Serial Number: RFP-FQ16146/NAC
Date of Issue: March 30, 2018
Original Proposal Due Date: February 3, 2017
Revised Proposal Due Date: April 13, 2018

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
600 FIFTH STREET, N.W.
WASHINGTON, DC 20001

March 30, 2018
AMENDMENT NO. 11
REQUEST FOR PROPOSALS
FOR
POTOMAC YARD METRORAIL STATION
FQ16146/NAC

TO WHOM IT MAY CONCERN:

The Request For Proposals and Proposal Documents accompanying RFP FQ16146/NAC requesting Proposals for the above project are hereby changed in part as listed below.

I. GENERAL INFORMATION

This amendment adds new technical specifications, and modifies specifications and Directive Drawings.

II. CHANGES TO DOCUMENTS

The Request For Proposals and Proposal Documents accompanying solicitation RFP/FQ16146/NAC are hereby changed in part as follows:

1. **VOLUME 1 – DIVISIONS 0 AND 1**
Delete the following pages and in lieu thereof substitute the accompanying pages:

DELETE	SUBSTITUTE	DESCRIPTION
00 86 07-Attachment Davis Bacon Rates 1/5/2018	00 86 07-Attachment Davis Bacon Rates 3/23/2018	Replaced
01_11_20-2 through -8	01_11_20-2 through -8	Revised

2. **VOLUME 2 – DIVISIONS 2 through 49**

DELETE	SUBSTITUTE	DESCRIPTION
n/a	28 40 00.1	New
n/a	28 40 00	New
n/a	28 40 01	New
n/a	28 40 02	New
n/a	28 40 03	New
n/a	28 40 04	New
n/a	28 40 05.1	New
n/a	28 40 05	New
n/a	28 40 06	New
n/a	28 40 07	New
n/a	28 40 08	New

3. VOLUME 3.1 – PROJECT DIRECTIVE DRAWINGS:

DELETE	SUBSTITUTE	DESCRIPTION
SK-202	SK-202	Revised

4. ACKNOWLEDGEMENT

Offerors are required to acknowledge receipt of this amendment on the Technical and Price Proposal Forms (Pages 00 41 20-1 and 00 41 30-1) in the space provided. Failure to acknowledge all amendments may cause the bid to be considered not responsive to the invitation, which would require rejection of the Proposal.

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Norie A. Calvert
Contracting Officer

Enclosures

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General Decision Number: VA180035 03/23/2018 VA35

Superseded General Decision Number: VA20170035

State: Virginia

Construction Types: Heavy (Heavy and Sewer and Water Line)

Counties: Alexandria*, Arlington, Clarke, Culpeper, Frederick, Fredericksburg*, Spotsylvania and Winchester* Counties in Virginia.

*INDEPENDENT CITIES

HEAVY CONSTRUCTION PROJECTS (Including Sewer and Water Lines)

Note: Under Executive Order (EO) 13658, an hourly minimum wage of $10.35 for calendar year 2018 applies to all contracts subject to the Davis-Bacon Act for which the contract is awarded (and any solicitation was issued) on or after January 1, 2015. If this contract is covered by the EO, the contractor must pay all workers in any classification listed on this wage determination at least $10.35 per hour (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on the contract in calendar year 2018. The EO minimum wage rate will be adjusted annually. Please note that this EO applies to the above-mentioned types of contracts entered into by the federal government that are subject to the Davis-Bacon Act itself, but it does not apply to contracts subject only to the Davis-Bacon Related Acts, including those set forth at 29 CFR 5.1(a)(2)-(60). Additional information on contractor requirements and worker protections under the EO is available at www.dol.gov/whd/govcontracts.

