the buried utility line. Tracer wire shall be rated for direct burial use at 30 volts and RoHS compliant. Tracer wire shall be PRO-TRACE ® HF-CCS PE30 as manufactured by Pro-Line Safety Products.

9.6.3 The tracer wire shall be spliced in the handholes and controller to form a continuous network.

9.7 Street Light Cable

9.7.1 Street light cable for underground lighting circuits shall be single conductor, Class B stranded, annealed copper, six-hundred (600) volt, ninety (90) degrees centigrade Type XHHW. Street light cable shall be of the size shown on the plans. All underground cable shall be in conduit of the type and size shown on the plans and shall conform to the National Electric Code currently in effect. Unless otherwise specified, use a 3 conductor #8 gauge XHHW (Black, White, Green) to feed between the luminaires and the meter pedestal.

9.8 Cable Installation

9.8.1 All classes of cable shall be shipped on substantially constructed reels plainly marked as to size, type, and insulation identification. Only one (1) length of cable will be shipped on each reel. All cable must be new. Damaged cable, or repairs to damaged cable, will not be permitted.

Prior to the installation of underground cable, the Contractor shall make sure that the conduit is open, continuous, free of water, and clear of debris. The cable shall be installed in such a manner and by such methods as to ensure against harmful stretching of the conductor, injury to the insulation, or damage to the outer protective covering of the cable. No splices or joints will be permitted to be drawn inside the conduit. Where more than one (1) cable is to be installed in the conduit, all shall be pulled at the same time. No splices or joints shall be made in any cable outside of pole bases or traffic signal heads. All splices or joints of cable in pole bases shall be made waterproof using high grade rubber splicing tape; and the finished splice or joints shall be waterproofed and covered with vinyl plastic tape to provide mechanical protection in accordance with these

special provisions. An approved cable lubricant may be used to aid in pulling cables through conduit when necessary to avoid stretching the conductor or damaging the insulation.

The Contractor shall provide drip loops at all signal hangers, wire inlet and service entrance heads. All wire inlets on the poles and signal heads shall be sealed with duct seal.

9.8.2 All splices and connectors shall be covered with rubber type electrical insulation tape, applied one and one-half (1-½) times the thickness of the cable insulation. All bolt type connectors shall be wrapped with one (1) layer of paper tissue prior to the application of the electrical insulation tape. The insulation tape shall be covered with a one-half (1/2) lapped layer of thermoplastic electrical insulating tape extended past the rubber insulation tape at each end of the splice. Splices shall be finished with an application of asphaltic impregnated open mesh fabric tape or coated with a waterproof compound. A layer of conductive shielding tape shall be applied to any splice of two (2) shielded cables to continue the shield through the splice. All splices shall be made in accordance with the cable manufacturer's recommendations.

Connectors shall be either a bronze, bolted type, soldered, or a compression sleeve type. Connectors of the proper size to fit the largest conductor in the connection shall be used to join wires in pullboxes and pole bases. All connectors shall be Underwriters Laboratory (UL) approved.

Wire ends must be thoroughly cleaned after the insulation is stripped off to insure complete contact with another wire, or the connector. If strands are damaged when the insulation is removed, the section of cable must be discarded. Nicked or damaged conductor strands will not be permitted inside of connectors. Loose wire ends shall not be used as "shims" to make a connection.

Covered connections must be arranged so that they will not be in contact with pullbox lids or metal pole bases.

All splices and connections shall be capable of satisfactory operation under continuous immersion of water.

Cable connections in signal heads and controller cabinets shall be made at the terminal boards provided for this purpose. All stranded wires inserted under a binder head screw shall be equipped with a solderless pressure type space connector with a pre-insulated shank. All solid wire shall have an eye bend and shall not have a terminal connector.

10. CONCRETE BASES

10.1 Concrete bases/foundation for traffic control cabinets, fiber hub cabinets, light poles, pedestal poles, electrical services and battery backups should be precast from a pre-approved vendor.

Traffic signal pole footings shall be installed with the conduit shown on the plans plus one additional 2" PVC conduit stubbed out of the footing for future use. Precast signal foundations are allowed, if precast foundations are provided, they shall be from an approved vendor. Traffic signal controller footings shall be installed with the conduit shown on the plans plus one additional 2" and one additional 3" PVC conduit stubbed out of the footing for future use. The ends of the conduit stubs shall be capped.

10.2 Prior to setting poles, the anchor bolts shall be covered in such a manner as to protect them against damage and to protect the public from possible injury. The foundations must be given a minimum of seven days to cure before poles are erected.

10.3 Backfilling of structures shall use floodable backfill material meeting the requirements of section 4134. Backfill may be placed in lifts up to 2 feet thick. To ensure uniform surface flooding and adequate compaction, fan-spray water in successive 1 to 2 foot increments using a 2 inch diameter hose for three minutes within each increment. Run hose fully, but with the water pressure low enough to avoid eroding material. After flooding, evaluate the effectiveness of the compaction with a vibratory pan or other approved compactor. If the compactor produces visible compaction, repeat the flooding process until the compactor produces no visible compaction.

10.4 During removal, all existing signal foundations shall be removed and disposed of. If there are circumstances that prevent their removal, the exposed concrete must be removed to 6 inches below the ground surface level.

10.5 Mastarm foundations must have a minimum 6" of threaded anchor bolt exposed above the foundation.

11. BONDING AND GROUNDING

11.1. Ground rods must be UL listed, made of copper-clad steel with a nominal diameter of 5/8 inches. Ground rod sections must be a minimum of 8 feet in length and manufactured for the sole purpose of providing electrical grounding.

11.2. Ground rod assemblies: consisting of one or more ground rods coupled together, such that the total length of the assembly is a minimum of 20 feet, driven into the earth at a single point, without disrupting the electrical continuity of the assembly. Ground rod assemblies shall be full length as shown on the plans and each rod length shall be the tapered end style, not threaded.

11.3. Ground Rod Array: is the inter-connection of the ground rods at each pole or structure at the site, consisting of two or more ground rod assemblies, bonded together in accordance with NEC Article 250 bonding.

11.4. Ground wires shall be connected to the ground rods with one (1) piece non-ferrous clamps which employ set screws as tightening devices ILSCO clear tap cat no. PCT(4/10), often referred to as Acorn Nuts. Connections to ground rods need not be taped. Ground rods and assemblies shall be of the length specified on the plans.

11.5. Cabinet location shall use a 20 foot ground rod assembly as specified in 11.2 with a #4 AWG, bare, tinned, solid annealed copper ground wire bonded back to the cabinet earth and electrical neutral bus at the cabinet and main service disconnect.

11.6. Ground rod assembly electrodes shall be provided in and accessible at the adjacent hand holes at each structure including but not limited to signal poles, pedestal poles and controllers as detailed on the plans. The entire intersection grounding array shall be a single ground array and bonded back to the cabinet ground along with the cabinet and main disconnect.

11.7. All metal structures and their associated grounds shall be bonded together to the cabinet main disconnect, (NEC Article 250 Bonding). Ground rods should extend to just below the top of the manhole or vault and be located between 3” and 6” of the side to allow measuring of ground array using a clamp- on tester and inspection of the connections as part of a preventative maintenance program.

11.8. All ground wires between metal structure and nearest ground rod shall be #4 AWG, bare, solid, annealed copper wire unless otherwise specified on the plans. Each steel pole or pedestal shall be firmly connected to the ground rod provided, by means of an internal grounding terminal or earth lug. Placing the ground wire under an anchor bolt nut, anchor bolt cover, or similar device will not be permitted.

11.9. All conduit, steel poles, pedestals, and hand holes in the immediate intersection shall be bonded between structures and cabinet to form a continuous effective ground array. Bonding ground wires shall be No. 6 AWG, XHHW insulated green, multi-strand copper wire or equal connected by appropriate sized split bolt or crimp connectors to the #4 ground wires specified in section 11.5.

11.10. The No. 6 AWG, XHHW insulated green multi-strand copper wire shall be installed in all PVC conduit that carries electrical conductors (including low voltage).

12. SIGNAL APPURTENANCES

12.1 Signal Faces

12.1.1 All traffic signal displays shall be installed as indicated on the plans. All overhead displays located on each mast arm shall have each green indication set at approximately the same elevation, unless otherwise directed by the Engineer. All signal head locations shall be confirmed in the field by the contractor to ensure proper location.

12.1.2 During the course of construction and until the signals are placed in operation, signal faces shall be covered or turned away from approaching traffic. When ready for operation, they shall be securely fastened in position facing toward approaching traffic and plumb.

12.2 Controller Cabinet

12.2.1 The controller cabinet shall be installed at the location indicated on the plans with the back of the cabinet toward the intersection such that the signal heads can be viewed while facing the controller, unless otherwise directed by the Engineer.

12.2.2 The controller cabinet shall be installed on pre-placed caulking material on the concrete base. After the cabinet is installed in place the Contractor shall also place caulking material around the base of the cabinet.

12.3 Pole Erection

12.3.1 All poles shall be erected so as to be vertical under normal load. The bases shall be securely bolted to the precast concrete foundations. Plumbing of poles shall be accomplished by adjusting the nuts. Shims or other similar devices for plumbing and raking will not be permitted, except for the leveling of the transformer bases. Shims and/or one nut or two nuts on each anchor rod may be used only between the transformer base and the foundation for leveling. One nut shall be turned on each anchor rod and the pole placed in position on these nuts. The top nuts shall then be turned into place loosely and the pole adjusted to the vertical position by adjusting both the upper and lower nuts.

12.3.2 After leveling the poles, expansive type grout shall be troweled between the pole base and the foundation for gaps of 1" or greater. Exposed edges of grout shall be neatly finished to present a pleasing appearance. A weep hole made from one-half inch (1/2”) diameter copper tubing shall be placed in the grout. This grouting should be conducted within the appropriate temperature range of the material used.

12.3.3 Each pole shall be grounded by installing a No. 4 AWG bare copper ground wire between the pole and the ground rod at the foundation handhole (see section on bonding and grounding).

12.4

If the painted or galvanized surface of any equipment is damaged in shipping or installation, such equipment shall be retouched, repaired or replaced in a manner satisfactory to the Engineer.

13. REPLACING DAMAGED IMPROVEMENTS

13.1 Improvements such as sidewalks, curbs, driveways, roadway pavement and any other improvements removed, broken, or damaged by the Contractor shall be replaced or reconstructed with the same kind of materials found on the work or with materials of equal quality. The new work shall be left in serviceable condition satisfactory to the Engineer. Whenever a part of a square or slab of existing concrete sidewalk, driveway, or pavement is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed.

13.2 Surface restoration shall be considered incidental to the bid items of the project and will not be paid for separately unless specified to be replaced and a bid item is provided.

14. ACTUATED CONTROLLER

14.1 General

14.1.1 For compatibility the actuated controller and cabinet shall be number “DBQTS2-NU-P” or DBQTS2-NU-R” depending on the location. The local intersection controller shall be fully compatible and interchangeable with the existing local controllers in the City of Dubuque System operating as a Closed-Loop System which are TACTICS Traffic Management System located in the Traffic Management Center. The system will be tied into the TACTICS via the fiber optics and network gear using an IP based communications. The controller shall also be capable of stand-alone remote dial-up operation including monitoring and upload/download capabilities without the need of a master or any additional equipment other than a standard dial-up modem.

15. CONTROLLER CABINET AND AUXILIARY EQUIPMENT

15.1 General

15.1.1 The cabinet and auxiliary equipment shall conform to the requirements of the National Electrical Manufacturer's Association (NEMA) Standard TS-1 and TS-2, most current revision, and to these specifications. The cabinet shall be a TS-2 Type 1 cabinet.

15.2 Electrical Design

15.2.4 Electrical connections from the controller and auxiliary devices to outgoing and incoming circuits shall be made in such a manner that the controller or auxiliary device can be replaced with a similar unit, without the necessity of disconnecting and reconnecting the individual wires. This may be accomplished by means of a multiple pin jack, a spring connected mounting or approved equivalent arrangement.

15.2.5 All cabinet wiring shall be neatly trained throughout the cabinet and attached to the interior panels using nonconductive clamps or tie-wraps. Bundles of cables shall be laced or tied or enclosed in a sheathing material. The cabinet wiring shall not interfere with the entrance, training, or connection of the incoming or outgoing field conductors.

Except where terminated by direct soldering, all wires shall be provided with terminal lugs for attachment to terminal blocks using screws. All wires shall be identified and labeled in accordance with the cabinet wiring prints.

All wire insulation shall have a minimum rating of 600 volts.

15.3 Documentation

15.3.1 Complete system documentation shall be provided. Such documentation shall, as a minimum consist of:

Three (3) complete operations manuals for each controller and associated signal equipment including equipment wiring diagrams, schematics, and parts lists sufficient for ordering any parts.

Three (3) sets of cabinet wiring diagrams. The corresponding phase numbers for each movement shall be indicated on the intersection layout diagram on the cabinet wiring diagram.

15.3.2 The controllers shall be provided with the most current software and documentation. Future software and documentation revisions to the local system controller shall be provided without charge.

15.3.3 Cabinet wiring diagrams shall include two sheets. One sheet shall indicate the manufacturer point to point wiring of the terminal facility complete with all harnesses for the controller unit and the conflict monitor. This drawing shall be an unaltered generic drawing. The second drawing shall indicate the electrical connections of all equipment and terminal connections for the traffic control cabinet for each cabinet provided. The drawings shall include pictorial representations of the intersection geometrics and phasings. Detectors shall be positioned for each approach and lane, being tagged with its harness (rack/slot) assignment. The controller cabinet shall be positioned and shown as a rectangle with the two crossing diagonal lanes. In addition to the three sets of wiring diagrams specified above, one digital copy shall be provided to the Engineer at the time of turn on at the intersection.

15.3.4 The Contractor shall provide a customized intersection graphic depicting the local intersection for each intersection provided. The customized intersection shall include the

following: correct number of lanes by function for each approach; graphically correct orientation of the intersection layout; proper phase assignment by lane; proper pedestrian phase assignments; street names on the lanes; key landmark indicators shown in the graphics. The Engineer will provide an 8 ½ x 11 pictorial of the intersection geometrics and the key landmark indicators to be shown in the graphic. System detectors shall be shown on the graphic and labeled in accordance with the card rack/slot plus system detector assignment numbers. Orientation for all intersection displays shall be north as top of screen.

15.3.5 The addition of any local intersections requires the Master Map to be modified. The Contractor shall provide a corrected map graphic for each intersection added to the group. The map graphic shall include geometrically proportioned locations of the intersections plus locations of all system detectors for each location. A table shall be provided on the graphic, which displays the current assignment of detectors by DR., DR2, CS1, CS2, NA1, and NA2. Modified maps shall be loaded into the computer system and viewed for proper operation. Orientation of the map shall be as selected by the Engineer to best display the System Operation.

15.4 Guarantee

15.4.1 The equipment furnished under this specification shall be new, of the latest model, fabricated in a first-class workmanship manner from good quality material.

15.4.2 The entire controller unit shall be warranted to be free from defects in workmanship and materials for a minimum of one year from date of acceptance. Any parts found to be defective shall be replaced free of charge.

15.4.3 The Owner shall be furnished with a certification from the equipment manufacturer stating that the equipment furnished under this specification complies with all provisions of this specification. If there are any items, which do not comply with this specification, then a list of those exceptions must be detailed on the certification.

16. VEHICLE TRAFFIC SIGNAL HEADS

16.1 This section of the specifications describes the minimum acceptable design and operating requirements for vehicular signal heads with twelve (12) inch diameter lens openings, including all fittings and brackets as shown on the plans. All components of the vehicular signal heads furnished under this specification shall comply with the latest version of the Institute of Transportation Engineers Standard(s) for Adjustable Face Vehicle Traffic Control Signal Heads. All vehicle signals will use LED modules.

16.2 Red Ball, Green Ball, and Green Arrow LED Modules

16.2.1 The low power LED red ball, green ball, and green arrow vehicle signals shall be installed in traffic signal housings rated as a 12" signal housing commercially manufactured with a durable polycarbonate material and be compatible with traffic signal mounting brackets utilizing serrated locking between signal sections. The LED signal section shall be a self-enclosed, sealed unit, with electrical connections to be terminated on the standard terminal block, spade termination, mounted in the traffic signal section. The signals shall be 120 VAC rated and shall be compatible with either public utility or backup power sources of a 60-hertz, +/- 5-hertz with a voltage variance between 80 and 135.

16.2.2 All electronics in the signal shall meet NEMA temperature rating of –40 to +74 ºC. The enclosure shall conform to NEMA Moisture Resistance Standard 250-1991 for Type 4 enclosures <ITE 6.4.6.2 Moisture Resistance>. The signal electronics shall meet FCC Title 47, Subpart B, Section 15 Regulations for Electrical Noise dissemination. The electronics shall be provided with an operating power factor correction of a minimum of 0.9 and shall be provided with fuse and transient suppression incorporated for line and load protection.

16.2.3 The traditional "ball" signal display, shall have the following characteristics:

Red Signal Display (Dialight 433-1210-003)	
Luminous Intensity # (cd)	339
Dominant Wavelength (nm)	622
Lens Tint	Red
Typical Wattage at 25 ºC	10.5 +/- 0.5
Meet or exceed ITE VTCSH Part 2 (July 1998)	
Green Signal Display (Dialight 433-2270-001)	
Luminous Intensity # (cd)	678
Dominant Wavelength (nm)	505
Lens Tint	Clear
Typical Wattage at 25 ºC	11.8 +/- 0.5
Meet or exceed ITE VTCSH Part 2 (July 1998)	

The traditional "green arrow" signal display, shall have the following characteristics:

Green Arrow Display (Dialight 430-2374-001)	
Dominant Wavelength (nm)	505
Lens Tint	Clear
Typical Wattage at 25 ºC	6.7 +/- 0.5

Arrow signals shall have power factor correction and temperature compensation.

16.2.4 The LED modules shall be rated for low power consumption and for use in a backup power installation. LED modules shall be compatible with NEMA TS-2 requirements for traffic controller installations and be fully compliant and compatible with industry standard conflict monitors and malfunction monitor units. LED modules shall be at the rated power consumption, without exception, as backup power sources have been rated based on these design parameters. Charging circuit design shall preclude battery damage caused by continuous battery charge power availability.

16.2.5 LED modules shall be warranted for a minimum field life of 36 months, repair or replacement; and, be designed for a minimum life of seven (7) years non-degrading for illumination output caused by lens deterioration or LED degrading.

16.3 Signal Head Assembly

16.3.1 The housing for the individual signal sections shall be made of a durable polycarbonate. It shall be clean, smooth and free from flaws, cracks, blowholes, and other imperfections. It shall be designed as a self-contained unit capable of separate mounting or inclusion in a signal face containing two or more signal sections rigidly and securely fastened together. It shall be equipped with openings and positive locking devices in the top and bottom so that it may be rotated between waterproof supporting brackets capable of being directed and secured at any angle in the horizontal plane. Doors and lenses shall be provided with suitable water-tight gaskets and doors shall be suitably hinged and held securely to the body of the housing by simple locking devices of non-corrosive material.

16.3.2 The optical system shall be so designed as to prevent any objectionable reflection of sun rays even at times of the day when the sun may shine directly into the lens.

16.3.3 Lenses shall be twelve (12) inches in diameter as specified on the plans. Lenses shall be polycarbonate. Glass lenses are not acceptable.

16.3.4 The visors for each signal section shall be durable polycarbonate not less than 0.10" in thickness. It shall be designed to fit tightly against the door, and shall not permit any perceptible filtration of light between it and the housing door. Visors shall be of the tunnel-type at least 8" long for all 12" rectangular pedestrian signals, at least 9 1/2" long for 12" diameter signals, shall angle slightly downward, and shall be of the type specified on the plans.

16.3.5 The reflector holder shall be designed to separately support the reflector and socket in proper relation to the lens. The reflector holder shall either be hinged to the left-hand side of the signal body when viewed from the front with the right-hand side held in place by a spring catch or other quickly releasable means, or the reflector shall be mounted in a manner that does not require it to be removed from its normal position during bulb replacement. Both the hinge device and the spring catch, or equivalent, shall be of a flexible nature which will permit the reflector holder to be pushed inwardly for at least one-sixteenth of an inch and to align itself correctly with the lens when the door of the optical unit is closed and pressed against the rim of the reflector holder. By such means, the joint between the reflector holder and the lens shall be rendered dust-tight. It shall not be necessary to remove any screws or nuts in order to swing the reflector holder out of the body section to obtain access to the light socket. The reflector shall be Alzak treated aluminum or Lexalite (C) polycarbonate. Glass is not acceptable. The reflector assembly shall be interchangeable and shall be designed so that it can be easily removed without the use of tools. When polycarbonate reflectors are furnished, gaskets shall be fabricated of silicone material.

16.3.6 The lamp receptacle shall be of the fixed focus type, positioning the lamp filament at the correct focal point in respect to the reflector. The assembly shall be designed so that the lamp socket can be rotated through 360 degrees and eight (8) positions of adjustment for proper positioning of the lamp filament after relamping the signal. The lamp socket shall be equipped with color coded wire, either red, yellow, or green, depending upon the lens color of the section. The socket wires shall be a minimum of 26 inches long, composed of wire with insulation designed to withstand 105 degrees centigrade. The wiring leads shall be terminated with spade lugs for ease of connection to the terminal block. The socket shall be equipped with a gasket to insure a dust-tight fit between the socket and reflector.

16.4 Specialized Options

16.4.1 One section of each three-section signal shall be equipped with a six position terminal block for termination of field wiring. Each five indication signal shall be equipped with an eight (8) position terminal block.

16.4.2 The color of all polycarbonate signal heads shall be black in their entirety. The color shall be an integral part of the materials composition.