Modification Number	Publication Date
0	01/05/2018
1	02/09/2018
2	02/23/2018
3	03/23/2018

BRVA0001-003 04/30/2017

	Rates	Fringes
MASON - STONE.....	$ 36.91	16.55

CARP0177-012 05/01/2017

	Rates	Fringes
CARPENTER, Includes Form Work....	$ 28.36	11.53

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* ELEC0026-023 11/06/2017

ARLINGTON COUNTY, Cities of Alexandria and Fredericksburg

	Rates	Fringes
ELECTRICIAN.....	$ 45.15	17.15+a

a. PAID HOLIDAYS: New Year's Day, Inauguration Day, Martin Luther King Jr.'s Birthday, Memorial Day, Independence Day, Labor Day, Veterans' Day, Thaksgiving Day, the day after Thanksgiving and Christmas Day.

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* ELEC0026-024 11/06/2017

CLARKE, CULPEPER, FREDERICK COUNTIES, SPOTSYLVANIA COUNTY (Excluding the City of Fredericksburg), City of Winchester

	Rates	Fringes
ELECTRICIAN.....	$ 30.82	16.42+a

a. PAID HOLIDAYS: New Year's Day, Inauguration Day, Martin Luther King Jr.'s Birthday, Memorial Day, Independence Day, Labor Day, Veterans' Day, Thaksgiving Day, the day after Thanksgiving and Christmas Day.

ENGI0077-019 05/01/2017

	Rates	Fringes
POWER EQUIPMENT OPERATOR:		
35 ton Cranes and Above.....	$ 36.24	8.95+a
Cranes Below 35 tons.....	$ 34.07	8.95+a
Mechanic.....	$ 36.24	8.95+a
Tower and Climbing Cranes...	$ 38.09	8.95+a
Tower Cranes and Cranes 100 tons and Over.....	$ 38.09	8.95+a

a.PAID HOLIDAYS: New Year's Day, Inaugural Day, Decoration Day, Independence Day, Labor Day, Martin Luther King's Birthday, Veterans' Day, Thanksgiving Day, Friday after Thanksgiving and Christmas Day.

b. PREMIUM PAY:
Tower crane and cranes 100-ton and over to receive $1.00 per hour premium.

LABO0011-010 06/01/2017

	Rates	Fringes
LABORER: Pipelayer.....	$ 25.14	8.04

PAIN0051-014 06/01/2017

	Rates	Fringes
GLAZIER		
Glazing Contracts $2		

million and under	$ 25.74	11.55
Glazing Contracts over $2 million	$ 29.87	11.55

PLAS0891-006 02/01/2018

	Rates	Fringes
CEMENT MASON/CONCRETE FINISHER	$ 28.15	10.58

SUVA2010-036 09/01/2010

	Rates	Fringes
DIVER TENDER	$ 22.53	3.98
DIVER	$ 23.73	4.21
IRONWORKER, REINFORCING	$ 22.45	11.85
IRONWORKER, STRUCTURAL	$ 20.55	8.25
LABORERS		
Common or General	$ 11.24	1.32
Flagger	$ 7.39	0.20
Landscape	$ 10.00	
POWER EQUIPMENT OPERATOR:		
Backhoe	$ 18.47	0.75
Bobcat/Skid Loader	$ 11.40	
Bulldozer	$ 17.54	
Excavator	$ 17.79	
Loader	$ 18.99	0.75
Trackhoe	$ 12.75	1.24
Tugboat	$ 19.00	
TRUCK DRIVER, Includes All Dump Trucks	$ 12.14	0.75

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

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Note: Executive Order (EO) 13706, Establishing Paid Sick Leave for Federal Contractors applies to all contracts subject to the Davis-Bacon Act for which the contract is awarded (and any solicitation was issued) on or after January 1, 2017. If this contract is covered by the EO, the contractor must provide employees with 1 hour of paid sick leave for every 30 hours they work, up to 56 hours of paid sick leave each year. Employees must be permitted to use paid sick leave for their own illness, injury or other health-related needs, including preventive care; to assist a family member (or person who is like family to the employee) who is ill, injured, or has other health-related needs, including preventive care; or for reasons resulting from, or to assist a family member (or person who is like family to the employee) who is a victim of, domestic violence, sexual assault, or stalking. Additional information

on contractor requirements and worker protections under the EO is available at www.dol.gov/whd/govcontracts.

Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of "identifiers" that indicate whether the particular rate is a union rate (current union negotiated rate for local), a survey rate (weighted average rate) or a union average rate (weighted union average rate).

Union Rate Identifiers

A four letter classification abbreviation identifier enclosed in dotted lines beginning with characters other than "SU" or "UAVG" denotes that the union classification and rate were prevailing for that classification in the survey. Example: PLUM0198-005 07/01/2014. PLUM is an abbreviation identifier of the union which prevailed in the survey for this classification, which in this example would be Plumbers. 0198 indicates the local union number or district council number where applicable, i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. 07/01/2014 is the effective date of the most current negotiated rate, which in this example is July 1, 2014.

Union prevailing wage rates are updated to reflect all rate changes in the collective bargaining agreement (CBA) governing this classification and rate.

Survey Rate Identifiers

Classifications listed under the "SU" identifier indicate that no one rate prevailed for this classification in the survey and the published rate is derived by computing a weighted average rate based on all the rates reported in the survey for that classification. As this weighted average rate includes all rates reported in the survey, it may include both union and non-union rates. Example: SULA2012-007 5/13/2014. SU indicates the rates are survey rates based on a weighted average calculation of rates and are not majority rates. LA indicates the State of Louisiana. 2012 is the year of survey on which these classifications and rates are based. The next number, 007 in the example, is an internal number used in producing the wage determination. 5/13/2014 indicates the survey completion date for the classifications and rates under that identifier.

Survey wage rates are not updated and remain in effect until a new survey is conducted.

Union Average Rate Identifiers

Classification(s) listed under the UAVG identifier indicate that no single majority rate prevailed for those classifications; however, 100% of the data reported for the classifications was union data. EXAMPLE: UAVG-OH-0010 08/29/2014. UAVG indicates that the rate is a weighted union average rate. OH indicates the state. The next number, 0010 in the example, is an internal number used in producing the wage determination. 08/29/2014 indicates the survey completion date for the classifications and rates under that identifier.

A UAVG rate will be updated once a year, usually in January of each year, to reflect a weighted average of the current negotiated/CBA rate of the union locals from which the rate is based.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

* an existing published wage determination
* a survey underlying a wage determination
* a Wage and Hour Division letter setting forth a position on a wage determination matter
* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour Regional Office for the area in which the survey was conducted because those Regional Offices have responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations
Wage and Hour Division
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

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END OF GENERAL DECISION

C. All design and field engineering Work required to be performed by the Design-Builder shall be performed under the direct supervision of the Design Engineering Manager by a licensed professional and shall satisfy the laws of the jurisdiction in which the Project is located.

D. Perform a code review for the Project and identify any potential conflicts amongst the design requirements, assumptions, field conditions, WMATA Manual of Design Criteria and jurisdictional codes that may affect scope, cost schedule, or quality of work. Notify the Contracting Officer Representative of potential conflicts as soon as practicable but no later than within [30] Days of NTP. The notification shall include a clear statement of the conflict, the source of the requirement and criteria, and a recommended solution to the potential conflict.

E. Perform additional detailed surveys and investigations to verify the Site conditions as needed for development of the final design.

F. Perform additional detailed geotechnical investigations and coordinate with the Jurisdictional Authorities as needed for the development of the final design and for obtaining all necessary permits.

G. Perform additional detailed environmental investigations and coordinate with the Jurisdictional Authorities as needed for development of the final design and for obtaining all necessary permits.