16.4.3 Signal mounting hardware for side of pole mounted signals shall consist of aluminum 1-1/2 inch pipe and appropriate fittings or PELCO SE-3036 ASTRO-BRAC ®. Signals shall be secured to pole by using a stainless steel cable mounting material. Pole mounted signal heads shall be mounted such that the traffic signal is between the pole and roadway.

16.4.4 All vehicle signal heads shall include back plates. Five inch (5”) back plates shall be furnished and attached to the signal faces to provide a dark background for signal indications. Backplates shall be constructed of one piece durable black plastic capable of withstanding a 100 M.P.H. wind.

16.5 Miscellaneous Requirements

16.5.1 The signal heads shall be constructed of the highest quality materials. High-grade workmanship shall be used throughout. Each head shall have a smooth surface both inside and outside and shall contain no sharp fins or sharp projections of any kind.

16.6 Certification

16.6.1 The Owner shall be furnished with a certification from the manufacturer of the signal head that the equipment furnished under this specification complies with all provisions of this specification. If there are any items that do not comply with this specification, a list of those exceptions must be detailed on the certification.

17. TRAFFIC SIGNAL LAMPS

17.1 ITE Standards

17.1.1 The traffic signal lamps (if applicable) shall be manufactured in accordance with the requirements of the latest Standard for Traffic Signal Lamps as approved by the Institute of Transportation Engineers, including the requirements in these specifications. All traffic signal lamps are required to be LED as described in the Vehicular Traffic Signal Head section.

18. PEDESTRIAN TRAFFIC SIGNAL HEADS

18.1 This section of the specifications describes minimum acceptable design and operating requirements for one-section, pedestrian traffic signal heads with International symbol messages to include all fittings and brackets, as specified on the plans. The pedestrian signal head shall comply with the latest version of the Institute of Transportation Engineers Standards on Pedestrian Traffic Signal Heads.

18.2 Signal Head Assembly

18.2.1 The mounting, housing, and visors for pedestrian signal heads shall conform to the provisions of "Vehicle Traffic Signal Heads" section in these specifications, and as shown on the plans.

18.2.2 Count down style LED Signal shall be a 16”x18” module, which incorporates a Portland orange hand and a lunar white walking person. Lenses shall be polycarbonate; glass lenses are not acceptable. LED lenses shall be used for the hand symbol and walking person.
LED lenses shall meet the following ITE specification: *Vehicle Traffic Control Signal Heads – Part 2: Light Emitting Diode (LED) Vehicle Traffic Control Signal Modules, An Interim Purchase Specification of the Institute of Transportation Engineers.*

18.2.3 Lenses shall have an effective area for the "HAND" or "WALKING PERSON" legends. The size shall comply with the Institute of Transportation Engineers Standards on Pedestrian Traffic Signal Heads.

The "HAND" symbol shall be red LED, the "WALKING PERSON" symbol lunar white LED.

18.2.4 The color of all polycarbonate signal heads shall be black in their entirety. The color shall be an integral part of the materials composition.

18.2.5 Signal mounting hardware shall consist of aluminum 1-1/2 inch pipe and appropriate fittings or PELCO ASTRO-BRAC ® for pedestrian head side of pole mounting. Signals shall be secured to pole by using a stainless steel cable mounting material.

19. PEDESTRIAN PUSH BUTTONS

19.1 Pedestrian push button detectors shall be Model Bulldog III manufactured by Polara and shall be Yellow in color with a black push button cup and shall be ADA compliant.

19.2 The push button shall be weatherproof and of sturdy design. The entire assembly shall be weather tight, secure against electrical shock, and able to withstand continuous hard usage. The contacts shall be normally open with no current flowing except at the moment of actuation.

19.3 The housing shall be made of aluminum alloy and furnished with suitable mounting hardware.

19.4 Push button signs shall be furnished and shall conform to the requirements of the current Manual on Uniform Traffic Control Devices (MUTCD). Signs shall be R10-3E as specified in the plans.

19.5 The Owner shall be furnished with a certification from the equipment manufacturer stating that the equipment furnished under this specification complies with all provisions of this specification. If there are any items, which do not comply with this specification, then a list of those exceptions must be detailed on the certification.

19.6 ***General Specifications***

19.6.1 Body Material: Die Cast Aluminum, Powder Coated.
19.6.2 Button Material: 316 Stainless Steel.
19.6.3 Piezo Driven Solid State Switch
19.6.4 Operating Temperature: -30°F to 165°F (-34°C to 74°C)
19.6.5 Operating Life: Greater than 100 million operations
19.6.6 BDPM3 (Momentary LED Model)
- 19.6.6.1 Operating Force: 3 lbs. Maximum
- 19.6.6.2 Operating Voltage: 15-36V DC or 12-28V AC
- 19.6.6.3 On Resistance: 10 Ω Typical.
- 19.6.6.4 Operating Standby Current: 10μA typical (equivalent to 2MΩ at 20V)
- 19.6.6.5 Operating Mode: Approx. 0.025 sec flash each time button is pressed.
- 19.6.6.6 Luminous Intensity: Greater than 1200 mcd (ultra bright red)
- 19.6.6.7 Viewing Angle: 160°

19.6.7 Audible Tone
- 19.6.7.1 Sounds simultaneously with button push.
- 19.6.7.1 Different tones for press and release: 2.6kHz and 2.3kHz
- 19.6.7.1 Beeper uses power from existing switch wires.

20. TRAFFIC SIGNAL POLES

20.1 General

20.1.1 This section of the Special Provisions described minimum acceptable design, material, and fabrication requirements for traffic signal poles. Poles shall be manufactured in accordance with the requirements of the latest Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals as approved by the American Association of State Highway and Transportation Officials.

After manufacture, they shall have minimum yield strength of 48,000 PSI. The base and flange plates shall be of structural steel conforming to AASHTO M183 (ASTM A36) and cast steel conforming to ASTM A27, Grade 65-35 or better.

20.2 Poles

20.2.1 The pole shall be designed to support the traffic signals and/or signs as shown on the plans. The pole shall be galvanized inside and out in accordance with the requirements of ASTM A123, latest revision. Where mast arms are used, the hole located on the upright pole shall be large enough for all the wires used for equipment located on the mast arm. The pole shall be equipped with a minimum 8"x 12" hand hole and aluminum cover located in the transformer base of the pole. Securing of the cover to the base shall be done with the use of simple tools. Hardware shall be corrosion resistant.

20.3 Combination Pole

20.3.1 Where a combination street lighting/signal pole is specified on the plans, the luminaire arm is to be mounted in the same vertical plane as the signal arm unless otherwise indicated on the plans.

20.3.2 The luminaire arm type shall be a single member type arm unless specified otherwise on the plans.

20.3.3 The luminaire arm shall provide the spread and nominal mounting height as shown on the plans.

20.3.4 Where a combination street lighting/signal pole is specified on the plans, the pole shall be equipped with a minimum 4"x 6" hand hole and cover located opposite the signal mast arm.

20.3.5 The luminaire arm shall be arched.

20.4 Hardware

20.4.1 The mast arms and poles shall be equipped with all necessary hardware, shims and anchor bolts to provide for a complete installation without additional parts.

20.4.2 The anchor bolts shall meet the requirements of ASTM A36 or better.

20.4.3 The anchor bolts shall be hot dip galvanized for a minimum of 12 inches on the threaded end.

20.4.4 The anchor bolts shall be threaded and exposed a minimum of 6 inches at one end and have a 4-inch long, 90 degree bend at the other end.

20.4.5 The fabricator shall submit drawings for anchor bolts and base design. All hardware shall be steel, hot dipped galvanized meeting the requirements of ASTM A123, Class D or electrodeposited coated of the same coating thickness, and so designed for this purpose.

20.5 Shop Drawings

20.5.1 All traffic signal poles shall be detailed on shop drawings by the manufacturer indicating pole and arm dimensions and attachment method along with signal weight, projected areas, and type of mounting that it is designed to accommodate.

20.6 Certifications

20.6.1 The fabricator shall certify that the mast arms are capable of withstanding winds up to 80 MPH with a 1.3 gust factor without failure; that only certified welding operators in accordance with AWS D1.1-80 or latest revisions were used; and that only electrodes as modified by AASHTO 1981 Standard Specifications for Welding of Structural Steel for Highway Bridges were used.

21. TRAFFIC SIGNS AND POSTS

21.0 General

21.1 Traffic signs shall conform to the requirements of Section 4186 of the Standard Specifications for Aluminum Type 1 signs. Signs to be prismatic sheeting unless otherwise noted.

21.2 When traffic signals are indicated to be mounted on a traffic signal standard, traffic signs shall be mounted on the signal standards utilizing a universally adjustable mounted sign bracket utilizing cable mounting vs. banding. Shop drawing to be submitted for traffic signs.

21.3 Sign on Posts or Ped Poles

21.3.1 The street name signs shall be white letters, clearview font in title case lettering (first letter in each word is capitalized) on a green background. HIP rated sheeting 10 inch blade with 6 inch upper case and 4.5 inch lower case lettering. The sign shall have a white border, .375 inch wide. The thickness of the aluminum sign blank shall be 0.08 inch. The corners of the sign blank shall have a 1 inch radius.

21.3.2 Traffic signs shall be mounted on posts as indicated. Posts to be metal, 4 inch x 4 inch, or 4 inch x6 inch wood with installation into the ground at a depth adequate to prevent sign installation from leaning or tipping. Posts shall conform to the requirements of Section 4186 for Type 2 posts unless otherwise noted.

21.4 Sign on Mast Arms

20.4.1 Traffic signs shall be mounted on the mast arms utilizing a universally adjustable mast arm mounted sign bracket.

21.4.2 The street name signs shall be white letters, clearview font in title case lettering (first letter in each word is capitalized) on a green background. HIP rated sheeting on a 18 inch blade with 12 inch uppercase and 9 inch lower case lettering. The sign shall have a white border, 1 inch wide. The thickness of the aluminum sign blank shall be .125 inches. The corners of the sign blank shall have a 3 inch radius.

22. FIBER OPTIC CABLE

This work shall consist of furnishing and installing a fiber optic cable of the type, size and number of fibers specified in the drawings.

22.1 General Requirements

48/24 hybrid
12, 24, 48, 72 or 144 SM
24 MM

22.1.1 Materials and Equipment

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products. The fiber optic shall conform to the following specifications. All materials and equipment furnished shall be completely free from defects and poor workmanship. All fibers shall be glass and be manufactured by Corning or pre-approved equal. The cable shall be rated for gigabyte data bandwidth. All fiber shall be loose tube construction for both indoor and outdoor installation. Indoor cabling shall use plenum rated conduit to within less than 50 foot of point of termination eliminating the requirement to convert to indoor cable.

22.1.2 Contractor Qualifications

Trained and experienced personnel shall supervise the fiber optic cable installation. Qualified technicians shall make the cable terminations and splices. The Contractor upon request of the Engineer shall provide documentation of qualifications and experience for fiber optic equipment installations. The Engineer shall determine if the Contractor is qualified to perform this work. The Contractor shall have attended a certified fiber optic training class mandated by these specifications prior to starting work.

22.1.3 Codes Requirements

The fiber optic cable installation shall be in accordance with or exceed all minimal requirements of State codes, National codes, and manufacturer codes as applicable.

22.1.4 Miscellaneous Equipment

The Contractor shall furnish and install all necessary miscellaneous connectors and equipment to make a complete and operating installation in accordance with the plans, standard sheets, standard specifications, special provisions, and accepted good practice of the industry.

22.1.5 General Considerations

The cable shall meet all requirements stated within this specification.

T he cable shall be new, unused, and of current design and manufacture.

22.1.6 Fiber Characteristics

All fibers in the cable must be usable fibers and meet required specifications. Fiber shall consist of a dry water block coupled with a dry tube construction.

Multi-mode Fiber	
Core diameter:	62.5 +3.0um
Cladding diameter:	125.0 +2.0um
Core-to-cladding offset:	<3.0um
Coating diameter	250 +15um
Graded Index	

Attenuation uniformity: No point discontinuity shall be greater than 0.25 dB, except terminations or patch cords, at either 850nm or 1300nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

Factory cable rating shall be 3.5 dB/KM at 850 nM and 1.0 dB/KM at 1300 nM, or less. Installed tolerance shall be less than 3.85 dB/KM at 850 nM and less than 1.1 dB/KM at 1300 nM, testing tolerance.

Single-Mode Fiber
Typical core diameter: 8.3um
Cladding diameter: 125 +1.0um by fiber end measurement
Core-to-cladding offset: <1.0um
Coating diameter: 250 +15um

Attenuation uniformity: No point discontinuity shall be greater than 0.1 dB, except terminations or patch cords, at either 1310nm or 1550nm. The coating shall be a layered UV cured acrylate applied by the fiber manufacturer. The coating shall be mechanically or chemically removable without damaging the fiber.

Factory cable rating shall be 0.35 dB/KM at 1310 nM and 0.30 dB/KM at 1550 nM. Installed tolerance shall be less than 0.44 dB/KM at 1310 nM and less than 0.33 dB/KM at 1550 nM, testing tolerance.

22.2 Fiber Specification Parameters

All fibers in the cable shall meet the requirements of this specification. The testing tolerance attenuation specification shall be a maximum attenuation for each fiber over the entire operating temperature range of the cable when installed.

The change in attenuation at extreme operational temperatures for single-mode fibers shall not be greater than 0.20 dB/km at 1550 nm, with 80 percent of the measured values no greater than 0.10 dB/km at 1550 nm.

Optical fibers shall be placed inside a loose buffer tube, minimum six (6) fibers per tube, normally twelve (12) fibers per tube. Actual number of fibers per tube shall be twelve fibers per tube unless specified differently on the Plans.

Multimode only – each buffer tube shall contain 12 or 6 fibers.
Single-mode only – each buffer tube shall contain 12 or 6 fibers.

The buffer tubes will meet EIA/TIA-598, “Color coding of fiber optic cables.”

All fiber cables shall be Gigabyte rated, i.e. multimode shall be 200/500 Meter for 850 and 1300 nM respectively and 5000 Meter for 1310 and 1550 nM.

Fiber count, tubes of fiber, shall be as specified on the plans. All fiber spools shall have manufacturer’s specification sheet specifying which tube are multi mode, and which tubes are single mode.

Fillers shall be included in the cable core to lend symmetry to the cable cross-section where needed.

The central anti-buckling member shall consist of a glass reinforced plastic rod. The purpose of the central member is to prevent buckling of the cable.

Each buffer tube shall be filled with materials that expand when contacted by moisture such as water blocking tape or fibers. Water blocking gel shall be acceptable for in buffer tube filler; however gel [icky-pic] for filler between buffer tubes shall not be acceptable for this Project.

Buffer tubes shall be stranded around a central member. Acceptable techniques include the use

of the reverse oscillation, or "SZ", stranding process.

All dielectric cables (with no armoring) shall be sheathed with medium density polyethylene. The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and flooding compound. Cable jacketing shall utilize the newer designs to provide maximum flexibility without loss or appreciable dB attenuation. Cable diameter shall not exceed 0.50 inch.

The jacket or sheath shall be marked with the manufacturer's name, the words "optical cable", the year of manufacture, number of fibers, type of fiber (SM or MM) and sequential feet or meter marks. The markings shall be repeated every one-meter or three feet. The actual length of the cable shall be within –0/+1% of the length marking. The marking shall be in a contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm. A copy of the manufacturer fiber definition and shipping sheet identifying all tests, results and fiber indexes shall be provided to the Engineer on delivery of cable to the City or shall be included with a contractor's listing of place(s) of installation when installed by a Contractor (See 22.3.2).

Where ever possible, six (6) buffer tubes with twelve (12) fibers each, or subsets specified, shall be provided and designated as follows:

Buffer Tube/Fiber	Tube/Fiber Color
#1, 1st tube or fiber	blue
#2, 2nd tube or fiber	orange
#3, 3rd tube or fiber	green
#4, 4th tube or fiber	brown
#5, 5th tube or fiber	slate
#6, 6th tube or fiber	white
#7, 7th tube or fiber	red
#8, 8th tube or fiber	black
#9, 9th tube or fiber	yellow
#10, 10th tube or fiber	violet
#11, 11th tube or fiber	rose
#12, 12th tube or fiber	aqua

22.3 Quality Assurance Provisions

All optical fibers shall be proof tested by the fiber manufacturer at a minimum load of 100 kpsi.

All optical fibers shall be 100% attenuation tested at the manufacturer. The attenuation of each fiber shall be provided with each cable reel. The measured attenuation shall be for both 850 and 1300 frequency for multimode and 1310 or 1550 frequency for single mode. This documentation shall be provided with each spool. The Contractor shall designate on the Plans and on this (See 22.2.11) documentation the location where each spool has been installed and provide this data to the Engineer.

22.4 Cable Installed in Ducts and Conduits

A suitable cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct off the reel. It shall be carefully inspected for jacket defects. If defects are noticed, the pulling operation shall be stopped immediately and the Engineer notified. Precautions shall be taken during installation to prevent the cable from being "kinked" or "crushed". A pulling eye shall be attached to the cable and used to pull the cable through the duct and conduit system. A pulling swivel shall be used to eliminate twisting of the cable. As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Dynamometers or breakaway pulling swing shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed on a cable during installation shall not be such that the cable is twisted or stretched. The pulling of cable shall be hand assisted at each controller cabinet. The cable shall not be crushed kinked or forced around a sharp corner. If a lubricant is used it shall be of water based type and approved by the cable manufacturer. Sufficient slack shall be left at each end of the cable to allow proper cable termination, minimum 50', this slack shall be in addition to installation slack as hereinafter specified. Additional slack cable, as defined in the drawings, shall be left in each hub cabinet, handhole, and at the top of each conduit riser. Excess slack at hub cabinets shall be re-pulled into the nearest handhole to provide a neat and orderly installation.

Storage of minimum slack cable in controller cabinets and additional slack at pull boxes shall be coiled. If multiple fiber cables are pulled through the same duct, this fiber should be coiled separately from one another. The slack coils shall be bound at a minimum of 3 points around the coil parameter and supported in their static storage positions. If stored in a manhole, fiber shall be stored along the outermost wall to allow unabated ingress and egress. The binding material and installation shall not bind or kink the cable. Storage of additional slack cable adjacent to conduit risers and support poles shall be as visibly marked/tagged as "CAUTION – FIBER OPTIC CABLE". Maximum length of cable pulling tensions shall not exceed the cable manufacturer's recommendations. Along with the fiber optic cable, one (1) #10 AWG tracer wire (see conduit system specifications for tracer wire), shall be pulled with ten feet (10') slack in each pull box. Fiber shall enter into the traffic control cabinet in the far left or right side. All fiber cables shall be marked with a metallic identifier in the handhole adjacent to the traffic controller and on the cable in the traffic controller at the point of termination. The identifier, both in the cabinet and in the handhole, shall indicate the direction the cable is going, cable contents [SM or SM/MM], and the abbreviated location for the other end destination. Fiber cabling between traffic controllers and adjacent hub locations shall be outdoor rated, loose tube fiber, when not linked by a direct, continuous conduit installation.

22.5 Minimum Bend Radius

For static storage, the cable shall not be bent at any location to less than ten times the diameter of the cable outside diameter or as recommended by the manufacturer. During installation, the cable shall not be bent at any location to less than twenty times the diameter of the cable outside diameter or as recommended by the manufacturer.

22.6 After the Fiber Optic Cable Installation

Each section of the cable shall be tested for continuity and attenuation as a minimum. If the attenuation is found not to be within the acceptable nominal values, the Contractor shall use an optical time domain reflectometer (OTDR) to locate points of localized loss caused by bends or kinks. If this is not successful the Contractor shall replace the damaged cable with no additional payment. Splices will not be allowed to repair the damaged section. After all fiber cable is installed between traffic controller cabinets and fiber links between fiber distribution points (FDP) complete links, all fibers, whether terminated or non-terminated, shall be tested for continuity (flash light). All terminated fiber shall be tested with an OTDR and Power Meter. The Contractor may jumper termination points at controller cabinets to minimize the number of tests and run a single OTDR test between several controller cabinets, subject to the range of the OTDR. Links

between FDP's shall be tested separately**.** Each OTDR trace, for documented test result submittal, shall be displayed individually and not be combined with other fiber traces as overlays. Multimode fiber shall be tested using 1300 nm and single mode fiber shall be tested at 1310 nM. The results of the OTDR test shall be provided on an electronic media (disk) and paper printout. The OTDR wave, pictorial diagram of dB loss over the length of fiber tested, shall be provided along with the measured data values. The printout shall contain the manufacturer's fiber optic Index of Refraction to the third decimal point for the fiber provided. The Contractor shall provide the Engineer with a written report showing all the values measured compared to the calculated values for length and coupler/connector losses at the completion of these tests. Outdoor patch cords between FDP and controller units less than 151 feet do not need be OTDR tested.

Documentation provided to the Engineer shall include a written indication of every splice, termination, patch cord, etc. for cable being measured. Power meter measurement recordings shall indicate the exact measured distance [OTDR or field measurement with cross reference for oscillation multiplier] on the sheet showing the power meter readings. Any deviations between fiber readings in the same tube shall be notated for OTDR graphs as well as deviations greater than 5% on power meter readings. Rated values for acceptable installation shall be based on the following parameters:

Patch cords/Pigtails	60 MM & .15 SM dB each
Unicam / Hotmelt Terminations	1.0 dB set of 2 [In and Out]
Splices	0.08 each
1 KM = 0.3077 KF where	KF is 1000 feet

Data documentation shall include for each test between cabinets or between FDP sites, the length of fiber as measured by OTDR, frequency used in test on OTDR by each fiber type, distance to each splice, termination or patch cord jumper, dB loss rating by manufacture from spool documentation, index of refraction by type of fiber in section, and the dB loss of each section as measured in the final test for each fiber. A special test shall be made on all continuous spliced fiber from start to end that includes the total dB loss measured and the OTDR plot on electronic disk. Splice points shall be identified on the trace.

Light Source - An LED light source with a wavelength that is the system wavelength, 850 and 1300 nm for multimode and 1310 and 1550 nm for single mode, shall be used. The LED shall be stable within 0.1 dB in intensity over a time period sufficiently long to perform the measurement. The output of the LED shall overfill the input end of the launch fiber/cable in both numerical apertures (NA) and core diameter. The accuracy of the combined light source and power meter shall be less than .05 dB and be temperature compensated stabilized to 0.01 dB over the operating range of the meter(s).

Power Meter -The detector in the power meter shall have an effective numerical aperture and active region that is larger than the receive reference cable and/or the fiber under test. The power meter shall have a minimum range from +3 DBMS to –40 DBMS. The power meter shall have an accuracy of +/-0.5 dB through the operating temperature and minimum resolution of 0.1 dB.

22.7 Testing

General

The Contractor shall provide all personnel, equipment, instrumentation and supplies necessary to perform all testing. All testing shall be performed in an accepted manner and in accordance with the testing equipment manufacturer's recommendations. All data shall be recorded and submitted to the Traffic Engineer as hereinbefore specified. The Contractor shall provide one copy of operating software to read and view all OTDR traces.

Attenuation

The end-to-end attenuation shall be measured for each fiber for each link after installation and termination. A patch cord jumper cable shall be connected to both the light source and the receive cable to the power meter by the use of a connector (barrel). The two reference cables shall then be connected via a termination coupler and the power meter "zeroed" to eliminate the line loss. This process results in a reading of the actual line loss (dB) of the input connector, fiber cable, exiting connector and any other splices or jumpers installed in the measured test link. The calculated "loss" shall not include the input or departing cables in the loss calculation. The calculated fiber loss measured shall list the number of terminations, including the input and departing connectors, the number of splices and the number of patch cords used to jumper the link(s) into the measured final link. The measured values for each terminated fiber in each tube shall include the Tube number, fiber number, number of feet in the link, the number of splices, the number of patch cords and the number of connectors, if any. The length of optical cable shall be as measured by the OTDR rather than the fiber cable jacket as the fiber is a reverse oscillation process resulting in a greater optical distance than the fiber cable jacket. The value for both the OTDR length and the cable jacket shall be provided in the recorded documentation for each link distance. All distances shall be recorded in feet rather than meters for both recorded lengths.

Fibers that are not continuous from beginning of the link to the end of the link shall be noted in the documentation; otherwise, all fibers in a single tube may be listed with a single data entry for all required data listed above for all fibers in the tube. The fiber documentation for each fiber shall identify the fiber being tested by either fiber number or fiber coating color and be recorded by complete tube, Tube 1 through Tube 6, fiber 1 through fiber 12. The OTDR to be performed in both directions of the test shall be recorded for information purposes only to resolve discrepancies in replicating the test during inspections of the final installation. The power meter reading recordings shall log total dB loss over the length of the fiber measured, equivalent to a dB loss budget.

Each tube of a cable shall be in the same file divider where the tube cover OTDR page shows the overview of all splices, patch cords, terminations from start to end. The second section shall include all Power Meter readings and the mandated documentation to show the calculated line loss (losses). The third section shall contain all OTDR traces, one trace per screen. The fourth section shall include the spool sheet for the fiber installed on the test section. An "explanation" sheet may be included where required to clarify an unusual reading that is valid but difficult to be explained through traditional data presentation, such as a video feed fiber that is attached to a jumper to provide continuous feed from the start to end of the tube length where other fibers in the same tube are simply spliced. The above format shall be repeated for each tube of a cable. Traffic multimode fiber measured in sections marked by traffic controller cabinets between Hub Sites may be sub-sectioned in an easy to understand format or may be jumpered using patch cords as a single OTDR Link with each section separated for power meter readings.

Documentation -The result of all testing shall be recorded along with date of test, name of person performing test, brand name, model number, serial number of equipment used during test, and any other pertinent information and data. The documentation shall be provided to the engineer in electronic format instead of paper copy format. The Contractor shall be responsible to provide input to the Engineer reviewing the recorded data documentation to resolve all questions or data discrepancies.

22.7 Cable Termination

Terminations shall be made using the method recommended by the connector manufacturer. All fibers shall utilize a fan-out kit of the size and type recommended by the manufacturer and of the number of fibers provided in each fiber tube. All fibers terminated shall utilize a ceramic ferrule (outdoor connections), LC or ST/SC, mechanical termination equal to Siecor UniCam connectors, or be a wide temperature (-40 to +170 degrees Fahrenheit) epoxy. Heat cured or epoxy type connections meeting the full temperature ratings are acceptable for this Project, including factory manufactured pigtails. The Contractor shall be required to provide proof of purchase of sufficient quantities of ceramic terminations for outdoor terminations to verify ceramic connector usage or temperature ratings on epoxy or heat cured processes prior to terminating any fibers. The Contractor may terminate fibers by splicing factory pigtails to the fiber ends and then connecting the pigtail to the fiber coupler in the fiber tray. When splicing pigtails to terminate, all splices shall be provided with the metal reinforced shrink tube protector. The contractor may terminate fibers by the use of UniCam mechanical termination connectors. All termination ST/SC couplers shall be rated for dual fiber application, MM and SM.

22.8 Breakout Kits

The breakout kits or termination boxes used to terminate each fiber cable in the cabinet shall provide for the separation and protection of the individual fibers with the buffer tubing and jacketing materials. The termination housing shall be installed within a wall or shelf mountable interconnect housing which shall provide for storing fibers, ample room for feed through cable, strain relief for multiple cables within unit, and accommodate LC or ST/SC compatible connectors. All fiber pigtails shall be terminated through LC or ST/SC connectors on the wall or shelf mounted interconnect panel. All terminations shall be LC or ST/SC type, ceramic core (outdoor connections), and plug into the provided controller unit internal fiber optic modem. Acceptable enclosures for combination termination/splice points shall be CCH-CS24 or FDC-CMP-072 enclosures or pre-approved equa1l. All new cabinets shall use high density CCH-CS24 enclosures. Splices to pigtail fiber, where used, shall utilize fan out kit protection to the fiber, heat shrink tubing with metal bar reinforcement and 900 micron rated pigtail insulation. Splices to factory pigtails shall use pigtails that are rated for a minimum temperature range of zero degrees to +150 degrees Fahrenheit. In the absence of pigtails meeting this temperature rating, fibers shall utilize loose tube fiber in fanout kit tubes and mechanical LC or ST/SC connectors. These splices, fiber cable to pigtails, may be external to splice trays mounted internally to the enclosure, when shown on the wiring diagrams. The glass/fiber in the pigtails shall be from the same manufacture of glass/fiber installed in the field. All other splices, not specified to be installed external to the fiber splice tray, shall be installed in splice trays and be supported with heat shrink tubing.

22.9 Connectors

Connectors shall be mechanical LC or ST/SC (ceramic ferrule-outdoor connections) compatible, field installable, and self-aligning and centering or factory fabricated pigtails. Connectors to the special devices used for Ethernet network connections shall utilize a factory converter cable of LC or SC to ST or manufacturer specified converter patch cord. Fiber optic equipment, used for terminating fibers, shall be rated for the type of connectors used. Connectors shall be Siecor CamLite, UniCam, or NEMA temperature rated epoxy type, or Engineer approved equal. All single mode fiber shall use LC or ST type connectors. All multimode fiber shall use SC type connectors.

22.10 Splices

The fiber cable shall be installed in continuous runs between cabinets. No splices shall be allowed, unless shown on the plans or for testing. Splices, where specified, shall be by fusion splice and shall be installed using an automatic fusion splicer. Splices between two fibers leaving the cabinet shall be supported in splice trays installed in splice enclosures. All splices shall be re-enterable splice capsules, gas or gel filled only and shall be protected by heat shrink tubing designed for fiber optic splicing applications. Fibers being terminated in two separate termination or splice enclosures shall be supported between enclosures by the use of buffer tubing or approved equal support material or shall be pigtail patch cords. Termination / splice enclosures shall be separated by less than 12 inches unless a conduit is installed between enclosures. All splices shall be performed by an automated splicer device that verifies the final splice termination quality. All splices shall be nominally .03 to .05 dB loss but shall be less than a 0.08 dB loss.

22.11 Launch Reference Attenuator

The launch attenuator, one each for single and multimode fiber testing, shall be utilized for all OTDR tests such that one launch cable shall be at the beginning of the fiber being tested. The launch attenuator(s) shall be of the same fiber core size and type as the fiber under test. The attenuator shall emulate the minimum distance specified by the OTDR manufacturer for stabilization of the pulse generation. ST/SC connectors shall be utilized with each attenuator to connect the device to the test device, OTDR. One launce cable shall be installed on the start of the fiber being tested.

The OTDR shall have the Threshold Loss set at a value to show each splice or termination junction of a single fiber in each tube with out showing the extraneous noise caused by handhole coils or turns into the cabinets. This level is normally a value [Threshold Loss] between 0.3 and 0.8 on the OTDR. This trace shall be provided for one fiber in each tube tested and each “event” shall be marked as to splice, jumper or patch cord. The Threshold Loss shall then be set to a value of 0.25 for multimode fiber tests and to a value of 0.10 for single mode fiber tests. The test of each fiber installed shall be conducted and any recorded events above this threshold shall be identified, such as jumper or patch cord. Events that are in excess the provided values shall be corrected prior to documentation submittal, such as terminations in excess of the rated value or bends in the fiber at the point of a splice entering of leaving the splice tray (See Testing). For measured values recorded in excess of the above (0.25 MM and 0.10 SM) listed values, refer to the paragraph 12.2 specification as hereinbefore defined. The Engineer reserves the right to spot test fiber terminations, splices, or re-testing of all fibers in a section to insure proper quality assurance both during and after installation and testing. Deviations from Engineer testing and report documentation shall be reviewed and the Contractor shall be able to retest any or all challenged measurements to verify a valid test. Inconsistent test results, in the sole opinion of the Engineer, shall be cause for the Contractor to retest the entire fiber installation.

23. EMERGENCY PREEMPTION

23.1 System Description

23.1.1 The required priority control system will consist of a Global Traffic Control (GTT) formerly Opticom equipment including a model 764 Card with a 768 interface panel along with model 721 receivers using model 138 detector cable all using data-encoded infrared communication to identify the presence of designated priority or probe vehicles. A record of system users, in the form of vehicle classification and identification number, will be created. In priority vehicle mode, the data-encoded communication will request the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available. In probe vehicle mode, no traffic signal priority is requested--only a record of the probe vehicle's presence is generated.

23.1.2 The priority control system will consist of a matched system of data-encoded emitters, infrared detectors, detector cable, phase selectors and system software.

23.1.3 The emitter will generate an infrared, data-encoded signal. The data-encoded signal will be detected and recognized by the infrared detectors at or near the intersection over a line-of-sight path of up to 2,500 feet (762m) under clear atmospheric conditions. The phase selector will process the electrical signal from the detector to ensure that the communication (1) is a valid base frequency, (2) is correctly data encoded, and (3) is within the user-settable priority request activation range, and (4) performs priority arbitration between simultaneous users of the system. If these conditions are met, the phase selector will generate a priority control request to the traffic controller (i.e., a green light) for the approaching priority vehicles, or record the presence of approaching probe vehicles by classification and identification number.

23.1.4 The system will require no action from the vehicle operator other than to turn the emitter on. The system will operate on a first-come, first-served basis. High priority requests will override Low priority requests. The system will interface with most traffic signal controllers and will not compromise normal operation or existing safety provisions.

23.2 Matched System Components

The required priority control, data-encoded, infrared communications system will be comprised of five basic matched components: data-encoded emitter, infrared detector, detector cable, phase selector and system software. In addition, a card rack and an electromechanical interface card will be available if required. To ensure system integrity, operation and compatibility, all components will be from the same manufacturer. The system will offer compatibility with most signal controllers, e.g., electromechanical, NEMA (National Electrical Manufacturers Association), 170. The system can be interfaced with most globally available controllers using the RS232 interface or with the card rack using designated external inputs. Interfacing to an electromechanical controller may require the use of an interface card.

23.2.1 Data-Encoded Emitter. The data-encoded emitter will trigger the system. It will send the encoded infrared signal to the detector. It will be located on the priority or probe vehicle.

23.2.2 Infrared Detector. The detector will change the infrared signal to an electrical signal. It will be located at or near the intersection. It will send the electrical signal, via the detector cable, to the phase selector.

23.2.3 Detector Cable. The detector cable will carry the electrical signal from the detector to the phase selector.

23.2.4 Phase Selector. The phase selector will accommodate data-encoded communication and will perform priority level arbitration, validate, identify, classify and record the signal

from the detector. It will be located within the controller cabinet at the intersection. It will request the controller to provide priority to the requesting vehicle and/or record presence of a probe vehicle.

23.2.5 System Software. The system software will be a Windows™ 7 (or greater) compliant program. It supports system configuration and gathering of operational information.

23.2.6 Card Rack. The card rack will provide simplified installation of a phase selector into controller cabinets that do not already have a suitable card rack.

23.2.7 Electromechanical Card. The electromechanical card will provide electrical interface between the phase selector and electromechanical-type traffic controllers.

23.3 System Component Specifications

23.3.1 Data-Encoded Infrared Emitter and Programming Software

23.3.1.1 The required data-encoded emitter will generate the infrared signal, which serves as the trigger to the rest of the priority control system. The infrared signal generated by the data encoded emitter will be a series of intense flashes from a single light source with integral power supply. The flash signal will consist of a fixed frequency base signal and a coded overlay signal that can be used to transmit information.

23.3.1.2 The data-encoded emitter will be powered by the DC voltage supplied from the battery of the vehicle, 10 to 16 volts DC. The unit will be equipped with a weatherproof in-line fuse holder and a weatherproof quick-disconnect plug.

23.3.1.3 The unit, including all electronics, will be miniaturized to a size no greater than 5.900 inches (15 cm) wide by 3.800 inches (9.7 cm) high by 3.500 inches (8.9 cm) deep to accommodate standalone and internal lightbar installation.

23.3.1.4 The data-encoded emitter will be supplied complete with a 25-foot (7.5 m) installation cable.

23.3.1.5 The flash sequence generated by the data-encoded emitter will carry three types of information:

The first type will be one of three distinctly different base frequencies of either approximately 10Hz for a Low priority emitter, or approximately 14Hz for a High priority emitter, or 12Hz for Probe frequency.

The second type of information generated by the data-encoded emitter will be a vehicle classification and identification code that is interleaved into the base frequency flashes. Setting the vehicle classification and identification code will be accomplished through emitter programming software. Each data-encoded emitter will be capable of setting 10 different classifications with 1,000 different identification numbers per class for a total of 10,000 codes per base frequency.

The third type of information generated by the data-encoded emitter will be reserved for setting the intersection detection range. A specially equipped emitter control module with a range setting command switch will enable the traffic engineer to activate the range code from his/her vehicle. The system

will accommodate setting a separate range from 200 feet (61m) to 2,500 feet (762m) with 1200 range set points, for both High and Low priority signals.

23.3.1.6 The emitter will include a multi-purpose communication port compliant with the SAE J1708 communication standard. This port enables unit configuration to be set into the emitter and read from the emitter. It also allows real-time communication between the vehicle and the emitter.

23.3.1.7 While operating, the data-encoded emitter will conduct self-diagnostics designed to monitor data transmission integrity by checking for missing pulses. Any failures of the self-diagnostic tests will be displayed by flashing of the ON/OFF switch indicator light.

23.3.1.8 An ON/OFF switch (available for each data-encoded emitter) will be equipped with an indicator light providing internal diagnostics to assist in troubleshooting. The indicator light will operate as follows:

Steady on when the emitter is operating

Flash at a 0.5Hz rate when the emitter is intentionally disabled
Flash at a 2Hz rate when the emitter is inoperative

23.3.1.9 The data-encoded emitter will be equipped with a disable input that, when activated, will stop the emitter from flashing, thereby eliminating the possibility of inadvertent signal transmission after the priority vehicle has arrived at its destination. The disable input will be programmable to operate in either a latching or non-latching mode. Operation of the disable input will be programmable using software.

23.3.1.10 The data-encoded emitter will be available with an optional visible light-blocking filter.

23.3.1.11 The data-encoded emitter will be configured with a grating to provide precise directionality control.

23.3.1.12 The data-encoded emitter will have a consistent flash intensity. The energy output per flash will be 0.84 Joules.

23.3.1.13 The data-encoded emitter will operate over a temperature range of –30°F (-34°C) to +165°F (+74°C).

23.3.1.14 The data-encoded emitter will operate over a relative humidity range of 5% to 95%.

23.3.1.15 Windows™ based software will be available for programming the emitter through its J1708 compatible multi-purpose port. The communication protocol will be made available upon request for creating software to implement real-time communication.

23.3.1.16 The emitter will provide operating modes that allow it to be powered on with the strobe active or inactive.

23.3.2 Infrared Detector

23.3.2.1 The required detector will be a lightweight, weatherproof device capable of sensing and transforming pulsed infrared energy into electrical signals for

use by the phase selection equipment.

23.3.2.2 The infrared detector will be designed for mounting at or near an intersection on mast arms, pedestals, pipes or span wires.

23.3.2.3 Each infrared detector will be supplied with mounting hardware to accommodate installation on mast arms. Hardware will be available for span wire installations. Additional hardware may be needed.

23.3.2.4 The infrared detector design will include adjustable tubes that lock into position, to enable their reorientation for span wire mounting without disassembly of the unit.

23.3.2.5 The detector will accept infrared signals from one or two directions and will provide single or dual electrical output signal(s).

23.3.2.6 The infrared detector will be available in three configurations:

Uni-directional with one output channel.

Bi-directional with one output channel.

Bi-directional with two output channels.

23.3.2.7 The detector will allow aiming of the two infrared sensing inputs for skewed approaches, wide roads or slight curves.

23.3.2.8 The infrared detector will have a built-in, labeled terminal block to simplify wiring connections.

23.3.2.9 The infrared detector will receive power from the phase selector and will have internal voltage regulation to operate from 18 to 37 volts DC.

23.3.2.10 The infrared detector will respond to a clear lens data-encoded emitter with 0.84 (±10%) Joules of energy output per flash at a distance of 2,500 feet (762m) under clear atmospheric conditions. If the emitter is configured with a visible light filter, the detector will respond at a distance of 1800 feet (549m) under clear atmospheric conditions. The noted distances will be comparable day and night.

23.3.2.11 The infrared detector will deliver the necessary electrical signal to the phase selector via a detector cable up to 1,000 feet (305m) in length.

23.3.3 Detector Cable

23.3.3.1 The detector cable will deliver sufficient power from the phase selector to the infrared detector and will deliver the necessary quality signal from the detector to the phase selector over a non-spliced distance of 1,000 feet (305m).

23.3.3.2 The cable will be of durable construction to satisfy the following installation methods:

Direct burial.

Conduit and mast arm pull.

Exposed overhead (supported by messenger wire).

23.3.3.3 The outside diameter of the detector cable will not exceed 0.3 inches (7.62mm).

23.3.3.4 The insulation rating of the detector cable will be 600 volts minimum.

23.3.3.5 The temperature rating of the detector cable will be +158°F (+70°C) minimum.

23.3.3.6 The conductors will be shielded with aluminized polyester and have an AWG #20 (7 x 28) stranded and individually tinned drain wire to provide signal integrity and transient protection.

23.3.3.7 The shield wrapping will have a 20% overlap to ensure shield integrity following conduit and mast arm pulls.

23.3.3.8 The detector cable will be comprised of three signal wires and a drain wire. Each wire will be 20 AWG (7 x 28). The capacitance will not exceed 48 pF per foot a 1 Khz. The detector cable wires will be stranded, individually tinned copper, color-coded insulation as follows:

Orange for delivery of detector power (+).

Drain wire for detector power return (-).

Yellow for detector signal #1.

Blue for detector signal #2 or ground, depending on model of detector being used.

23.3.4 Phase Selector

23.3.4.1 The phase selector, designed to be installed in the traffic controller cabinet, will accommodate data-encoded signals and is intended for use directly with numerous controllers. These include California/New York Type 170 controllers with compatible software, NEMA controllers, or other controllers along with the system card rack and suitable system interface equipment and controller software.

23.3.4.2 The phase selector will be a plug-in, four channel, multiple-priority device intended to be installed directly into a card rack located within the controller cabinet.

23.3.4.3 The phase selector will be powered from 115 volt (95 volts AC to 135 volts AC), 60Hz mains and will contain an internal, regulated power supply that supports up to twelve infrared detectors.

23.3.4.4 Programming the phase selector and retrieving the data stored in it will be accomplished using an IBM PC-compatible computer and the system interface software. The connection can be made either directly, via the computer's communication (COM) port, or remotely via a modem. The communication port on the phase selector will be 10/100Mb Ethernet communication, USB 2.0 and RS232 interface located on the front and back of the unit. The communication protocol will be made available upon

request for creating software to implement other communication applications.

23.3.4.5 The phase selector will include the ability to directly sense the green traffic controller signal indications through the use of dedicated sensing circuits and wires connected directly to the field wire termination points in the traffic controller cabinet.

23.3.4.6 The phase selector will have the capability of storing up to 10,000 of the most recent infrared and GPS priority control calls, probe frequency passages, or unauthorized vehicle occurrences. When the log is full, the phase selector will drop the oldest entry to accommodate the new entry. The phase selector will store the record in non-volatile memory and will retain the record if power terminates. Each record entry will include ten points of information about the priority call, as follows:

Classification: Indicates the type of vehicle.

Identification number: Indicates the unique ID number of the vehicle.

Priority level: Indicates whether High or Low priority, or Probe frequency is requested by the vehicle.
Direction: Channel A, B, C, or D; indicates the vehicle's direction of travel.