H. ADAAG Design and Construction Compliance

1. Design and construct the Work in accordance with ADAAG regulations and Federal Transit Agency Accessibility Handbook for Transit Facilities. In projects that address only a portion of an existing facility, ADAAG requirements state that the connection to public use space shall be accessible to the public at finish of construction. Alterations cannot decrease public accessibility. Accessible paths must be provided both within scope of the facility being constructed or renovated and to adjacent properties. ADAAG requirements apply to facilities open to the public as well as facilities for Authority employees in accordance with ADAAG reference 4.1.1.5.

2. Should ADAAG regulations and Federal Transit Administration Accessibility Handbook for Transit Facilities requirements conflict, the most stringent shall apply.

3. Exceptions to ADAAG regulations and FTA requirements: NOT APPLICABLE

4. Ensure that facility designs, except as noted, comply with ADAAG and FTA requirements by providing a duly certified ADAAG Design Compliance Certification Form using the form provided by the Authority. Refer to Attachment to this Section: Federal Transit Administration (FTA): Key and New Rail Station Checklist.

I. This Project has a goal to obtain LEED Silver certification at its completion in accordance with the LEED Reference Guide for New Construction and Major Renovation. For purposes of preparing the LEED Project Checklist, the Design-Builder may incorporate some or all of the following exceptions and modifications to the LEED v4 Minimum Program Requirements (MPR). WMATA is responsible for obtaining USGBC concurrence in these exceptions and modifications.

1. MPR 2, “MUST USE REASONABLE LEED BOUNDARIES:”

a. Additional Guidance, Site: The gross footprint of the rail station should be no less than 2% of the gross land area within the LEED project boundary.

b. Additional Guidance, Building: The LEED project should include the entire station and complete scope of work.

c. Additional Guidance, Building: LEED Rail stations may include more than one physically distinct building in a single LEED project. For new construction projects, each building in the application must be less than 25,000 sq. ft. of contiguous enclosed gross floor area.

2. MPR 3, “MUST COMPLY WITH PROJECT SIZE REQUIREMENTS:” for a complete above-ground rail station, no minimum enclosed area requirement applies.

J. Develop and provide Design Drawings and Design Specifications. WMATA Standard Drawings and WMATA Standard Specifications shall be incorporated into the Design Drawings and Design Specifications without edits. Develop Project-specific specifications for work not addressed in the WMATA Standard Specifications. Submittals specified in the Project-specific specifications developed by the Design-Builder shall be submitted to WMATA for information only.

K. Indicate on Design Drawings work to be carried out By Others such as by the Authority, Utilities, Jurisdictional Agencies, and other WMATA contracts.

L. Design work pertaining to rehabilitation of existing facilities shall be based on the assumption that the facility will remain operational during on-Site inspections, design development, and construction. Coordinate facility access through the Contracting Officer Representative.

M. Design Reviews: Authority will review and Approve milestone design submittals based on the requirements of the WMATA Manual of Design Criteria, WMATA Standard Specifications, and program requirements established in this Section. Set up meetings with Authority including outside agencies, if needed, to present the design packages for all milestone submittals. The Design Engineering Manager is responsible for obtaining comments from Jurisdictional Authorities and Utilities. Proceeding with furthering design prior to the resolution of all review comments from all entities to the Authorities satisfaction is at the Design-Builder’s own risk. The City of Alexandria will review and approve milestone design submittals for Potomac Yard Park and Potomac Greens Park based on the requirements of the City of Alexandria and the contract documents. The Design Builder shall provide separate submittals based on the City of Alexandria requirements in addition to the required WMATA submittals listed in this RFP.

N. Permits: Prepare designs necessary to submit plans and obtain all permits needed to implement the Project. Do not modify Contract Document requirements based on comments from Jurisdictional Authorities or Utilities without approval from the Authority.

O. Provide Engineering and Architectural services during construction, such as performing Request for Information and submittal reviews prior to their submittal to the Contracting Officer Representative as further described in Section 01 33 00, SUBMITTAL PROCEDURES, and prepare As-Built Drawings and As-Built Specifications as further described in Section 01 77 50, CLOSEOUT.