Call duration: Indicates the total time in seconds the priority status is active.

Final greens at end of call: Indicates which phases are green at the end of the call.

Duration of the final greens: Indicates the total time final greens were active at the end of call.

Time and date call started and ended: Indicates the time a priority call started and ended; provided in seconds, minutes, hours, day, month, year.

Maximum signal intensity: Indicates the strongest signal intensity measured by the phase selector during call.

Priority output active: Indicates if the phase selector requested priority from the controller for the call.

23.3.4.7 The phase selector will include several control timers that will limit or modify the duration of a priority control condition, by channel, and can be programmed from an IBM PC-compatible computer. The control timers will be as follows:

MAX CALL TIME: Will set the maximum time a channel is allowed to be active. It will be settable from 60 to 65,535 seconds in one-second increments.

CALL HOLD TIME: Will set the time a call is held on a channel after the priority signal is no longer being received. It will be settable from one to 255 seconds in one-second increments. Its factory default must be six seconds.

CALL DELAY TIME: Will set the time a call must be recognized before the phase selector activates the corresponding output. It will be settable from

zero to 255 seconds in one-second increments. Its factory default must be zero seconds.

23.3.4.8 The phase selector's default values will be re-settable by the operator using an IBM PC-compatible computer, or manually using switches located on its front.

23.3.4.9 The phase selector will be capable of three levels of discrimination of data-encoded infrared signals, as follows:

Verification of the presence of the base infrared signal of either High priority, Low priority or Probe frequency.

Validation of the infrared signal data-encoded pulses.

Determination of when the vehicle is within the prescribed range.

23.3.4.10 The phase selector's card edge connector will include primary infrared detector inputs and power outputs. Two additional detector inputs per channel will be provided on a front panel connector.

23.3.4.11 The phase selector will include one opto-isolated NPN output per channel that provides the following electrical signal to the appropriate pin on the card edge connector:

6.25Hz ± 0.1Hz 50% on/duty square wave in response to a Low priority call.

A steady ON in response to a High priority call.

23.3.4.12 The phase selector will accommodate three methods for setting intensity thresholds (emitter range) for high and low priority signals:

Using a data-encoded emitter with range-setting capability.

Using any encoded emitter by manipulating the front panel switches.

Inputting the range requirements via the communication port.

23.3.4.13 The intensity threshold will have 1200 set points. There will be separate intensity thresholds for the primary detector and the auxiliary detectors.

23.3.4.14 The phase selector will have a POWER ON LED indicator that flashes to indicate unit diagnostic mode and illuminates steadily to indicate proper operation.

23.3.4.15 The phase selector will have internal diagnostics to test for proper operation. If a fault is detected, the phase selector will use the front panel LED indicators to display fault information.

23.3.4.16 The phase selector will have a High (High) and Low (Low) LED indicator for each channel to display active calls.

23.3.4.17 The phase selector will have a test switch for each channel to test proper operation of High or Low priority.

23.3.4.18 The phase selector will properly identify a High priority call with the presence

of 10 Low priority data-encoded emitter signals being received simultaneously on the same channel.

23.3.4.19 The phase selector will have write-on pads to allow identification of the phase and channel.

23.3.4.20 The phase selector will have the capability to enter unique names for each channel via the interface software.

23.3.4.21 The phase selector will provide one isolated confirmation light control output per channel. These outputs are user configurable through software for a variety of confirmation light sequences.

23.3.4.22 The NEMA model of the phase selector will have outputs for the control of NEMA controllers that lack internal preemption capability. This function will be accomplished through the use of Manual Control Enable, Interval Advance, and Phase Omit options.

23.3.4.23 The NEMA model will also have the option of providing separate outputs for High and Low priority calls for controllers that do not recognize a 6.25Hz pulsed Low priority request.

23.3.4.24 The NEMA model of the phase selector will have the capability to set Interval Advance rates as low as once every 200 mSec for Low priority calls. It will also be able to operate in the Manual Control Enable Mode for Low priority calls and activate a standard preemption output for high priority calls.

23.3.4.25 The phase selector will have the capability of recording the presence of a vehicle transmitting at the specified Probe frequency. The phase selector will at no time attempt to modify the intersection operation in response to the Probe frequency.

23.3.4.26 The phase selector will have the capability of providing Low priority in a mode where the output to the controller is gated or controlled by timing relationships within the controller cycle.

23.3.4.27 The phase selector will have the capability to assign a relative priority to a call request within High or Low priority. This assignment will be based on the received vehicle class.

23.3.4.28 The phase selector will have the capability to discriminate between individual ID codes, and allow or deny a call output to the controller based on this information.

23.3.4.29 The phase selector will have the capability to log call requests by unauthorized vehicles.

23.3.4.30 The phase selector will have the ability to command an emitter to relay a received code to the next intersection.

23.3.4.31 The phase selector will have the capability of functionally testing connected detector circuits and indicating via front panel LEDs non-functional detector circuits.

23.3.4.32 The phase selector will incorporate a precision real time clock synchronized

to an AC power line frequency.

23.3.4.33 The clock will have the capability to automatically adjust itself for changes in daylight saving time. Interface software will be used to set the clock and to input the appropriate dates and times for daylight saving changes.

23.3.4.34 The phase selector shall have the capability to set the minimum time between Low priority calls.

23.3.4.35 An auxiliary interface panel will be available to facilitate interconnections between the phase selector and traffic cabinet wiring.

23.3.5 Card Rack

23.3.5.1 The required card rack will provide simplified installation of a phase selector into controller cabinets that do not already have a suitable card rack.

23.3.5.2 The card rack will be factory wired to one connector, located behind the card slot, and a terminal block, located next to the phase selector slot, on the front of the card rack.

23.3.5.3 The card rack connector on the front will provide for all connections to the traffic controller.

23.3.5.4 The card rack will provide labeled terminal blocks for connecting the primary infrared detectors to a phase selector.

23.3.6 Interface Card for Electromechanical Controllers

23.3.6.1 The required interface card for electromechanical controllers will provide electrical and logic interface between the phase selector and an electromechanical-type controller and shall be a Model 764 card.

23.3.6.2 The inputs to the interface card for electromechanical controllers will be connected to the outputs of the phase selector.

23.3.6.3 The outputs of the interface card for electromechanical controllers will be connected to the Hand Control Switch or Police Panel where the dial motor and its self-generated solenoid advance pulses are disconnected from the cam/solenoid assembly and replaced by pulses generated by the action of the Hand Control Switch in the electromechanical-type controller.

23.3.6.4 The interface card for electromechanical controllers will decode the outputs of the phase selector(s) and advance the controller to the phase that is set for that channel by sensing the traffic controller signal indications.

23.3.6.5 The interface card for electromechanical controllers will have one input to disable the interface card.

23.3.6.6 The interface card for electromechanical controllers will include the following switches:
Channel 1 Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when in Phase 1 green.

Channel 2 Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when in Phase 2 green.

Channel 3 Green Time: 16-position rotary switch; Controls timing between

advance pulses, in seconds, when in Phase 3 green.

Channel 4 Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when in Phase 4 green.

NON Green Time: 16-position rotary switch; Controls timing between advance pulses, in seconds, when no indications are green.

Power Switch.

23.3.7 Interface Software

23.3.7.1 The priority control interface software will be provided on a single CD-ROM to interface with the phase selector. The CD-ROM will include a utility to create 3.5" 1.44 mB diskettes to be used on computers without CD-ROM drives. It must run on most IBM-compatible computers equipped with at least 64M RAM, Windows™ 98 and color VGA display capability.

23.3.7.2 The priority control interface software must accommodate:

Setting up and presenting user-determined system parameters.

Viewing and changing settings.

Viewing activity screens.

Displaying and/or downloading records of previous activity showing class, code, priority, direction, call duration, final greens at end of call, duration of final greens, time call ended in real time plus maximum signal intensity (vehicle location information). This information may be used to reconstruct the route taken by a priority (or probe) vehicle to track the vehicle.

23.3.7.3 The priority control interface software must accommodate operation via a mouse or via the keyboard, or in combination.

23.3.7.4 The priority control interface software must provide menu displays to enable:

Setting of valid vehicle ID and class codes.

Establishing signal intensity thresholds (detection ranges), modem initialization, intersection name and timing parameters.

Setting of desired green signal indications during priority control operation and upload and download capability to view.

Resetting and/or retrieving logged data and priority vehicle activity.

Addressing for each card in a multi-drop connected system.

Confirmation light configuration.

NEMA Control Parameters.

23.3.7.5 The interface software will provide readout of noise levels detected by the detectors. This noise level will serve as a troubleshooting tool.

23.3.7.6 The interface software will provide a real-time activity screen

which will provide the following information:
Call intensity value even if below threshold.
Vehicle class and ID.
Emitter priority level.
Indication of detection on primary or auxiliary detector
Indication if call is being serviced or is pending.
Indication if vehicle is in range.
Readout for four separate vehicles per channel.
Detector noise level readout.
Green phase monitoring with information on the current greens.

23.4 Reliability

23.4.1 All equipment supplied as part of the infrared priority control system intended for use in the controller cabinet will meet the following electrical and environmental specifications spelled out in the NEMA Standards Publication TS2 1992, Part 2:

1. Line voltage variations per NEMA TS2 1992, Paragraph 2.1.2.
2. Power source frequency per NEMA TS2 1992, Paragraph 2.1.3.
3. Power source noise transients per NEMA TS2 1992, Paragraph 2.1.6.1.
4. Temperature range per NEMA TS2 1992, Paragraph 2.1.5.1.
5. Humidity per NEMA TS2 1992, Paragraph 2.1.5.2.
6. Shock test per NEMA TS2 1992, Paragraph 3.13.9.
7. Vibration per NEMA TS2 1992, Paragraph 3.13.8.

23.4.2 Each piece of equipment supplied as part of the priority control system intended for use in or on priority vehicles will operate properly across the entire spectrum of combinations of environmental conditions (temperature range, relative humidity, vehicle battery voltage) per the individual component specifications.

23.5 Qualifications

23.5.1 The manufacturer of the required infrared priority control system will verify the proven, safe operation of the system's infrared communication technology. Upon request, the manufacturer will produce a list of user agencies having experience interfacing priority control equipment with electromechanical, solid state and programmable controller types.

23.5.2 The manufacturer will demonstrate the ability to finance ongoing technical support, written product warranties, and responsibility for product failure.

23.5.3 Upon request, the manufacturer will produce a copy of its last full year and four previous year's corporate financial statements.

23.5.4 The manufacturer will have an independent quality department that has complete authority to control product integrity and is answerable only to the senior officer of the organization.

23.6 Responsibilities

23.6.1 The manufacturer of the required infrared priority control system and/or the manufacturer's representative will provide responsive service before, during and after installation of the priority control system. The manufacturer and/or the manufacturer's representative, as consultants to the installer, will provide certified, trained technicians having traffic systems industry experience and operational knowledge of priority control systems.

23.6.2 The lowest fully responsive bidder will be required to supply working production components specified in this Specification within 14 calendar days from the bid opening date. Failure to do so will render the bid non-responsive.

23.6.3 The requirements of Section 31.6.2 will not be required if, prior to the bid opening, the bidder demonstrated to the city that the equipment bid meets these specifications.

23.7 Substantiated Warranty

23.7.1 A copy of the manufacturer's written warranty outlining the conditions stated above will be supplied with the bid. Coverage and coverage limitations are to be administered as detailed in the manufacturer's Warranty/Maintenance document.

23.8 Certificate of Insurance

The manufacturer of the required infrared priority control system will provide a certificate of product liability insurance protection for $5,000,000 assuring the priority control user that the manufacturer is insured against civil damages if proven to be at fault for an accident due to equipment failure within the system of matched priority control components. This certificate, however, need not, and is not meant to, provide liability insurance protection to the priority control system dealer, installer or user.

23.9 User Support Services

The manufacturer of the required infrared priority control system will offer support programs to assist the purchase and implementation of a priority control system program, including:

A preferred lease program to finance purchase of a system.
Public relations assistance to promote the system within the user community.
Intersection survey service to document appropriate equipment interfaces.
Customized proposals to assist the procurement process.

23.10 Certification

The manufacturer of the required infrared priority control system will certify that all component products are designed, manufactured and tested as a system of matched components and will meet or exceed the requirements of this specification.

24. STREET LIGHTING

24.1 Mast-arm mounted street lighting (40 foot tall)

Commercial style lighting shall use a galvanized Valmont four anchor bolt style transformer base with 12” bolt circle, 15 foot arm length.

LED luminaires shall be a Lumec / Philips brand Roadview RVS-135W80LED4K-R-LE3-UNIV-GY3-RC -Cobra head style multi-tap luminaires set for 240-volt operations with housing of single piece aluminum castings with integral slipfitter for two-inch bracket mounting. The slipfitter shall be arranged to accommodate a two-inch standard pipe bracket, shall consist of bracket clamps, and shall provide for vertical adjustment and horizontal leveling of the luminaire. A weatherproof, hinged access door shall be provided for quick access to the terminal block and mounting arrangement. All exposed metal parts shall be made from non-ferrous metal or stainless steel.

Lamps shall be Type III, and may vary depending on the width of the Roadway.

Photoelectric control shall be provided as part of the Lighting controller as shown on the plans. All lights should be controlled via metered lighting controller (see 29.2 paragraph 8).

24.2 Street and subdivision lighting

Streetlight installation - Follow City of Dubuque street lighting standards but include the following Supplemental Street lighting specifications:

1. 2" HPDE or Sch 40 PVC conduit shall be used.
2. Hand-holes shall be spaced a maximum of 200 feet using a Quazite PG 12"X12" with heavy duty cover or pre-approved equivalent.
3. Place hand-hole next to each light. All splicing shall be performed in hand-hole, not in light-pole.
4. Hand-hole shall be centered between back of curb and front of sidewalk on 18 " of clean stone. Hand-hole shall be set in concrete 6" thick and extend 12 " on each side of box. Fill in space between curb and box, and sidewalk and box.
5. Place 5/8 " X 8' ground rod in box closest to light pole. Run ground wire from light pole to hand-hole with ground rod. Bond adjacent street lights together with a bonding wire (see section on bonding and grounding).
6. Use Idea # 30-260 water tight connector used in pole and Ilsco # uspa 350ss-db water tight, underground in line splice used in hand-hole
7. Each light shall contain in-line fusing and all wiring shall be XHHW.
8. An approved UL-508 pad mounted metered service pedestal/dedicated lighting controller will be located central to the lights installed and adjacent to the power source. The nearest streetlight to the controller will contain a photo-eye that will be wired to the lighting controller. Size conductors for a maximum 5% voltage drop at furthest point. This lighting controller must be Nema 3R approved and contain a factory installed breaker panel with separate circuits for each electrical branch or direction. Lighting controller must be set on a precast concrete foundation over 18 inches of clean stone and must comply with all local electrical codes.
9. Subdivision Style lighting shall use a Valmont three anchor bolt style base (DS-200 style 20 foot galvanized pole) with a Hadco “Athens” style 59630 “Grey” 40 watt, Type III, 3000 Degree LED with Philips driver. The Hanover brand equivalent will also be acceptable.
10. If part of a new subdivision, a separate street lighting plan shall be submitted

on its own page detailing lighting, conduit, hand-holes, grounding, bonding, lighting controller and service locations. Include an overview map showing a summary of lighting locations.

25. BATTERY BACKUP INSTALLATION

25.1 When specified, the Contractor shall supply and install a Tesco, model 27-22 combination battery backup with Dubuque Specifications, electrical service with meter and lighting controller as shown in the plan details. Dedicated conduits shall connect the 27-22 with the fiber hub cabinet, traffic cabinet and quazite handhole (for streetlighting). A 5/8 inch by 10 foot ground rod shall be driven in near the base of the 27-22 BBS. Ground wires shall be connected to the ground rod with one (1) piece non-ferrous clamps which employ set screws as tightening devices. The service pedestal shall be part of the continuously grounded system discussed in section 11 of this specification. See plan details.

When specified the Contractor shall supply and install a side mount Tesco, model 2200 battery backup system as specified below.

25.2 Enclosure Specifications:

Anodized aluminum weatherproof enclosure shall house BBS and batteries. Enclosure shall be TIG welded construction with welding materials specifically designed for the material to be welded. Enclosure shall have fully framed side hinged outer doors with swaged close tolerance sides for flush fit with drip lip and closed cell neoprene flange compressed gaskets. Front door shall incorporate a full-length piano hinge, pad-lockable draw latch (center area on door-latch side), and a pad lockable welded-in place vandal-proof tabs rated at 2000 lbs. There shall be no exposed nut, bolts, screws, rivets or other fasteners on the exterior of the enclosure. Maximum cabinet dimensions 46” H x 20” W x 10.25” D. Weight 250 lbs. with batteries. BBS shall be mounted in an interior tilt out housing with 800 lb. rated stops. Battery connectors shall be Anderson Connectors with silver plated contacts. Batteries shall be installed in fixed position framed trays for seismic safety and be readily accessible for maintenance. Batteries shall be mounted allowing airflow front and back. Enclosure can include two transfer bypass switches, one for BSS bypass the second for auxiliary generator (optional). All switched must be panel mounted on interior dead front panel board. UV resistant plastic laminated nameplates shall identify all controls and major components. A plastic covered wiring diagram will be attached to the inside of the front door. All components shall be factory wired and conform to required NEMA, NEC, and UL standards. A chassis ground point shall be provided. Panel shall be UL 508 Industrial Control Panel rated.

25.3 BBS Panel Minimum Features:

- System shall provide 700 watts of full control run time for two (2) hours. In addition the system shall provide six (6) to eight (8) hours of flash.
- BBS bypass and BBS isolation switch.
- Deadfront safety panel board with all switches, indicating fuses, plugs, and isolation fuses for each battery pre-wired with phenolic nameplates.
- All nameplates shall be screwed on phenolic engraved type.
- All wire terminating lugs shall be full wrap around type.
- All batteries shall be captive spaced from external captive sides in earthquake proof buckets.
- Cabinet ventilation shall be by (qty. 2) 4” x 1/4” louvers top and bottom with encapsulated bug screens, cleanable filters and 100cfm fan to completely exchange air 25 time minimum per minute.
- All DC terminals and connections shall incorporate safety covers such that the safety covers are in place for every normal maintenance mode.
- Event Counters & Total Run Time Counter.

25.3 BBS Unit Minimum Specifications:

BBS unit shall provide a true sine-wave output with minimum 1400 Volt-Amp continuous capacity. BBS must provide for utility service isolation when in operation. The minimum rating for wattage output will be 950 watts. The BBS shall be capable of running an intersection with LED lights (for

Run Time consult manufacturer). The unit shall operate off-line, with transfer time of 2 ms or less, with battery condition indicator, with automatic test provisions, and with hot-swappable batteries (all batteries in system). BBS will automatically recharge batteries from full discharge to 95% capacity within 6 hours. BBS will provide on-line operation for a minimum input on 92 to 145 VAC, provide full load output of 120VAC - 10% / +4% at 60 Hz +/- 0.05% over a temperature range of -37° C (optional adder) to +74° C and be a UL Approved Design. For Safety and maintenance the BBS shall not exceed 28 pounds. The BBS unit will be delivered with maintenance manuals and schematic diagrams.

25.5 BBS Unit Minimum Features:

- 1400VA 950 Watts, with quick make/break connectors and plugs. (Systems requiring hard wiring termination to/from the inverter are unacceptable).
- Surge energy withstand 480 Joules, 6.5kA
- Common mode clamping 0 ns < 5ns typical UL 1449
- Conditioned power - Computer quality
- Transient lighting protection - 160 Joules
- Transfer to battery time - 2ms
- Retransfer to utility - 2ms
- Each battery shall be 24 volts @ 18 AH with heavy duty Anderson plugs and isolated fused (deadfront panel mounted 30 amp) connections to the BBS for greater system reliability and ease of maintenance. Series wiring in unacceptable.
- Fan cooling shall be fused for locked rotor current.
- Cooling air shall be ducted to cool the front and back of each battery with air space on all four sides and top of battery.
- BBS covers shall be 60% open on both sides to diminish the environmental effects of extreme temperatures.
- Includes USB & RS232, DB9 Computer Interface Ports.
- Low voltage safety design at 24v DC. (Higher voltage DC systems are unacceptable).

25.6 BBS Communication Module:

All inverter connections shall be made without the use of tools. This includes: A/C-Input, A/C-Output, Normally-Open, and Normally-Closed programmable contacts.

Smart Slot Relay I/O Module;

Input #1	Turn the BBS on.
Input #2	Turn the BBS off.
Input #3	Start the BBS self-test.
Input #4	Shut down the BBS (when on battery).
Output #1	The BBS is on-battery (during a power failure, self-test or run time calibration).
Output #2	BBS has a low battery - Programmable.
Output #3	The protected load is not receiving power from the BBS.
Output #4	Replace the BBS batteries.
Output #5	The BBS is overloaded.
Output #6	Any BBS fault or self-test failure.

25.7 Batteries:

Batteries shall be maintenance-free, type AGM/VRLA (Absorbed Glass Mat / Valve Regulated Lead Acid), such as APC Smart-UPS RMXL or approved equal. Batteries shall be independently pre-wired and individually fused. Batteries shall be furnished with heavy-duty 50 amp rated silver-plated Anderson Connectors. 100 Amp internal fuse by Battery supplier. Batteries shall be lightweight for personnel safety and protection plus ease of installation and maintenance. Batteries with a weight of over 26 lbs. are not acceptable.

25.8 Enclosure Temperature Compensation:

Operating temperature shall be a minimum -37°C to + 74° C.

25.9 Power System Analyzer and Conflict Resolution Module:

The 1400XL incorporates an integrated Power System Analyzer and Conflict Resolution Module. The Analyzer will evaluate and make limited adjustments to the incoming utility power and will automatically transfer load to the battery back-up power if utility power is lost. When utility power becomes available, the BBS will analyze the power to verify stability and return to normal operation. The system provides automatic BBS failure detection and automatically isolates the failed BBS and locks the unit on to utility power. Once the failure has been corrected, the system will return to the normal operation.

25.10 Triple Bypass System For Offline BBS:

- SPACT – Smart Power Analyzer with Conflict Monitor Isolation and Transfer Module.
- PCM – Power Conflict Monitor.
- The PCM is a totally redundant failsafe system. The PCM monitors load bus power available continuously. If load bus power fails for 5ms the PCM will transfer and isolate the BBS and guarantee that commercial power will be locked on.
- Watchdog Timer – Redundant 5 ms delay and hard transfer to utility power.
- The outboard Smart Transfer Switch shall not interrupt the normal controller function. Transfer time shall be 2ms.
- Onboard Smart I/O module will execute lockout of battery back up system upon Smart detection of any inverter BBS fault. If BBS resets itself, it will automatically be available for backup.
- ON Inverter to timed relay for Full Time control of Output, 0 to 10 hours.

25.11 Smart Battery Charger:

Small charge from shut off discharge to 95% fully charged in less than 6 hours. Batteries shall be ambient enclosure compensated to less than 120°. The battery charger shall utilize Smart Cell Technology to extend battery life.

25.12 Intelligent Battery Management:

Cell Guard means longer battery life – Improved reliability results from a precision battery charging system, and automatic true-load battery tests. Redundant overcharge protection contributes to longer battery life. Smart Boost and SmartTrim regulate under and over voltages without switching to battery.

25.13 Battery Replacement Warning prevents downtime

1400XL-BBS automatically performs a self-test every two weeks. This ensures that you will be alerted to degrading batteries before they wear out. Through software, or the push of a button, self-tests may be performed at any time. Faster Recharge Time – 1400XL-BBS battery charging systems are microprocessor controlled to precisely charge batteries in less time than legacy BBS systems. This makes the system available more quickly for subsequent power disturbance.

25.14 Hot-Swappable Battery Replacement:

The 60 second, user friendly, hot-swappable battery replacement system – Saves the time and expense of returning the BBS to the factory for battery service, and allows safe and easy replacement of batteries while your system is up and running. Replacement battery packs ship in a reusable box for convenient return of exhausted batteries to a recycling center.

26. ELECTRICAL SERVICE

26.1 General

The service pedestal shall be installed as shown in the plans. Two inch conduit connecting the service pedestal and the control cabinet shall be installed as shown in the plans.

The meter shall be an Alliant Energy approved meter. The contractor shall verify acceptability with Alliant Energy and coordinate power connection to the meter from the power source.

27. FIBER HUB CABINET (FH 332)

27.1 Meets all Caltrans and FHWA requirements.

27.2 Combined 24V DC power supply and power distribution assembly.

27.3 Aluminum (0.125" thick), Natural Finish. Dimensions 66" H x 24" W x 30" D, Mounting Base Mounted, Bolt Pattern 25" x 15" with (4) 3/4" x 16" Anchor Bolts, Full size doors, front and back.

27.4 100 CFM Fan with Thermostatic Control. Filtered air intake in front door. Door Stops 90º & 180º stop, each door, top & bottom (± 10º).

27.5 Three Point Lock System

27.6 Rack Assembly Removable, Standard, 19" EIA Rack

28. SMARTSENSOR MATRIX VEHICLE DETECTION

28.1 General.

This item shall govern the purchase of above-ground radar presence detector (RPD) equivalent to the Wavetronix SmartSensor Matrix.

Matrix Stop-bar radar detection.

Provide the proper number of sensors, harnesses, home run cable, interface-panels with a terminal server, and contact closure cards required for proper operation, based on Engineers quantities or plan documents.

Provide the following part numbers as required for proper operation:

Part Number	Description
WX-SS-225, Matrix with mounting bracket	Stop-bar detector
WX-SS-704-XXX	Sensor Harness
WX-SS-705-XXXX	Home Run cable
WX-SS-B01-0005	4 Sensor interface panel
WX-SS-B01-0003	2 Sensor interface panel
WX-CLK-650	4 sensor interface panel with SDLC port
WX-CLK-301	Terminal server
WX-CLK-114	4 Channel card rack contact closure card
WX-CLK-104	4 Channel Din rail contact closure card

28.2 Sensor Outputs.

The RPD shall present real-time presence data in 10 lanes.

The RPD shall support a maximum of eight zones.

The RPD shall support four channels and have user-selectable channel assignments.

The RPD shall use OR logic to combine multiple zones to a channel output, and shall have channel output extend and delay functionality.

The RPD algorithms shall mitigate detections from wrong way or cross traffic.

The RPD system shall have fail-safe mode capabilities for contact closure outputs if communication is lost.

28.3 Detectable Area.

Detection Range. The RPD shall be able to detect and report presence in lanes with boundaries as close as 6 ft. from the base of the pole on which the RPD is mounted.

The RPD shall be able to detect and report presence in lanes located within the 140 ft. arc from the base of the pole on which the RPD is mounted.

Field of View. The RPD shall be able to detect and report presence for vehicles within a 90 degree field of view.

Lane Configuration. The RPD shall be able to detect and report presence in up to 10 lanes.

The RPD shall be able to detect and report presence in curved lanes and areas with islands and medians.

28.4 Preassemble Backplate.

Each RPD shall have a traffic cabinet preassemble backplate with the following:

- AC/DC power conversion
- Surge protection
- Terminal blocks for cable landing
- Communication connection points

The preassembled backplate for the RPD shall be a cabinet side mount or rack mount.

Contact Closure Input File Cards. The RPD shall use contact closure input file cards with 2 or 4 channel capabilities.

The contact closure input file cards for the RPD shall be compatible with industry standard detector racks.

28.5 Maintenance.

The RPD shall not require cleaning or adjustment to maintain performance.

The RPD shall not rely on battery backup to store configuration information, thus eliminating any need for battery replacement.

Once the RPD is calibrated, it shall not require recalibration to maintain performance unless the roadway configuration changes.

28.6 Physical Properties.

The RPD shall not exceed 4.2 lbs. in weight.

The RPD shall not exceed 13.2 in. by 10.6 in. by 3.3 in. in its physical dimensions.

Enclosure. The RPD shall be enclosed in a Lexan EXL polycarbonate.

The enclosure shall be classified “f1” outdoor weatherability in accordance with UL 746C.

The RPD shall be classified as watertight according to the NEMA 250 Standard.

The RPD enclosure shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures. Test results shall be provided for each of the following type 4X criteria:

- External Icing (NEMA 250 clause 5.6)
- Hose-down (NEMA 250 clause 5.7)
- 4X Corrosion Protection (NEMA 250 clause 5.10)
- Gasket (NEMA 250 clause 5.14)

The RPD shall be able to withstand a drop of up to 5 ft. without compromising its functional and structural integrity.

The RPD enclosure shall include a connector that meets MIL-C-26482 specification. The MIL-C-26482 connector shall provide contacts for all data and power connections.

28.7 Power.

The RPD shall consume less than 10 W.

The RPD shall operate with a DC input between 9 VDC and 28 VDC.

28.8 Communication Ports.

The RPD shall have two communication ports, and both ports shall communicate independently and simultaneously.

The RPD shall support the upload of new firmware into the RPD's non-volatile memory over either communication port.

The RPD shall support the user configuration of the following:

- Response delay
- Push port

The communication ports shall support a 9600 bps baud rate.

28.9 Radar Design.

The RPD shall be designed with a matrix of radars

Frequency Stability. The circuitry shall be void of any manual tuning elements that could lead to human error and degraded performance over time.

All transmit modulated signals shall be generated by means of digital circuitry, such as a direct digital synthesizer, that is reference to a frequency source that is at least 50 parts per million (ppm) stable over the specified temperature range, and ages less than 6 ppm per year. Any upconversion of a digitally generated modulated signal shall preserve the phase stability and frequency stability inherent in the digitally generated signal.

The RPD shall not rely on temperature compensation circuitry to maintain transmit frequency stability.

The bandwidth of the transmit signal of the RPD shall not vary by more than 1% under all specified operating conditions and over the expected life of the RPD.

Antenna Design. The RPD antennas shall be designed on printed circuit boards.

The vertical beam width of the RPD at the 6dB points of the two-way pattern shall be 65 degrees or greater.

The antennas shall cover a 90 degree horizontal field of view.

The sidelobes in the RPD two-way antenna pattern shall be -40dB or less.

Resolution. The RPD shall transmit a signal with a bandwidth of at least 245 MHz.

RF Channels. The RPD shall provide at least 8 RF channels so that multiple units can be mounted in the same vicinity without causing interference between them.

Verification. The RPD shall have a self-test that is used to verify correct hardware functionality.

The RPD shall have a diagnostics mode to verify correct system functionality.

28.10. Configuration.

Auto-configuration. The RPD shall have a method for automatically defining traffic lanes, stop bars and zones without requiring user intervention. This auto-configuration process shall execute on a processor internal to the RPD and shall not require an external PC or other processor.

The auto-configuration process shall work under normal intersection operation and may require several cycles to complete.

Manual Configuration. The auto-configuration method shall not prohibit the ability of the user to manually adjust the RPD configuration.

The RPD shall support the configuring of lanes, stop bars and detection zones in 1-ft. increments.

Windows Mobile®-based Software. The RPD shall include graphical user interface software that displays all configured lanes and the current traffic pattern using a graphical traffic representation.

The graphical interface shall operate on Windows Mobile, Windows XP and Windows Vista in the .NET framework.

The software shall support the following functionality:

- Operate over a TCP/IP connection
- Give the operator the ability to save/back up the RPD configuration to a file or load/restore the RPD configuration form a file.
- Allow the backed-up sensor configurations to be viewed and edited.
- Provide zone and channel actuation display
- Provide a virtual connection option so that the software can be used without connecting to an actual sensor.
- Local or remote sensor firmware upgradability.

28.11 Operating Conditions.

RPD operation shall continue in snow or in rain up to 1 in. per hour.

The RPD shall be capable of continuous operation over an ambient temperature range of -40°F to 165.2°F.

The RPD shall be capable of continuous operation over a relative humidity range of 5% to 95% (noncondensing).

28.12 Mounting Assembly.

The RPD shall be mounted directly onto a mounting assembly fastened to a mast arm, pole or other solid structure.

The RPD mounting assembly shall provide the necessary degrees of rotation to ensure proper installation.

The RPD mounting assembly shall be constructed of weather-resistant materials and shall be able to support a 20-lb (9.1 kg) load.

28.13 Mounting Location.

The RPD shall be mounted at a height that is within 15-30 feet per manufacturer's recommended mounting heights.

The RPD shall be mounted at an offset from the first lane that is not less than 6 feet per the RPD's minimum offset.

The RPD shall be mounted so that at least 20 feet along the farthest lane to be monitored is within the field view of the RPD.

The RPD shall be mounted with its cable connector down and shall be tilted so that the RPD is aimed at the center of the lanes to be monitored. Typically, the RPD is titled off of vertical by 20-30 degrees.

The RPD shall be mounted on a vertical signal pole or on the horizontal mast arm.

The RPD shall be mounted so that its field of view is not occluded by poles, signs or other structures.

RPDs that are mounted within 20 ft. (6.1 m) of each other or that are monitoring the same intersection shall be configured to operate on different RF channels regardless of the pointing direction of the RPDs.

It is recommended that the manufacturer be consulted to verify final RPD placement if the RPD is to be mounted near large planar surfaces (sound barrier, building, parked vehicles, etc.) that run parallel to the monitored roadway.

28.14 Cabling.

Ground wire #4 AWG shall be provided from the equipment location to the foundation ground. The cable shall be SmartSensor 6-conductor wire. The cable end connector shall meet the MIL-C-26482 specification and shall be designed to interface with the appropriate MIL-C-26482 connector. The connector backshell shall be an environmentally sealed shell that offers excellent immersion capability. All conductors that interface with the connector shall be encased in a single jacket, and the outer diameter of this jacket shall be within the backshell's cable O.D. range to ensure proper sealing. The backshell shall have a strain relief with enough strength to support the cable slack under extreme weather conditions. Recommended connectors are Cannon's KPT series, and recommended backshells are Glenair Series 37 cable sealing backshells.

The cable shall be the Orion Wire Combo-2204-2002-PVC-GY or an equivalent cable that conforms to the following specifications:

- The RS-485 conductors shall be a twisted pair.
- The RS-485 conductors shall have nominal capacitance conductor to conductor of less than 71pF/Ft at 1 Khz.
- The RS-485 conductors shall have nominal conductor DC resistance of less than 16.5 ohms/(304.8 m) at 68o F (20°C).
- The power conductors shall be one twisted pair with nominal conductor DC resistance of less than 11.5 ohms/(304.8 m) at 68° F (20°C).
- Each wire bundle or the entire cable shall be shielded with an aluminum/mylar shield with a drain wire.

The cable shall be terminated only on the two farthest ends of the cable.

The cable length shall not exceed 2000 ft. (609.6 m) for the operational baud rate of RS-485 communications (9.6 Kbps).

If 12 VDC is being supplied for the RPD then the cable length shall not exceed 110 ft. (33.5 m).

If 24 VDC is being supplied for the RPD then the cable length shall not exceed 600 ft. (182.9 m).

Both communication and power conductors can be bundled together in the same cable as long as the above-mentioned conditions are met.

28.15 In Cabinet Interface Equipment.

The RPD shall be installed using the SmartSensor Matrix Preassembled Traffic Cabinet Backplate or an equivalent that provides input power surge suppression, sensor cable surge suppression, AC to DC power conversion (if necessary), and terminal blocks. The surge protection devices shall meet or exceed the EN 6100-4-5 Class 4 specifications.

28.16 Power Supply.

If needed, the RPD shall be installed using the Click! 202, Click! 204 or an equivalent AC to DC power converter that meets the following specifications:

The power converter shall be power rated at 48 W for temperates less that 140° F (60°C) with a 5% power decrease for each degree increase up to 158° F (70°C).

The power converter shall operate in the temperature range of -29.2° F to +165.2° F (-34° C to 74° C).

The power converter shall operate in the humidity range of 5% to 95% at 77° F (25°C) non-condensing.

The power converter shall accept an input voltage of 85 VAC to 264 VAC or 120 VDC to 370 VDC.

The power converter shall operate at an input frequency of 47 Hz to 63 Hz.

The power converter shall produce an output voltage of 24 VDC ±4%.

The power converter shall withstand a voltage across its input and output of 2kV. The power converter shall withstand a voltage across its input and ground of 1.5 kV.

The power converter shall conform to safety standards UL 60950 and EN60950.

The power converter shall conform to EMC standards EN55022 Class B and EN61000-3-2, 3.

In brown-out conditions (i.e. <85VAC input), the output voltage of the power converter shall be less than 1 VDC.

The terminal blocks shall be color-coded insulation displacement terminal blocks.

The terminal blocks shall be prewired to the other in-cabinet equipment so that no wiring other than cable terminations, connecting input power and connecting input file cards shall be required during installation.

28.17 Input File Cards.

The Click! 114, Click! 112 or an equivalent that meets the following specifications shall be used.

The input file cards shall be compatible with 170, 2070, NEMA TS1, and NEMA TS2 style input racks.

The input file card shall translate data packets from the RPD into contact closure outlets.

The input file card shall support presence detection.

The input file card shall receive data packets over an RS-485 bus at a baud rate of 9600 bps.

The input file card shall autobaud and auto-detect an RPD over wired and wireless communication channels that have a maximum latency of 500 ms.

The input file card shall comply with the NEMA TS2-1998 Traffic Controller Assemblies with NTCIP Requirements (Section 2.8 specification).

29. SMARTSENSOR HD DETECTION

29.1 General.

This item shall govern the purchase of above-ground radar vehicle sensing devices (RVSD) equivalent to the Wavetronix SmartSensor HD.

Wavetronix, HD Count station.

Provide the proper number of sensors, harnesses, home run cable, interface and communication equipment for proper operation, based on Engineers quantities or plan documents.

Part Number	Description
WX-SS-126, HD	ITS Sensor
with mounting bracket	
WX-SS-706-XXX	Sensor Harness
MAS-3000-01	Custom Solar Engine
MAS-3000-02	Custom AC Engine
WX-CLK-400	900 MHz radios
Radios to include surge, antennas and cabling required for full operation	
WX-CLK-301	Terminal server
WX-CLK-200	Surge arrestor
WX-CLK-201	1 amp Power Supply
WX-CLK-205	AC lighting surge protection
WX-CLK-206	Resettable circuit breaker

29.2 Measured Quantities.

The RVSD shall provide volume, average speed, occupancy, classification counts, 85th percentile speed, average headway, average gap, speed bin counts and direction counts for user-configurable time intervals for up to 10 lanes of traffic.

The RVSD shall provide up to eight length-based classification bins.

The RVSD shall provide up to 15 speed bins.

The RVSD shall provide speed, length, class, lane assignment, and range data for each vehicle detection.

The RVSD shall provide presence data for up to 10 lanes of traffic.

29.3 Detectable Area.

29.4 Maximum Lanes.

The RVSD shall be able to detect and report information from up to 10 lanes.

29.5 Detection Range.

The RVSD shall be able to detect and report information in lanes with boundaries as close as 6 ft. (1.8 m) from the base of the pole on which the RVSD is mounted.

The RVSD shall be able to detect and report information in lanes located with the far boundary at 250 ft. (76.2 m) from the base of the pole on which the RVSD is mounted.

The RVSD shall be able to simultaneously detect and report information from a lane located at the minimum offset and from a lane located at the maximum range.

29.6 Lane Size and Spacing.

The RVSD shall allow any spacing of traffic lanes positioned from the minimum offset to the maximum range. Gore and unequally sized or spaced lanes shall be handled so that detections from the lanes meet all performance specifications.

29.7 Performance.

29.8 Volume Accuracy.

The volume data shall be within 5% of truth for a direction of travel during nominal conditions. Individual lane volume data shall be within 10% of truth during nominal conditions. The percentage of missed detection and the percentage of false detections for each lane shall not exceed 15% during nominal conditions. Nominal conditions exist when average speeds are greater than 10 mph (16 kph) in every lane; when there is less than 20% truck traffic per lane; and when at least 50 cars per lane are counted in the interval.

29.9 Speed Accuracy.

Average speed data shall be accurate to within 3 mph (5 kph) for any direction of travel when there are more than five cars per lane in an interval. Average speed data for any individual lane shall be accurate to within 3 mph (5 kph) when there are more than five cars per lane in an interval.

The RVSD shall provide per-vehicle speed measurements on 95% of vehicles that are not occluded by other vehicles or by barriers. The RVSD shall provide per-vehicle speed measurements in which 90% of the measurements are within 5 mph (8 kph).

The RVSD shall measure speed using a dual-radar speed trap that calculates the time delay between two different radar beams.

29.10 Occupancy Accuracy.

Occupancy data shall be within 10% of truth for any direction of travel on a roadway during nominal conditions. For example, if the true occupancy in a lane is 20%, then the measured occupancy shall be between 18% and 22%. Individual lane occupancy shall be within 20% during nominal conditions. Nominal conditions exist when true occupancy is less than 30%, without merging traffic; when average speeds are greater than 10 mph (16 kph) in every lane; and when there is less than 20% truck traffic per lane.

29.11 Classification Accuracy. The RVSD shall correctly determine classification for 80% of detected vehicles when the classification bins are at least 10 ft. (3 m) wide and occupancy of all lanes is below 30%.

29.12 Performance Maintenance.

The RVSD shall not require cleaning or adjustment to maintain performance. The RVSD shall not rely on battery backup to store configuration information, thus eliminating any need for battery replacement.

Once the RVSD is calibrated, it shall not require recalibration to maintain performance unless the roadway configuration changes.

The RVSD shall be manufactured using techniques that will yield a mean time between failures of 10 years.

29.13 Physical Properties.

The RVSD shall not exceed 5 lbs. (2.3 kg) in weight.

The RVSD shall not exceed 14 in. by 12 in. by 4 in. (35.6 cm x 30.5 cm x 10.2 cm) in its physical dimensions.

29.14 Enclosure.

The RVSD shall be enclosed in a Lexan polycarbonate.

The enclosure shall be classified "f1" outdoor weatherability in accordance with UL 746C. The RVSD shall be classified as watertight according to the NEMA 250 Standard.

The RVSD enclosure shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures.

Test results shall be provided for each of the following type 4X criteria:

- External Icing (NEMA 250 clause 5.6)
- Hose-down (NEMA 250 clause 5.7)
- 4X Corrosion Protection (NEMA 250 clause 5.10)
- Gasket (NEMA 250 clause 5.14)

The RVSD shall be able to withstand a drop of up to 5 ft. (1.5 m) without compromising its functional and structural integrity.

The RVSD enclosure shall include a connector that meets the MIL-C-26482 specification. The MIL-C-26482 connector shall provide contacts for all data and power connections.

29.15 Power.

The RVSD shall consume less than 9.5 W. The RVSD shall operate with a DC input between 12 VDC and 28 VDC.

29.16 Communication Ports.

The RVSD shall have an RS-485 port and an RS-232 port, and both ports shall communicate independently and simultaneously.

The RS-232 port shall be full-duplex and shall support true RTS/CTS hardware handshaking for interfacing with various communication devices.

The RVSD shall support the upload of new firmware into the RVSD's non-volatile memory over either communication port.

The RVSD shall support the user configuration of the following:

- Baud rate
- Response delay
- Data push
- RS-232 flow control (RTS/CTS or none)

The communication ports shall support all of the following baud rates: 9600, 19200, 38400, 57600 and 115200 bps.

29.17 Data Protocols.

The RVSD shall support three different data protocols for all lanes being monitored: interval (bin) data, event (per vehicle) data, and real-time true presence data.