1.05 DESIGN CONTROL PLAN

A. Develop and maintain a Design Control Plan (DCP) that establishes basic guidelines for the preparation and development of design documents culminating in Issued for Construction Drawings and Issued for Construction Specifications. The DCP shall address the following requirements as a minimum:

1. Control of design inputs and changes shall be managed by the Design-Builder in a manner that assures Contract and Design-Builder requirements are correctly translated into the drawings and specifications used for procurement, manufacturing, construction, and testing.

2. Establish processes and procedures for preparing and checking of design calculations, drawings, and specifications for each milestone design submittal.

3. Detailed checking of documents shall be carried out by an individual who has qualifications and experience equal to or greater than the preparer. Maintain record of check sets through the life of the Project and submit these with each milestone design submittal. Authority will audit these check sets periodically. Identify superseded documents with a stamp to avoid wrongful use of documents.

4. Configuration management.

B. Prepare plans for each design activity and define responsibility for its implementation.

C. Provide verification and validation of software products designed for the Project.

D. Design verification shall include checking and back-checking calculations, drawings, specifications, and other design elements without reliance on review and comments from the Authority and shall be conducted before providing each milestone design submittal to the Authority and before the start of construction or fabrication.

E. Provide certification with each milestone design submittal stating that the documents being submitted are reviewed, checked and back-checked.

F. Design and submit test, acceptance, and verification criteria and procedures for the product being specified. Test and acceptance criteria and procedures may be used by the Authority and its on-call architectural and engineering consultants to verify designs and products. The design verification process shall test the design to assure that it meets Contract Document requirements.

G. Implement configuration management and document change control for the duration of this Project for calculations, drawings, specifications, documents, systems, operating and maintenance documentation, and the physical materials. Maintain document change control and update all documents as the design and installation progresses. Configuration management system shall provide an accurate historical record that can trace decisions made through the life of the Contract. At the end of the Contract, submit to the Authority in accordance with Section 01 77 50, CLOSEOUT, a complete configuration management database.

H. The Authority has the right to accept or deny a requested design change and no design change shall be implemented without Authority Approval. The Authority will only consider requested design changes, which are submitted to the Contracting Officer Representative with the following supporting documentation:

1. A valid reason for the change.

2. Evidence that the change is feasible

3. An explanation of why the change is desirable

4. Estimates of effects on performance, costs and schedule

I. Include a means for contemporaneously relating the modification status of equipment and construction to the corresponding drawing or specification.

J. Maintain process control, including:

1. Completion of quality procedures, work instructions, and initial coordination meetings prior to the start of a design activity.

2. Documented procedures for checking of calculations and survey computations.

3. A formal system of continuous feedback of problems and their resolution shall be developed between the Designer and construction staff.

1.06 MILESTONE DESIGN SUBMITTALS

A. Preliminary Design – Design Drawings, Design Specifications, calculations, and all associated design documents shall be completed to include the minimum requirements listed below:

1. Drawings:

a. Plan and profile location of all potentially affected utilities and structures – Complete

b. Plan confirming adjacent property lines – Complete

c. Plan showing temporary and permanent Right-of-Way requirements – Complete

d. Plan and details of applicable Survey Control Monuments – Complete

e. Plan of existing conditions – Complete

f. Civil sections – In Progress

g. Sizing of primary structural members – Complete

h. Retaining wall elevations and sections – In Progress

i. Architectural plans and elevations – In Progress

j. Architectural wall sections – In Progress

k. Architectural floor plans – In Progress

l. Sizing of primary structural members - Complete

m. Mechanical equipment list – In Progress

n. Electrical single line diagram – In Progress

o. Applicable codes and standards – Complete

p. CADD files for verification of file structure

2. Specifications: Index of all specification Sections - Complete

3. Preliminary design calculations for each discipline commensurate with design development.

4. Design Report including documentation of:

   a. Constructability and Construction Staging Plan - Draft

   b. Utility and Structures Relocation/Protection/Support - Draft

   c. Traffic Impact Assessment including constraints, maintenance plans, parking inventories, truck haul routes, and new/modified road systems - Draft

   d. Handling and Disposal of Excavated Material - Draft

   e. Hydrology/Stormwater Management and Drainage -Draft.