29.18 Occupancy Accuracy.

Occupancy data shall be within 10% of truth for any direction of travel on a roadway during nominal conditions. For example, if the true occupancy in a lane is 20%, then the measured occupancy shall be between 18% and 22%. Individual lane occupancy shall be within 20% during nominal conditions. Nominal conditions exist when true occupancy is less than 30%, without merging traffic; when average speeds are greater than 10 mph (16 kph) in every lane; and when there is less than 20% truck traffic per lane.

29.19 Classification Accuracy.

The RVSD shall correctly determine classification for 80% of detected vehicles when the classification bins are at least 10 ft. (3 m) wide and occupancy of all lanes is below 30%.

29.20 Performance Maintenance.

The RVSD shall not require cleaning or adjustment to maintain performance.

The RVSD shall not rely on battery backup to store configuration information, thus eliminating any need for battery replacement.

Once the RVSD is calibrated, it shall not require recalibration to maintain performance unless the roadway configuration changes.

The RVSD shall be manufactured using techniques that will yield a mean time between failures of 10 years.

29.21 Physical Properties.

The RVSD shall not exceed 5 lbs. (2.3 kg) in weight.

The RVSD shall not exceed 14 in. by 12 in. by 4 in. (35.6 cm x 30.5 cm x 10.2 cm) in its physical dimensions.

29.22 Enclosure.

The RVSD shall be enclosed in a Lexan polycarbonate.

The enclosure shall be classified “f1” outdoor weatherability in accordance with UL 746C.

The RVSD shall be classified as watertight according to the NEMA 250 Standard.

The RVSD enclosure shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures. Test results shall be provided for each of the following type 4X criteria:

- External Icing (NEMA 250 clause 5.6)
- Hose-down (NEMA 250 clause 5.7)
- 4X Corrosion Protection (NEMA 250 clause 5.10)
- Gasket (NEMA 250 clause 5.14)

The RVSD shall be able to withstand a drop of up to 5 ft. (1.5 m) without compromising its functional and structural integrity.

The RVSD enclosure shall include a connector that meets the MIL-C-26482 specification. The MIL-C-26482 connector shall provide contacts for all data and power connections.

29.23 Power.

The RVSD shall consume less than 9.5 W.

The RVSD shall operate with a DC input between 12 VDC and 28 VDC.

29.24 Communication Ports.

The RVSD shall have an RS-485 port and an RS-232 port, and both ports shall communicate independently and simultaneously.

The RS-232 port shall be full-duplex and shall support true RTS/CTS hardware handshaking for interfacing with various communication devices.

The RVSD shall support the upload of new firmware into the RVSD's non-volatile memory over either communication port.

The RVSD shall support the user configuration of the following:

- Baud rate
- Response delay
- Data push
- RS-232 flow control (RTS/CTS or none)

The communication ports shall support all of the following baud rates: 9600, 19200, 38400, 57600 and 115200 bps.

29.25 Data Protocols.

The RVSD shall support three different data protocols for all lanes being monitored: interval (bin) data, event (per vehicle) data, and real-time true presence data.

The interval (bin) data packet protocol shall support:

- Sensor ID
- A timestamp that records the year, month, day, hour, minute, and second of the end of time interval
- Total volumes of more than 65536
- Average speed values in either mph or kph
- Occupancy in 0.1% increments
- Volume in up to eight length-based user-defined vehicle classification bins
- Volume in up to 15 user-defined speed bins (bin by speed)
- Volume for both directions of traffic (bin by direction)
- Average headway in seconds
- Average gap in seconds
- 85^{th} percentile speed in either mph or kph

The event (per vehicle) data packet protocol shall support:

- Sensor ID
- A timestamp that records the year, month, day, hour, minute, second and millisecond of the time the vehicle left the detection zone
- Lane assignment
- Speed values in either mph or kph
- Vehicle length
- Classification using up to eight user-defined classes
- Range

The real-time true presence data packet protocol shall support:

- Sensor ID
- True presence information for each lane being monitored

29.26 Data Buffering.

The RVSD shall store, in non-volatile memory, at least 9,000 interval data packets with the maximum number of lanes and approaches configured and all interval fields enabled.

The RVSD shall timestamp interval data using a real-time clock that maintains accurate time even when power is disconnected from the sensor for extended periods of time.

29.27 Radar Design.

The RVSD shall employ a dual radar design that includes two receive channels.

29.28 Frequency Stability.

The circuitry shall be void of any manual tuning elements that could lead to human error and degraded performance over time.

All transmit modulated signals shall be generated by means of digital circuitry, such as a direct digital synthesizer, that is referenced to a frequency source that is at least 50 parts per million (ppm) stable over the specified temperature range, and ages less than 6 ppm per year. Any upconversion of a digitally generated modulated signal shall preserve the phase stability and frequency stability inherent in the digitally generated signal.

The RVSD shall not rely on temperature compensation circuitry to maintain transmit frequency stability.

The bandwidth of the transmit signal of the RVSD shall not vary by more than 1% under all specified operating conditions and over the expected life of the RVSD.

29.29 Antenna Design.

The RVSD antennae shall be designed on printed circuit boards.

The vertical beam width of the RVSD at the 6dB points of the two-way pattern shall be 65 degrees of greater.

The horizontal beam width of the RVSD at the 6dB points of the two-way pattern shall be 7 degrees or less.

The sidelobes in the RVSD two-way antenna pattern shall be -40dB or less.

29.30 Resolution.

The RVSD shall transmit a signal with a bandwidth of at least 240 MHz.

29.31 RF Channels.

The RVSD shall provide at least 4 RF channels so that multiple units can be mounted in the same vicinity without causing interference between them.

29.32 Auto-configuration.

The RVSD shall have a method for automatically defining traffic lanes or detection zones without requiring user intervention. The auto-configuration process shall execute on a processor internal to the RVSD and shall not require an external PC or other processor.

The auto-configuration process shall automatically define traffic lanes or detection zones by detecting the relative position of vehicles within the RVSD's field of view.

The RVSD shall include a transceiver capable of detecting multiple vehicles present within its field of view. The RVSD shall also include a processor or computer with executable instruction that estimates the position of each of the vehicles, records the position of the vehicles, generates a probability density function estimation from each position of the vehicles, and defines traffic lanes from that probability density function estimation. The

probability density function estimation represents the probability that a vehicle will be located at any range.

The RVSD auto-configuration process shall define all lanes within the detectable area of the RVSD, up to the maximum number of lanes, during free-flow conditions; when at least 50% of a sedan is visible above any barriers; when at least 10 cars pass in each lane during configuration time; and there are less than 10% lane-changing vehicles.

29.33 Manual Configuration.

The auto-configuration method shall not prohibit the ability of the user to manually adjust the RVSD configuration.

The RVSD shall support the configuring of lanes or detection zones in 1-ft. (0.3-m) increments.

29.34 Windows Mobile®-based Software.

The RVSD shall include graphical user interface software that displays all configured lanes and the current traffic pattern using a graphical traffic history representing at least the last 1.5 seconds of detected traffic. This graphical traffic history shall also allow the option of displaying the measured speed or length of a detected vehicle.

The graphical interface shall operate on Windows Mobile, Windows 2000, Windows XP, Windows Vista, and Windows 7 in the .NET framework.

The software shall support the following functionality:

- Automatically find the correct baud rate
- Automatically find the correct serial communication port
- Operate over a TCP/IP connection
- Support dial-up modem connectivity
- Give the operator the ability to save/back up the RVSD configuration to a file or load/restore the RVSD configuration from a file
- Provide a virtual connection option so that the software can be used without connecting to an actual senor

29.35 Operating Conditions.

The RVSD shall maintain accurate performance in all weather conditions, including rain, freezing rain, snow, wind, dust, fog and changes in temperature and light, including direct light on sensor at dawn and dusk.

RVSD operation shall continue in snow or in rain up to 4 in. (10.2 cm) per hour.

The RVSD shall be capable of continuous operations over an ambient temperature range of -40°F to 165.2°F (-40°C to 74°C).The RVSD shall be capable of continuous operation over a relative humidity range of 5% to 95% (non-condensing).

29.36 Manufacturing.

The RVSD shall be manufactured and assembled in the U.S.A.

29.37 Mounting Assembly.

The RVSD shall be mounted directly onto a mounting assembly fastened to a pole or other solid structure.

The RVSD mounting assembly shall provide the necessary degrees of rotation to ensure proper installation.

The RVSD mounting assembly shall be constructed of weather-resistant materials and shall be able to support a 20-lb. (9.1 kg) load.

29.38 Mounting Location.

The RVSD shall be mounted at a height that is within 9-50 feet per manufacturer's recommended mounting heights.

The RVSD shall be mounted at an offset form the first lane that is between 6-50 feet per the RVSD's minimum offset.

The RVSD shall be mounted so that the farthest lane to be monitored is not more than 200 feet per maximum range of the RVSD.

The RVSD shall be mounted with its cable connector down and shall be tilted so that the RVSD is aimed at the center of the lanes to be monitored. Typically, the RVSD is tilted off of vertical by 10-20 degrees.

The RVSD shall be aligned so that the horizontal angle is within approximately ±2 degrees of perpendicular to the flow of traffic. The RVSD alignment tool shall be used to verify pointing accuracy.

Two RVSD units shall not be mounted so that they are pointed directly at each other.

A distance of 40 ft. (12.2 m) or more, along the direction of the roadway, shall separate the RVSDs if they are located on opposing sides of a roadway and the RVSDs shall be configured to operate on different RF channels.

RVSDs that are mounted within 20 ft. (6.1 m) of each other shall be configured to operate on different RF channels regardless of the pointing direction of the RVSDs.

When possible, the pole selected for the RVSD shall be where there is no guardrail or other type of barrier between the pole and the first lane of traffic.

The RVSD shall not be installed in areas with overhead structures. For example, overhead sign bridges, tunnels and overpasses should be avoided. The RVSD shall be mounted at least 30 ft. (9.1 m) to the side of any such overhead structure.

It is recommended that the manufacturer be consulted to verify final RVSD placement if the RVSD is to be mounted near large planar surfaces (sound barrier, building, parked vehicles, etc.) that run parallel to the monitored roadway.

29.39 Cabling.

The cable shall be SmartSensor wire. The cable end connector shall meet the MIL-C-26482 specification and shall be designed to interface with the appropriate MIL-C-26482 connector. The connector backshell shall be an environmentally friendly sealed shell that offers excellent immersion capability. All conductors that interface with the connector shall be encased in a single jacket, and the out diameter of this jacket shall be within the backshell's cable O.D. range to ensure proper sealing. The backshell shall have a strain relief with enough strength to support the cable slack under extreme weather conditions. Recommended connectors are Cannon's KPT series, and recommended backshells are Glenair Series 37 cable sealing backshells.

The cable shall be the Orion Wire Combo-2207-2002-PVC-GY or an equivalent cable that conforms to the following specifications:

- The RS-485 conductors shall be a twisted pair.

- The RS-232 and RS-485 conductors shall have nominal capacitance conductor to conductor of less than 71pF/Ft at 1 Khz.
- The RS-232 and RS-485 conductors shall have nominal conductor DC resistance of less than 16.5 ohms/(304.8 m) at 68°F (20°C).
- The power conductors shall be one twisted pair with nominal conductor DC resistance of less than 11.5 ohms/(304.8 m) at 68°F (20°C).
- Each wire bundle or the entire cable shall be shielded with an aluminum/mylar shielded with a drawn wire.

The cable shall have a single continuous run with no splices.

The cable shall be terminated only on the two farthest ends of the cable.

The cable length shall not exceed the following limits for the operational baud rate of RS-485 communications:

Baud Rate	Cable Length
115.2 Kbps	300 ft. (91.4 m)
57.6 Kbps	600 ft. (182.9 m)
38.4 Kbps	800 ft. (243.8 m)
19.2 Kbps	1000 ft. (304.8 m)
9.6 Kbps	2000 ft. (609.6 m)

NOTE: These represent maximum data rates. The data used should be the minimum data rate required for operation.

If communication is conducted over the RS-232 bus, then the RS-232 driver must be able to source and sink $\pm$7 mA or more.

The cable length shall not exceed the following limits for the operational baud rate of RS-232 communications:

Baud Rate	Cable Length
115.2 Kbps	40 ft. (12.2m)
57.6 Kbps	60 ft. (18.3 m)
38.4 Kbps	100 ft. (30.5 m)
19.2 Kbps	140 ft. (42.7 m)
9.6 Kbps	200 ft. (61 m)

NOTE: These represent maximum data rates. The data used should be the minimum data rate required for operation.

If 12 VDC is being supplied for the RVSD then the cable length shall not exceed 110 ft. (33.5m).

If 24 VDC is being supplied for the RVSD then the cable length shall not exceed 600 ft. (182.9 m).

If a cable length of 600 ft. (182.9 m) to 2000 ft. (609.6 m) is required, the power cable shall be an ANIXTER 2A-1402 or equivalent cable that meets the following requirements:

- 10 AWG conductor size/gauge
- Two conductor count
- Stranded cable type
- Bare copper material
- 600 V range

- 194°F (90°C) temperature rating
- PVC/nylon insulation material
- PVC- polyvinyl chloride jacketing material
- 25 A per conductor

Both communication and power conductors can be bundled together in the same cable as long as the above-mentioned conditions are met.

29.40 Lighting Surge Protection.

The RVSD shall be installed using lighting surge protection on all communication and power lines. The surge protection devices shall meet or exceed the EN 61000-4-5 Class 4 specifications.

The lighting surge protection unit shall be the Wavetronix Click! 200™ or equivalent.

29.41 Power Supply.

The RVSD shall be installed using the Click! 201, Click! 202 or an equivalent AC to DC power converter that meets the following specifications:

The power converter shall be power rated at 15 W or greater at 77°F (25°C) and 10 W or greater at 165.2 (74°C).

The power converter shall operate in the temperature range of to -29.2°F to +165.2°F (-34°C to +74°C).

The power converter shall operate in the humidity range of 5% to 95% at 77°F (25°C) non-condensing.

The power converter shall accept an input voltage of 85 VAC to 264 VAC or 120 VDC to 370 VDC.

The power converter shall operate at an input frequency of 47 Hz to 63 Hz.

The power converter shall produce an output voltage of 24 VDC +4%.

The power converter shall have a hold-up time of greater than 20 ms at 120 VAC.

The power converter shall withstand a voltage across its input and output of 2kV.

The power converter shall withstand a voltage across its input and ground of 1.5kV.

The power converter shall conform to safety standards UL 60950 and EN60950.

The power converter shall conform to EMC standards EN55022 Class B and EN61000-3-2, 3.

In brown-out conditions (i.e. <85VAC input), the output voltage of the power converter shall be less than 1 VDC.

29.42 Input File Cards.

If input file cards are used in the detection system, then the Click! 172, Click! 174 or an equivalent that meets the following specifications shall be used.

The input file cards shall be compatible with 170, 2070, NEMA TS1, and NEMA TS2 style input racks.

The input file card shall translate data packets from the RVSD into contact closure outputs.

The input file card shall support dual loop (speed trap) emulation, as well as the following modes of operation:

- Pulse (a single 125 ms output pulse for each vehicle)
- Presence (an output pulse corresponding to the duration of each vehicle in the detection zone)
- Actuation (true presence output in real time)
- Single loop speed (duration of the pulse is inversely proportional to the speed of the vehicle)

The input file card shall receive data packets over an RS-485 bus at any of the following baud rates: 9600, 19200, 38400 and 57600 bps.

The input file card shall autobaud and auto-detect an RVSD over wired and wireless communication channels that have a maximum latency of 500 ms.

The input file card shall comply with the NEMA TS2-1998 Traffic Controller Assemblies with NTCIP Requirements (Section 2.8 specification).

30. ADVANCE MICROWAVE VEHICLE DETECTION

30.1 General.

This item shall govern the purchase of above ground continuous tracking advance detector (CTAD) equivalent to the Wavetronix SmartSensor Advance®.

Advance, Advance CTAD radar detection.

Provide the proper number of sensors, harnesses, home run cable, interface-panel with a terminal server, and contact closure cards required for proper operation, based on Engineers quantities or plan documents.

Part Number	Description
WX-SS-200V, Advance with mounting bracket	Advance Sensor
WX-SS-200E, Advance with mounting bracket	Extended Range Advance
WX-SS-704-XXX	Harness
WX-SS-705-XXXX	Home Run cable
WX-SS-B01-0005	4 Sensor interface panel
WX-SS-B01-0003	2 Sensor interface panel
WX-CLK-650	4 sensor interface panel with SDLC port
WX-CLK-301	Terminal server
WX-CLK-112	2 Channel card rack contact closure card
WX-CLK-104	4 Channel Din rail contact closure card

30.2 Measured Quantities And Outputs.

The CTAD shall detect range, speed, vehicle estimated time of arrival (ETA) to the stop bar for vehicles or clusters of vehicles moving in the user selected direction of travel. The CTAD shall also detect instantaneous roadway efficiency.

The CTAD shall be able to simultaneously detect and report information from up to 25 vehicles on the roadway when they are serially sequenced between the near and far boundaries.

The CTAD shall turn on a zone output when the range, speed, ETA, and qualified count or instantaneous roadway efficiency requirements for that zone are satisfied.

The CTAD shall turn on a latched channel output when the on alert is turned on and the delay time is satisfied. The CTAD shall turn off a latched channel output when the off alert is turned on or the max timer expires and the extension time is satisfied.

The CTAD shall provide vehicle call and extend data on up to eight channels that can be connected to contact closure modules compliant with NEMA TS1, NEMA TS2, 170, and 2070 controller cabinets.

The CTAD shall be capable of providing data for each tracked detection over the serial ports.

30.3 Detectable Area

Mounting Location. The CTAD shall be able to detect and report vehicle information when mounted within 50' (15.2 m) of the center of the lanes of interest.

The CTAD shall be able to detect and report vehicle information when mounted at heights up to 40' (12.2m) above the road surface.

Detection Range. The CTAD shall be able to detect and report information on the roadway located with the near boundary at 50' (15.2m) from the base of the pole on which is CTAD is mounted.

The CTAD shall be able to detect and report information on the roadway located with the far boundary at 500' (152.4m) from the base of the pole on which the CTAD is mounted.

For incoming traffic, 95 percent of large vehicles within the line-of-site of the CTAD shall be detected and reported before they arrive 400' (121.9m) from the sensor. For incoming traffic, 90 percent of all motor vehicles within the line-of-site of the CTAD shall be detected and reported before they arrive 400' (121.9m) from the sensor.

30.4 Performance

Detection Accuracy. The CTAD shall detect at least 98 percent of large vehicles like truck-trailer combinations and at least 95 percent of all motor vehicles within the line-of-sight of the CTAD sensor where multiple detections of multi-unit vehicles are not considered false detections and merged detections of adjacent lane vehicles are not considered missed detections.

Range Accuracy. The CTAD shall provide range measurements in which 90 percent of the measurements are accurate within 10' (3m) when the vehicle is tracked independently.

Speed Accuracy. The CTAD shall provide per vehicle speed measurements in which 90 percent of the measurements are accurate within 5 mph when tracked independently.

ETA Accuracy. The CTAD shall provide estimated time-of-arrival (ETA) measurements in which 85 percent of the measurements are accurate within one second, when the detected vehicles are tracked independently at a constant speed above 40 mph (64 kph) and are within 2.5 and 5.5 seconds of the stop bar.

30.5 Performance Maintenance.

The CTAD shall not require cleaning or adjustment to maintain performance.

The CTAD shall not rely on battery backup to store configuration information, thus eliminating any need for battery replacement.

Once the CTAD is calibrated, it shall not require recalibration to maintain performance unless the roadway configuration changes.

30.6 Physical Properties.

The CTAD shall not exceed 5 lbs. (2.3 kg) in weight.

The CTAD shall not exceed 14 in. by 12 in. by 4 in. (35.5 cm x 30.5 cm x 10 cm) in its physical dimensions.

Enclosure. The CTAD shall be enclosed in a Lexan polycarbonate.

The enclosure shall be classified "f1" outdoor weatherability in accordance with UL 746C.

The CTAD shall be classified as watertight according to the NEMA 250 Standard.

The CTAD enclosure shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures. Test results shall be provided for each of the following type 4X criteria:

- External Icing (NEMA 250 clause 5.6)
- Hose-down (NEMA 250 clause 5.7
- 4X Corrosion Protection (NEMA 250 clause 5.10)
- Gasket (NEMA 250 clause 5.14)

The CTAD shall be able to withstand a drop of up to 5' (1.5 m) without compromising its functional and structural integrity.

The CTAD enclosure shall include a connector that meets the MIL-C-26482 specification. The MIL-C-26482 connector shall provide contacts for all date and power connections.

30.7 Power.

The CTAD shall consume less than 8 W.

The CTAD shall operate with a DC input between 12 VDC and 28 VDC.

30.8 Communication Ports.

The CTAD shall have two serial communication ports, and both ports shall communicate independently and simultaneously.

The CTAD shall support the upload of new firmware into the CTAD's non-volatile memory over either communication port.

The CTAD shall support the user configuration of the following:

- Baud rate
- Communication port response delay
- Contact closure output frequency

Both communication ports shall support all of the following baud rates: 9600, 19200, 38400, 57600 and 115200 bps.

The contact closure output frequency shall be user configurable as short as 10 ms, with a default near 130 ms for compatibility.

Contact closure data shall be reliably communicated over homerun cable connections as long as 600' (182.9 m) with latency from the time of channel requirement satisfaction to the eventual reporting of on the back edge of the contact closure card in 15 ms or less.

30.9 Radar Design.

Frequency Stability. The circuitry shall be void of any manual tuning elements that could lead to human error and degraded performance over time.

All transmit modulated signals shall be generated by means of digital circuitry, such as a direct digital synthesizer, that is referenced to a frequency source that is at least 50 parts per million (ppm) stable over the specified temperature range, and ages less than 6 ppm per year. Any upconversion of a digitally generated modulated signal shall preserve the phase stability and frequency stability inherent in the digitally generated signal.

The CTAD shall not rely on temperature compensation circuitry to maintain transmit frequency stability.

The bandwidth of the transmit signal of the CTAD shall not vary by more than 1 percent under all specified operating conditions and over the expected life of the CTAD.

Antenna Design. The CTAD antennae shall be designed on printed circuit boards.

The vertical beam width of the CTAD at the 6dB points of the two-way pattern shall be 65 degrees or greater.

The horizontal beam width of the CTAD at the 6dB points of the two-way pattern shall be 11 degrees or less.

The sidelobes in the CTAD two-way antenna pattern shall be -40dB or less.

RF Channels. The CTAD shall provide at least four RF channels so that multiple units can be mounted in the same vicinity without causing interference between them.

30.10 Configuration.

Auto-configuration. The CTAD shall have a method for automatically configuring the sensitivity of detection in at least 5' (1.5-m) increments.

The auto-configuration method shall not prohibit the ability of the user to manually adjust the CTAD configuration.

The CTAD shall support the configuration of up to eight channel outputs with up to four alerts per channel and up to four zones per alert, resulting in 32 configurable alerts and 128 configurable zones.

Zone Configuration. The CTAD shall support the configuring of zones in 5' (1.5 m) increments.

The CTAD shall support detection zones as long as 450' (137.2 m).

The CTAD shall support user configurable high-speed and low-speed detection filters for each zone.

The CTAD shall support the configuring of speed filters in 1-mph (1.6-kph) increments.

8 The CTAD shall support user configurable upper and lower estimated time-of-arrival (ETA) filters for each zone.

The CTAD shall support the configuring of ETA filters in increments of 0.1 seconds.

The CTAD shall provide configurable upper and lower count filters that help determine if a required number of qualified detections are present.

The CTAD shall support the configuring of qualified count filters in increments of one.

Windows Mobile®-based Software. The CTAD shall include graphical user interface software that displays the current traffic pattern using a graphical traffic representation.

The graphical user interface shall provide a means of logging the vehicular track files with an update rate of greater than five times per second.

The graphical interface shall operate on Windows Mobile, Windows 2000, Windows XP and Windows Vista in the .NET framework.

The software shall support the following functionality:

- Automatically find the correct baud rate
- Automatically find the correct serial communication port
- Operate over a TCP/IP connection
- Provide a virtual sensor connection for software usability without a sensor
- Give the operator the ability to save/back up the CTAD configuration to a file or load/restore the CTAD configuration from a file.

30.11 Operating Conditions.

The CTAD shall maintain accurate performance in all weather conditions, including rain, freezing rain, snow, wind, dust, fog and changes in temperature and light, including direct light on sensor at dawn and dusk.

CTAD operation shall continue in snow or rain up to 4 in. (10 cm) per hour.

The CTAD shall be capable of continuous operation over an ambient temperature range of -40°F to 165°F (140°C to 74°C).

The CTAD shall be capable of continuous operation over a relative humidity range of 5% to 95% (non-condensing).

30.12 Manufacturing.

The CTAD shall be manufactured and assembled in the U.S.A.

30.13 Mounting and Installation.

Mounting Assembly. The CTAD shall be mounted directly onto a mounting assembly fastened to a pole, overhead mast arm, or other solid structure.

The CTAD mounting assembly shall provide the necessary degrees of rotation to ensure proper installation.

The CTAD mounting assembly shall be constructed of weather-resistant materials and shall be able to support a 20-lb. (9.1 kg) load.

Mounting Location. The CTAD shall be mounted at a height that is within 17-40 feet per manufacturer's recommended mounting heights.

The CTAD shall be mounted in a forward-fire position, looking towards either approaching or departing traffic.

The CTAD shall be mounted so that it is pointed within 10 ft. (3 m) of the target point as defined by the manufacture's table of target points for mounting offsets and mounting heights.

The CTAD shall be mounted so that its vertical center line is within 5 degrees of the lanes of interest as described in the manufacture's documentation.

Aligning the CTAD's center line with the roadway ensures that the antenna beam of the CTAD is positioned along the roadway.

Two CTAD units shall not be mounted so that they are pointed directly at each other.

CTADs that are mounted within 20 ft. (6.1 m) of each other shall be configured to operate on different RF channels regard-less of the pointing direction of the CTAD.

The CTAD shall not be installed in areas with overhead structures. For example, overhead sign bridges, tunnels and overpasses should be avoided. The CTAD shall be mounted at least 30 ft. (9.1 m) to the side of any such overhead structures.

30.14 Cabling.

Ground wire #4 AWG shall be provided from the equipment location to the foundation ground. The cable shall be SmartSensor wire. The cable end connector shall meet the MIL-C-26482 specification and shall be designed to interface with the appropriate MIL-C-26482 connector. The connector backshell shall be an environmentally sealed shell that offers excellent immersion capability. All conductors that interface with the connector shall be encased in a single jacket, and the outer diameter of this jacket shall be within the backshell's cable O.D. range to ensure proper sealing. The backshell shall have a strain relief with enough strength to support the cable slack under extreme weather conditions. Recommended connectors are Cannon's KPT series, and recommended backshells are Glenair Series 37 cable sealing backshells.

The cable shall be the Orion Wire Combo-2207-2002-PVCGY or an equivalent cable that conforms to the following specifications:

- The RS-485 conductors shall be a twisted pair.
- The RS-232 and RS-485 conductors shall have nominal capacitance conductor to conductor of less than 71pF/Ft at 1 Khz.
- The RS-232 and RS-485 conductors shall have nominal conductor DC resistance of less than 16.5 ohms/(304.8 m) at 68°F (20°C).
- The power conductors shall be one twisted pair with nominal conductor DC resistance of less than 11.5 ohms/(304.8 m) at 68°F (20°C).
- Each wire bundle or the entire cable shall be shielded with an aluminum/mylar shield with a drain wire.

The cable shall have a single continuous run with no splices.

The cable shall be terminated only on the two farthest ends of the cable.

The cable length shall not exceed the following limits for the operational baud rate of RS-485 communications:

Baud Rate	Cable Length
115.2 Kbps	300 ft.
57.6 Kbps	600 ft.
68.4 Kbps	800 ft.
19.2 Kbps	1000 ft.
9.6 Kbps	2000 ft.

If communication is conducted over the RS-232 bus, then the RS-232 driver must be able to source and sink ±7 mA or more.

The cable length shall not exceed the following limits for the operational baud rate of R-S232 communications.

Baud Rate	Cable Length
115.2 Kbps	40 ft.
57.6 Kbps	60 ft.
38.4 Kbps	100 ft.
19.2 Kbps	140 ft.
9.6 Kbps	200 ft.

If 12 VDC is being supplied for the CTAD then the cable length shall not exceed 110 ft.

If 24 VDC us being supplied for the CTAD then the cable length shall not exceed 600 ft.

If a cable length of 600 ft. to 2000 ft. is required, the power cable shall be an ANIXTER 2A-1402 or equivalent cable that meets the following requirements:

- 10 AWG conductor size/gauge
- 2 conductor count
- Stranded cable type
- Bare copper material
- 600 V range
- 194°F temperature rating
- PVC/nylon insulation material
- PVC- poly vinyl chloride jacketing material
- 25 A per conductor

Both communication and power conductors can be bundled together in the same cable as long as the above-mentioned conditions are met.

30.15 Lightning Surge Protection.

The CTAD shall be installed using lightning surge protection devices that meet or exceed the EN 61000-4-5 Class 4 specifications. The lightning surge protection unit shall be the Wavetronix Click! 201, Click! 202 or an equivalent AC to DC power converter that meets the following specifications.

30.16 Power Supply

The CTAD shall be installed using the Click! 201, Click! 202 or an equivalent AC to DC power converter that meets the following specifications.

The power converter shall be power rated at 15 W or greater at 77°F and 10 W or greater at 165°F.

The power converter shall operate in the temperature range of to -29°F to 165°F.

The power converter shall operate in the humidity range of 5% to 95% at 77°F non-condensing.

The power converter shall accept an input voltage of 85 VAC to 264 VAC or 120 VDC to 370 VDC.

The power converter shall operate at an input frequency of 47 Hz to 63 Hz.

The power converter shall produce an output voltage of 24 VDC ±4%.

The power converter shall have a hold-up time of greater than 20 ms at 120 VAC.

The power converter shall withstand a voltage across its input and output of 2 kV. The power converter shall withstand a voltage across its input and ground of 1.5 kV.

The power converter shall conform to safety standards UL 60950 and EN60950.

The power converter shall conform to EMC standards EN55022 Class B and EN61000-3-2, 3.

In brown-out conditions (i.e. <85 VAC input), the output voltage of the power converter shall be less than 1 VDC.

30.17 Input File Cards.

If input file cards are used in the detection system, then the Click! 172, Click! 174 or an equivalent that meets the following specifications shall be used.

The input file cards shall be compatible with 170, 2070, NEMA TS1, and NEMA TS2 style input racks.

The input file card shall translate data packets from the CTAD into contact closure outputs.

The input file card shall support actuation mode (passage detection output in real time) of operation.

The input file card shall receive data packets over an RS-485 bus at any of the following baud rates: 9600, 19200, 38400 and 57600 bps.

The input file card shall autobaud and auto-detect an CTAD over wired and wireless communication channels that have a maximum latency of 500 ms.

The input file card shall comply with the NEMA TS2-1998 Traffic Controller Assemblies with NTCIP Requirements (Section 2.8 specification).

31. PAN/TILT-ZOOM CAMERAS

31.1 PTZ Camera

PTZ Camera DAY/NIGHT VERSION WITH 20X ZOOM LENS AND IMAGE STABILIZATION
PTZ camera shall be Axis 6045-E.

31.2 General Requirements

31.2.1 This product shall be manufactured by a firm whose quality system is in compliance with the IS/ISO 9001/EN 29001, QUALITY SYSTEM.

31.2.2 The manufacturer shall provide a three year (3) warranty.

31.2.3 The product specified shall be a rugged, outdoor surveillance domed camera system. The camera system consists of an integrated high resolution, CCD camera using a 1/4-inch imager and a 36X (3.5-91 mm) F1.6 to F3.8 auto-iris, auto-focus optical zoom lens; 12x digital zoom; a variable/high speed, 360° pan/tilt unit; and an intelligent, integral receiver/driver. This camera is designed to perform over a wide range of environmental and lighting conditions and automatically adjusts from daytime to nighttime operation.

31.2.4 The camera shall automatically switch from daylight color operation to a higher sensitivity nighttime monochrome mode when light levels fall below an adjustable threshold level. Day/night operation may also be manually switched on or off from the system switcher/controller keyboard.

31.2.5 The camera shall provide a selectable slow shutter (frame integration) function that increases the camera's sensitivity up to 50 times by reducing the shutter speed. Selectable slow shutter speeds shall be from 1/33000 sec. to ¼ sec. at 60 Hz., and fully automatic.

31.2.6 The camera shall be equipped with a 36x optical zoom lens. A full 12x digital zoom shall then be functional once the maximum 36x optical zoom limit has been reached. The 12x digital zoom lens shall be on/off selectable from the system controller keyboard.

31.2.7 The camera's 360º pan rotation shall is divided into 16 independent sectors with 16-character titles per sector. Any or all of the 16 sectors may be blanked from the operator.

31.2.8 In addition to the blanking function, a privacy masking feature shall be provided that allows creation of up to six (6) rectangular masks that prohibit areas of the field of view from being seen even if the camera is panned, tilted, or zoomed.

31.2.9 Digital image stabilization shall be provided using electronic compensation that filters out vibrations caused by wind and other environmental conditions. This image stabilization function shall be on/off selectable from the controller's system keyboard.

31.2.10 A Fast Addressing method for setting the camera address number for control shall be remotely programmable from the system controller keyboard. The camera address may also be directly settable via thumbwheel switches located within the camera.

31.2.11 The camera shall allow the storage of up to 99 preset scenes with each preset programmable for 16 character titles. A tour function shall be available to consecutively display each of the preset scenes for a programmed dwell time. Any or all of the presets may be included or excluded from the tour.

31.2.12 The camera shall be capable of recording two (2) separate tours (macros) of an operator's keyboard movements consisting of, tilt, and zoom activities for a total combined duration time of 15 minutes. Recorded tours can be continuously played back.

31.2.13 When an operator stops manually controlling the camera, and a programmed period of time is allowed to expire, the camera will execute one of the following programmable options: 1) return to preset #1; 2) return to the automated tour previously executed; 3) do nothing.

31.2.14 The camera shall ensure that any advanced commands required to program the camera are accessed via three levels of password protection ranging from low to high security.

31.2.15 The camera system shall provide a feature that automatically rotates, or pivots, the camera to simplify tracking of a person walking directly under the camera.

31.2.16 The camera shall provide four (4) normally open or normally closed alarm input contacts and one (1) relay output. Any or all of the input contacts may be programmed upon activation to automatically move the camera to any preposition location, close the output relay for a programmed period of time, and display an alarm indication on the on-screen display of the display monitor.

31.2.17 The camera shall be available in wall mount, mast mount (pole), and corner mount versions that include an integral outdoor power supply box. Roof mount (parapet) and pipe mount versions are provided with a separate outdoor power supply box.

31.2.18 The camera system shall be provided in a NEMA 4X or IP66 certified, rugged, weather-resistant package.

31.2.19 Cameras shall be installed into the City of Dubuque's existing video management system via an AXIS 241S video server by a qualified Network/Video company regularly engaging in these technologies and services. Any additional Milestone licenses need to be included in the cost. The yearly support agreement should be prorated to match the City of Dubuque's existing maintenance contract with Milestone.

31.3 CAMERA SPECIFICATIONS

31.3.1 Imager: 1/4-inch interline transfer CCD
(NTSC: 768h x 494v) (PAL: 752h x 582v)
31.3.2 Horizontal Resolution: 470 TVL (NTSC): 460 TVL (PAL)
31.3.3 Lens: 20x zoom(4.45-89 mm), F1.6 to F2.9
31.3.4 Digital Zoom: 12X
31.3.5 Field of view: 3.49° to 62.98°
31.3.6 Focus and iris: Automatic with manual override
31.3.7 Aperture correction: Horizontal and vertical

31.4 ELECTRICAL SPECIFICATIONS

31.4.1 Main supply input voltage/current, as required by the application:
NTSC: 115VAC, 60Hz,
NTSC: 24VAC, 60Hz,
31.4.2 Power (camera): 21-28 VAC, 50/60 Hz, 15W maximum.
Power (heater): 21-28 VAC, 50/60 Hz, 30 W maximum.
31.4.3 Video output: 1.0Vp-p ± 0.1Vp-p, 75 ohms.
31.4.4 Synchronization: Line-lock (-120° to +120° vertical phase adjust) or internal crystal.
31.4.5 Sensitivity: (usable video):
Day mode w/slow shutter off: 0.2fc/2.0 lux
Night mode w/slow shutter off: 0.025fc/0.25 lux
Day mode w/slow shutter on: 0.013fc/0.13 lux
Night mode w/slow shutter on: 0.0016fc/0.016 lux

31.4.6 Signal to Noise Ratio: Greater than 50 dB.

31.5 MECHANICAL SPECIFICATIONS

30.5.1 Weight: 13 lb (5.9 kg)
30.5.2 Pan/tilt: 360° continuous pan; -5° to 90° tilt from horizontal plane.
30.5.3 Pre-position speed: 360°/sec. +/-.50° accuracy.
30.5.4 Variable speed: 120°/sec.

31.6 ENVIRONMENTAL SPECIFICATIONS

31.6.1 Humidity: 0% to 100% relative, condensing.
31.6.2 Operating temperature: -40°C to +50°C (-40°F to +122°F)
31.6.3 Housing Rating: NEMA 4X and IP66 Certified.

31.7 AGENCY APPROVALS

31.7.1 Safety: CE, UL

32. WIRELESS VEHICLE DETECTION SYSTEM

General Information

A. Furnish and install the Wireless Vehicle Detection System as shown on the Plans. The wireless vehicle detection system shall be manufactured by Sensys Networks, Inc. The wireless detector or sensor shall be a VSN240F. The access point shall be an AP240E supporting Ethernet interface. If a repeater is used, then it shall be a RP240-B-LL with a recommended battery replacement every 8 years. A card rack with power supply shall be installed in the signal cabinet for the necessary Master Contact Closure (cc) and Expansion (EX) cards required for the operation of each intersection. One access box shall be supplied for each (cc).

B. The Traffic Signal Detector shall be of the magnetic field (magnetometer) sensing technology capable of detecting and reporting volume count, speed, occupancy and headway, as a minimum. The sensor section of the detector shall be embedded in the roadway pavement and shall utilize a radio transmitter link for the detector to a receiver radio being provided to the traffic controller and/or central monitoring server. The detector sensor embedded in the pavement shall not exceed a four (4) inch diameter and a depth of two and a quarter (2 ¼) inches and shall be installed by the Contractor in a factory defined four (4) inch diameter, two and a half (2.5) inch deep cored hole in the pavement, centered in the travel lane. Detector sensors, embedded at a distance greater than one-hundred and twenty five (125) feet from the receiver unit installed at the traffic controller cabinet, shall have a repeater installed to relay the sensor data to the receiver. The embedded detector sensor shall be battery operated with a battery design rated for eight (8) year life in this application.

C. Detector Sensing System shall deploy a field proven and tested design of a minimum of one year prior to the issuance of this specification. The field proven and tested design shall have included an actual field installation utilizing a minimum of four (4) sensors and a central receiver functioning per specifications for a continuous twelve months. Each detector sensor unit shall self-calibrate and self-configure their electronics for proper detection application. Each sensor unit shall be provided with flash memory upgrade capability to allow upgraded operation or safety enhancements to be “flashed” into local memory without removing the device from the pavement.

D. Detector Sensing System shall deploy a design that supports a minimum of eight sensor units being controlled by a radio repeater and a design that incorporates repeaters and a single receiver that supports a cumulative sum of eighty (80) separate detector sensors concurrently at any traffic signalized intersection. The design shall structure data transmissions in a manner as to be non-interfering with other sensors installed. This design shall include a non-interference technique that allows radio link from the detector sensor to the repeater/receiver and a radio link from each repeater to the receiver base at the traffic controller. Repeater devices shall deploy a battery operation or be provided with a battery with solar recharging installation. Batteries shall be rated for a minimum of eight (8) years. Each repeater device or receiver device shall be capable of receiving up to eight (8) embedded detector sensors at a range of up to 150 feet from the repeater to the embedded detector sensor.

E. Furnish and install factory provided epoxy fill for the roadway based on the pavement surface where the detectors are being installed, that being asphalt or concrete. The Contractor shall be required to utilize the proper epoxy when temperatures are below or above the standard epoxy type rating.

F. Furnish and install detector cards for traffic control detector rack positions. Each detector card shall be a four channel device and be capable of providing detector ground true input to the traffic controller as well as linking the detector data to a remote Ethernet port for remote monitoring, concurrently. Traffic controller detector sensor card units shall be compatible with TS-1 terminal facility terminations, unless otherwise specified on the Plans. The Contractor shall furnish and install the number of detector cards and Expansion Modules required providing one detector input to the traffic controller for each detector sensor installed, as shown on the Plans.

G. Furnish and install one repeater site for all embedded sensors installed in excess of 125 feet from a receiver or repeater. The Contractor shall furnish and install an additional repeater for any repeater that is installed at a distance greater than 900 feet from a repeater or receiver and/or does not provide sufficient radio propagation to properly support a radio link – repeater to repeater or repeater to receiver, such as could occur with non-line of sight locations.

H. Provide factory or factory representative turn-on support for all radio installations to implement the radio and device programming. Radio transceivers shall utilize devices that are compliant with IEEE 802.15.4 standards and are able to operate on any of the allocated 16 channels of the 2.4 to 2.48 GHz spectrum. The factory support shall include the programming of the embedded sensor time slots and shall provide a written copy of the final design to the City Traffic Engineer plus one copy for the traffic controller cabinet. One software set of device programming (GUI), if other than standard WEB Browser via SNMP protocol, shall be provided for each intersection where devices are installed. The factory representative shall certify proper installation of the devices, the radio links, device settings and the traffic controller detector assignments. The factory representative shall provide an on-site computer and shall link to the Contractor furnished and installed Access Box for all programming.

I. Furnish and provide a training course for the programming of the detectors by a Factory Technician or their field representative on the design, operation, and maintenance of the Detector Sensing System and the supplied GUI program. The GUI software, Contractor furnished to the City, shall provide real time management and monitoring of the Detector Sensing System as well as the Event Processing Software. One copy of the Event Processing Software shall be provided. The Event Processing Software shall be installed and made operational on a City supplied SQL Server connected to the traffic network.

General Characteristics of Components

A. Wireless sensor

Sealed unit; no user access to internals
- 10 year expected battery life
- Built-in antenna and two-way radio
- Automatic self-calibration
- Unique address per unit
- Software updated via the wireless channel

B. Access Point

Sealed NEMA Type 4 enclosure; embedded Linux-based microprocessor
- Built-in antenna; 16 channel two-way radio
- Pole mounted; maximum range to Sensors: 175 feet (53 m)
- Supports up to 48 Sensors (at default settings)
- 2W – 3.5W power consumption
- Built-in Ethernet 10Base-T port
- Optional CDMA/GPRS cellular port (backhaul)
- Unique address per unit
- Software updated via IP-based connection
- Manageable from remote site
- Collects vehicle detection data from Sensors and Repeaters
- Forwards detections to traffic signal controllers, district front-end processors, or other traffic management systems
- Optionally calculates and stores statistics describing vehicle detection events
- Master timebase for all network devices
- Central management point for all network devices

Access Points are powered via a traffic controller, solar panel or other power source available in the field. Typically there is one Access Point per network installation.

C. Repeater

Repeaters are used when the *distance* between Sensors and the Access Point exceed the practical limits

of wireless radio, or the *angle* of the devices to one another results in poor signal reception.
Sealed NEMA Type 4 enclosure
• Battery powered (minimum two year1 expected life)
• Built-in antenna; 16 channel two-way radio
• Pole mounted; maximum range to Sensors: 175 feet (53 m)
• Supports up to 10 Sensors (at default settings)
• Maximum range to Access Point : 1,000 feet (305 m)
• Unique address per unit
• Software updated via the wireless channel

D. Contact Closure Card

The Interface from the Sensys network to the traffic signal controller is called a Contact Closure (CC) master card.
Installs directly into controller shelf
• Occupies one or two controller slots depending on configuration
• Wired connection to Access Point (carrying power and channel signal)
• Emulates two or four channel loop amplifier cards
• Supports up to 15 Sensors per channel
• Individually configurable channels
• Supports pulse or presence modes and delay or extension modes
• Supports visual and audible channel status indicators
• Can be configured and managed remotely
Unique address per unit
• Software updated via wired Access Point connection

Additional Sensor or channel capacity can be provided by a Sensys Contact Closure Expansion (EX) card. Expansion cards use the same form factor as Master cards and are daisy-chained to a master card by front-panel cables.

E. Access Box

A Sensys AccessBox is a small, three-port junction device used with Sensys Contact Closure cards. It provides a wired port for IPbased access to the Access Point for the purposes of device management, configuration or data collection. An AccessBox is required for each Contact Closure Master (CC) card;

F. Data Communications

All Sensys devices comply with a message acknowledgment protocol so that data not received due to communication errors is automatically resent. Additionally, two metrics – RSSI and LQI - characterize radio communication efficiency and provide a means for evaluating radio performance in the field.

1. RSSI (Received Signal Strength Indicator)

RSSI characterizes the power loss in a received radio signal5. For example, a signal with an RSSI value of -60dBm is considerably stronger than a signal with an RSSI value of -80dBm. Typical RSSI values found in the field will range from -50dBm (excellent) to -95dBm (the far edge of RF coverage).

Typically, count applications can tolerate a weaker signal than intersection applications. Therefore, sensors in count mode should exhibit RSSI values greater than -79dBm; sensors in stop bar applications should exhibit RSSI values greater than -69dBm.

2. LQI (Line Quality Indicator)

LQI is an indicator of link error rate or signal-to-noise ratio (SNR). For reliable performance, LQI values must be at 90 or above. Poor LQI in the presence of strong RSSI is indicative of local ISM band interference (for example, a nearby Wi-Fi modem). Use an alternative RF channel to improve performance.

As vehicle event data is collected by an Access Point, any combination of the following types of additional processing may occur.

3. Forward Detections to Traffic Controller

A Sensys detection network can be interfaced to a local traffic controller with a Contact Closure (CC) card. Controllers receive signals in exactly the same fashion as they do from copper loops, radar or video-based systems. Reprogramming the controller is not required.

4. Backhaul to Traffic Management Center

Vehicle detection data (or statistical summaries) can be backhauled to the TMC via either of the following interfaces:

• Ethernet (10baseT)
• Cellular modem (GPRS or CDMA)

These interfaces support IP-based communications, and also enable remote management of the Access Point and the other devices on the network. (*Note*: using these interfaces does not conflict with legacy backhaul technology that may exist at a given controller.)

5. Calculate Statistics

Vehicle detections can be used to calculate statistics such as volume, occupancy, and speed. Statistics can be computed on a *per-lane* or *per-vehicle* basis. The statistical process may execute on the Access Point or other platform.

6. Store Event Data

Vehicle detections may be stored on the Access Point for periodic download. Storage requirements depend on the application requirements and the configuration of the network. Typical installations may store over one month of detection data.

Design Factors
Power and Communication Requirements

- Power reaches an Access Point via an 4-pair CAT5 or better, outdoor rated Ethernet cable, terminated with male RJ45 connectors, through an integrated bulkhead connector.
- Power sources may include:
- 12 – 24 VDC from a traffic controller detector rack or input file
- 10 – 20 VDC from a low-voltage source such as a solar panel
- Available Power-over-Ethernet (PoE) device such as a local area network hub, switch, or router • 120 VAC outlet

When an Access Point is powered from the controller rack, a Sensys *Contact Closure card* and a Sensys *AccessBox* are required. This is typical of intersection applications.

- An Access Point without an integrated cellular modem draws approximately 2 W of power; when equipped with a cellular modem, an Access Point draws approximately 3.5 W.
- The length limit of standard Ethernet compatible, outdoor rated, 4-pair CAT5 cable is 100 meters (328 feet). This is the maximum supported distance between an Access Point and its power source.
- The cable must be terminated with male RJ45 connectors according to the TIA/EIA 568-B specification.

Installation Procedures for System

Sensors

- Place Sensors in the middle of the driving lane. The initial sensor should be installed approximately 3 feet behind the stop bar or typical vehicle stopping location and then further sensors spaced between 10 an d12 feet apart as specified in the design plan.
- Wireless sensors are installed in a hole measuring approximately 4” (10 cm) in diameter and 2¼” (6 cm) deep, cored into the pavement using a manufacturer specified core drill or equivalent.
  Sensors may be placed up to 125 to 175 feet (38 to 53 meters) away from an Access Point or Repeater depending on the mounting height of the latter.

Access Points

- Mount an Access Point at least sixteen feet (five meters) above the road surface; greater height normally supports more distance between the Access Point and Sensors. (See *Table 1* below.)
- Orient the front of the Access Point so that its bulkhead connector is facing downward and the Access Point faces its Sensors.
- When operating with default settings, an Access Point supports up to 48 Sensors, of which 20 may be repeated.
- When operating with default settings, an Access Point supports up to 15 Repeaters.
- Maintain a line of sight between the Access Points and its Sensors and/or Repeaters.
- Use a distance of 328 feet (100 meters) or less between an Access Point and its power source.
  The maximum range between an Access Point and any Sensor is determined by such site specific variables as the local terrain, the mounting height of the Access Point and the orientation of the Access Point to the Sensor (for example, pointing directly at the Sensor).

  In general, a maximum range of 125 feet (38 meters) can be obtained. Range expectations as a function of mounting height are summarized in the following table:

Height of Access Point Relative to Road Surface	**Maximum Recommended Range to Sensor**
16 feet (5 meters)	125 feet (38 meters)
20 feet (6 meters)	150 feet (46 meters)
30 feet (9 meters)	175 feet (53 meters)

Table 1: Recommended Maximum Access Point to Sensor Ranges by Access Point Mounting Height

Given a clear line-of-sight between the face of the Access Point and the face of a Repeater, reliable communications can be expected across distances up to 1,000 feet (305 meters). Given a clear line-of-

sight between the face of an Access Point or Repeater and the *back* of the other unit, use 400 feet (122 meters) as a maximum separation.

Repeaters

- Install a Repeater at least sixteen feet (five meters) above the road surface; greater height normally supports more distance between the Repeaters and Sensors.
- Orient the front of the Repeater so that it faces slightly downward toward its Sensors and faces its Access Point.
- Repeaters may be installed in *tandem* (to a total depth of three Repeaters in series) to accommodate distances or obstructions.
- Use a distance of 1,000 feet (304.8 meters) or less between a Repeater and its Access Point (or tandem Repeater).
- Maintain a line of sight between the Repeater and its Access Point (or tandem Repeater).
- When operating with default settings, a Repeater may support up to 10 Sensors.11

Contact Closure Cards

- Install Contact Closure cards into the card rack of the traffic controller.

33. STOP BAR MONITORING CAMERAS

33.1 The Stop Bar Monitoring Camera System utilized on the project shall be a Axis Model No. Axis-1614-E network camera manufactured by AXIS.

33.2 Follow manufacturer's recommendations for power feed between power cabinet to the camera/outdoor enclosure and traffic cabinet.

33.3 Power and Network cabling to consist of outdoor rated UV resistance CAT6 network cabling between AXIS 1614-E camera and network switch mounted inside of the traffic cabinet. The CAT6 cable shall be OSP Broadband BBDN6 shielded with aluminum or approved equal. If multiple cameras are installed at one intersection use PowerDsine 9004G POE to supply power to the cameras.

33.4 Outdoor Enclosure to be mounted near the end of mast-arm using a Skybracket cable mount camera support with 2 foot extension.

33.5 Cameras shall be installed and tied into the City of Dubuque's existing Milestone video management system by a qualified Network/Video company. Any additional Milestone licenses need to be included in cost. The yearly support agreement should be prorated to match the City of Dubuque's existing maintenance contract with Milestone.

33.6 The Network and Video electronic equipment shall be provided and installed by a single company regularly engaging in these technologies and services.

34. ITS COMPONENTS

34.01 Network Products

A. All items defined in these sections are considered mandatory and must be adhered to for this project.

B. Network switches: There will be three different hardware configurations required of the network switches

1. Head-end Layer 3 switch with the following capabilities:
   - 1.1. Ability to route traffic between vlans.
   - 1.2. Access control lists.
   - 1.3. 24 10/100/1000BaseT ports
   - 1.4. 4 SFP ports with 2 1000Base-LX fiber optic SFPs installed
   - 1.5. Stacking capability to add SFP ports in future
   - 1.6. Port mirroring ability for network analysis
   - 1.7. Supports 802.1w Rapid Spanning Tree
   - 1.8. Supports 802.1q Vlan trunks
   - 1.9. Supports SNMPv3 manageability
   - 1.10. Supports secure web management through https
   - 1.11. Supports QoS with ToS/DiffServ
   - 1.12. Supports RMON
   - 1.13. Supports IGMP and multicast pruning
2. Hardened backbone Layer 2 switch with following capabilities:
   - 2.1. NEMA TS-2 Certified
   - 2.2. Capacity of 16 10/100Base-T ports
   - 2.3. Port mirroring ability for network analysis
   - 2.4. Two Field-upgradeable module slots with 4 port 100Base-FX fiber module and 2 port1000Base-LX fiber module installed
   - 2.5. Supports 802.1w Rapid Spanning Tree
   - 2.6. Supports 802.1q Vlan trunks
   - 2.7. Supports SNMPv3 manageability
   - 2.8. Supports secure web management through https
   - 2.9. Supports QoS with ToS/DiffServ
   - 2.10. Supports RMON
   - 2.11. Supports IGMP Snooping and multicast pruning
3. Hardened edge Layer 2 switch with following capabilities:
   - 3.1. TS-2 Traffic
   - 3.2. Capacity of 16 10/100Base-T ports
   - 3.3. Port mirroring ability for network analysis
   - 3.4. Two Field-upgradeable module slots with 4 port 100Base-FX fiber module installed
   - 3.5. Supports 802.1w Rapid Spanning Tree
   - 3.6. Supports 802.1q Vlan trunks
   - 3.7. Supports SNMPv3 manageability
   - 3.8. Supports secure web management through https
   - 3.9. Supports QoS with ToS/DiffServ
   - 3.10. Supports RMON

34.02 IP Based Integrated Digital Video Management System (IPDVMS)

A. The existing system that shall be tied into is Milestone Video Management system.

B. The system shall support an integrated IP Based Digital Video Management recording solution that provides the following features and capabilities:

1. The IPDVMS system shall provide 1 NVR (Network Video Recorder) to be installed in the existing 19” rack located in the system control center with the

following minimum specifications: DVC-EX Chassis-3U, 19-inch rack mount chassis, Core 2 Quad Q9650, 3.0 GHz, 12MB L2 Cache, 1333MHz FSB processor with Windows XP Professional operating system, 2GB DDR2 (4x 512 MB) 667 MHz ECC SDRAM; Dual 10/100/1000 Ethernet ports, CD/RW-DVD/R ROM, one 80 GB internal hard drive for OS, eight – 500 GB SATA 7,200 rpm hard drives for video storage to be included, (2) USB 2.0 ports, keyboard, optical mouse and rack mount rail kit.

2. The IPDVMS shall be computer hardware independent and must meet or exceed the manufacturer's minimum specification for the computer and related devices.

3. The IPDVMS shall incorporate a modular architecture and be able to support an unlimited number of cameras

4. The IPDVMS shall be able to simultaneously record and display live video and display recorded video.

5. The IPDVMS shall support both event based and continuous recording.

6. The IPDVMS shall mark all events and they shall be available for playback and or archiving at any time

7. Video events shall be linked to system events in the system database and only one database shall be acceptable for this interface.

8. Up to 32 simultaneous users shall be able to access any video feed from any recorder on the network.

9. User defined profiles shall be available for tailoring granular access to configuration and operation

10. Shall have the ability to enhance a frame of video with embedded features or off the shelf software while providing security for the original video image to preserve integrity.

11. Shall be capable of independent camera setup for, compression rate, brightness, contrast and other factor setups.

12. The IPDVMS shall support Ethernet 10BT, Ethernet 100BT and 1000BT. Network protocols shall be supported including TCP/IP, IPX, and UDP.

13. The network interface shall allow remote access of the IPDVMS from anywhere on the end-users LAN/WAN.

14. Shall support limiting of frame rate transmission to individual clients.

15. The IPDVMS shall support either Multicast or Unicast streaming technology.

16. The IPDVMS shall be have the ability to playback stored video over the LAN / WAN for remote access of video clips.

17. The IPDVMS shall support World Time Zone.

18. Any alarm / event in the system shall have the ability to be associated with a digital video clip in real time. The IPDVMS shall support user defined pre and

post roll.

19. Each camera shall be configurable for a 32 alphanumeric character name and shall allow for the setup and adjustment of brightness, contrast, archiving, motion detection, Pan / Tilt / Zoom, on a per camera basis.

20. The IPDVMS shall support CCTV PTZ control via the system video interface.

21. The IPDVMS shall support Analog CCTV PTZ control via approved Video Encoding Devices.

22. The IPDVMS shall support MJPEG and MPEG4 formats for multiple IP Video Cameras and IP Video Encoders from approved sources.

23. The IPDVMS shall support integral time stamping upon receipt of video from the camera.

C. The IPDVMS shall support the following configuration and customization parameters:
   1. Compression percentage
   2. Pre and Post Roll in seconds
   3. Motion Detection Alarms
   4. Set Time Lapse Recording
   5. Continuous Recording Mode
   6. The ability to enforce user authentication to specify individuals or groups that have the ability to view live or recorded video or make modifications to the system.
   7. The ability to change any or all of the associated IP camera passwords manually or on schedule.
   8. User determination of Event Locking method.
   9. Dual Path Fail Over support
   10. Blind Camera (Obstructed View) Alarm reporting.
   11. Presets on Alarm
   12. Event Locking to protect specific video events from being overwritten
   13. UNC path support for Network Attached Storage Devices
   14. Configuration of Off-line cameras
   15. Support for Intelligent Motion Video Searching

D. Each alarm / event condition shall have the ability to mark the start of a video event or the end of a video event in real time.

E. The IPDVMS shall support uni-directional audio recording utilizing built in audio recording devices on select IP cameras

F. The IPDVMS shall support automatic firmware downloads to select IP cameras.

G. The IPDVMS shall support both internal camera video storage and external camera video storage. Internal storage shall allow the camera to store video events and then download these events to the IPDVMS on a predetermined schedule or on demand

34.03 Pan / Tilt / Zoom Control from Monitoring locations

A. The IPDVMS shall support PTZ control from the Alarm Monitoring workstation. The PTZ control shall support approved IP PTZ cameras and Analog Cameras connected to approved IP Servers.

B. The IPDVMS shall support the following PTZ features:
   1. Priority Levels
   2. Device Group Control
   3. PTZ Override (Lockout)
   4. Proportional PTZ Control

5. Preset Lock via video screen
6. Preset Tour

34.04 Video Archiving

A. The Archive Server software shall be hardware independent, providing the ability to utilize commercial off-the-shelf mass storage devices, including SAN (Storage Area Network) solutions, Tape Libraries, and direct connect external storage drive arrays.

B. The Archive Server software shall provide the ability to manage and store video information from multiple video recorders to a central location, without operational degradation.

C. Each IPDVMS shall have the ability to set its own unique archiving properties. Video shall automatically be archived based on user defined "percentage full" settings. When the IPDVMS reaches the designated capacity threshold, video shall be automatically copied to the archive storage media and space on the recorder is released for over-write by new video information.

D. Regardless of the storage location (local on the recorder or in archive) the system will automatically retrieve video associated with an event on demand. The actual storage location shall be transparent to the user.

34.05 Real Video Time Monitoring

A. The IPDVMS shall allow monitoring of real time video from any Alarm Monitoring client workstation. DVS and Camera status shall be displayed on a System Hardware Tree.

34.06 Video Player

A. The IPDVMS shall support an advanced matrix view of multiple On-line camera views. Up to a total of 128 fps @ CIF resolution and 72 fps @ 4CIF resolution shall be available for viewing in the Matrix View. The 128 frame rate limitation of video shall be any combination of Live or Recorded video. The number of open video windows shall be dependent on the frame rate and resolution of the cameras. The Video Player shall allow operator sizing of the video windows in the matrix view.

34.07 Video Camera Groups / Video Camera Tours

A. An unlimited number of camera groups shall be supported, and each camera group shall support an unlimited number of cameras. Cameras within a camera group shall span multiple digital video servers. Cameras shall have the ability to be placed into multiple camera groups.

B. The system shall provide for video camera tours that rotate live video between each of the cameras defined in the video camera group at a user defined increment. The time increment shall be user definable in whole seconds.

34.08 Still Image Capture / Save

A. During playback or monitoring of video, the system shall have the ability to create and save a still picture. This operation shall not affect any other operation and shall not alter the recorded video. The file format shall be an industry standard format allowing for file transfer via e-mail, printing or file transfer to other media

34.09 Export Video Clip to File

A. The system shall have to ability to save and export recorded video to a file for the purpose of sharing and reviewing video clips. The start and end times for each video segment shall be user defined. The exported video clip shall be viewable via a standard Windows media player.

34.10 Video Image Processing

A. The IPDVMS shall support video image processing of a single frame captured image through use of an integral image processing module which shall offer the following

features:

1. Intensity, Contrast and Saturation
2. Gamma Correct
3. Histo-Contrast and Histo-Equalize
4. Flip, Reverse, Invert and Rotate
5. Shear
6. Add Noise, Average, Sharpen, Mosaic, Posterize and Median
7. Halftone
8. Emboss
9. Gray Scale

B. The IPDVMS shall allow the ability to save any combination of effects as a defined profile. Profiles shall have the ability to be added or deleted from the system at any time.

34.11 Video Loss Detection

A. The system shall detect video loss from any or all cameras and activate an alarm.

34.12 Automated Motion Video Searching

A. The IPDVMS shall support advanced automated motion video searching against pre-recorded video. The automated motion video search shall analyze frames in a video segment to detect motion activity from image to image. It shall display thumbnail images of the frames with activity, complete with a histogram depicting the relative amount of activity within each frame.

C. The search shall be defined by selecting a specific camera and a specific time period in which the suspected activity took place and all motion events associated with that camera and time period shall be displayed in either a trace or thumbnail format for review.

34.13 Remote Monitoring Application

The IPDVMS shall support a Remote Monitoring Application that allows the operator to monitor video from any computer connected to the network.

34.14 Intelligent Video Analysis System (IVAS)

A. The system shall provide the ability for an Intelligent Video Analysis solution that shall seamlessly integrate with the IPDVMS. The set of Intelligent Video Analysis algorithms shall provide the following functionality:

A.1. Alert Types

- A.1.1. Smart Video Motion Detection (the IVAS shall ignore minor vibration and provide motion masking)
- A.1.2 Camera Tampering (shall occur when the IVAS detects a camera is moved from its original position, when the camera view is obstructed or when the focus is changed)
- A.1.3. Sudden Change in Light Intensity (shall occur when the IVAS detects an extreme change in ambient light – light to dark or dark to light)
- A.1.4. New Object in Scene (shall occur when the IVAS detects an object not present when the IVAS originally learned the scene view is left in that view)
- A.1.5. Object Removed from Scene (shall occur when the IVAS detects an object that was present when the IVAS originally learned the scene view
- A.1.6. Object Detected in Scene (shall occur when the IVAS detects an object defined by specific properties including people, automobiles or an object of a specific color)
- A.1.7. Congestion in Defined Area (shall occur when the IVAS

detects congestion in a specific region)

A.1.8. Directional Motion (shall occur when the IVAS detects an object moving in a direction specified in the setup of this feature)

A.2.1. Object Crosses a Defined Region (shall occur when the IVAS detects an object moving across a virtual boundary or area from a specified direction)

A.2.2. Moving Object Stops (shall occur when the IVAS detects a moving object in the scene ceases to move)

A.2.3. Static Object Starts to Move (shall occur when the IVAS detects a static object in the scene starts to move)

A.2.4. Object moves too fast (shall occur when a pre defined speed has been exceeded)

A.2.5. Loitering (shall occur when the IVAS detects a person in the scene slows down or ceases to move for a specified period of time)

A.2.6. Detection of a Human Face (shall occur when the IVAS detects a frontal view of a human face is detected in the scene)

A.2.7. People Counting (shall occur when the IVAS is set for a top down view of a portal. This feature shall provide an alarm with a positive count for entry and a negative count for exit)

A.2.8. The IVAS shall support the ability to store the graphical output for a specific event for use with IVAS alarms. This feature shall allow the graphical output of a specific event to be stored as a file and later used as an overlay to be used and associated with an alarm for historical searching.

A.3. The IVAS shall support CIF, 4CIF and D1 video resolutions during video processing.

A.4. The IVAS shall support video infra-red imaging.