   f. Supplemental Geotechnical Investigation – Complete

   g. Supplemental Environmental Documentation – Draft

   h. Systems Interface Management Plan - Complete

   i. Identification of required permits and jurisdictional authority approvals - Complete

5. Material sample boards

6. Public meeting presentation materials

7. Quality Assurance Documentation

8. Risk Assessment Documentation

9. Design Schedule - Complete.

10. Response to Authority and Jurisdictional Authority Review Comments

B. Final Design – Design Drawings, Design Specifications, calculations, and all associated design documents shall be complete, checked, and ready for signing and sealing after Approval by the Authority.

C. Issued For Construction – Design Drawings, Design Specifications, and calculations signed and sealed by Architect and Engineer of Record.

D. The Design Builder shall provide a presentation to the Commission of Fine Arts (CFA) at approximately the 60% level of design. This presentation shall be scheduled and coordinated with WMATA and the City of Alexandria.

1.07 ADDITIONAL PROGRAM REQUIREMENTS

A. Listed below are Project-specific Program Requirements that supplement or replace requirements imposed by WMATA Manual of Design Criteria, Contract Drawings, and Contract Specifications. NOT USED

PART 2 – PRODUCTS (not used)

PART 3 – EXECUTION

3.01 DESIGN MANAGEMENT

A. Appoint a Design Engineering Manager to lead and coordinate the Design-Builder's design effort.

3.02 IMPLEMENTATION

A. Prepare the design by developing detailed Issued for Construction Drawings, Issued for Construction Specifications, design calculations, analyses and reports, with all engineering required in accordance with accepted industry practices and submit milestone design submittals to the Contracting Officer Representative for Authority Approval.

1. WMATA recognizes that the Design Builder will provide designs prepared by subcontractors and suppliers instead of by the designer of record (DOR). In those instances, those design documents must be submitted to WMATA for review and approval and the drawings must be in the standard WMATA format. The Design Builder is responsible for developing an index of drawings that incorporates the subcontractor and/or supplier drawings into the drawing set created by the DOR. Drawings provided by subcontractor or supplier are to be submittal as part of the As-Built set of drawings and subject to all WMATA submittal requirements.

B. Provide the engineering design as specified for facilities owned by states, cities, agencies, districts, and utilities including service connections, and facility modifications and relocations as applicable.

C. Coordinate and resolve conflicts for locations and sizes of openings, conduits, equipment placement, power and HVAC requirements, and clearances and weights of all elements among all the disciplines as applicable.

D. Immediately notify the Contracting Officer Representative in writing upon identification of design issues or problems, which may affect cost, schedule, the work of Utilities, or other contracts.

E. Issued for Construction Drawings and Issued for Construction Specifications, design calculations, analyses, and reports and certifications shall be signed and sealed by registered Professionals

licensed to practice engineering, architecture, and landscape architecture in all jurisdictions where the Project will be constructed, as applicable.

F. Coordinate design with governmental, public and private agencies and others. Such coordination shall include attending meetings as may be necessary. Notify Contracting Officer Representative of coordination meetings a minimum of 2 Days prior to meetings. Prepare and submit to the Contracting Officer Representative meeting minutes of all such meetings attended. Promptly notify the Contracting Officer Representative in writing of any betterments or other work beyond the scope of the Contract Documents that are requested by jurisdictional authorities, Utilities and property owners.

3.03 INTERFACE REQUIREMENTS

A. Investigate existing systems. Design, furnish, and install systems and materials, which interface with and are fully compatible with existing systems and that function in a fully compatible regard to safety, reliability, and maintainability as specified in Section 01 11 30, SYSTEMS INTEGRATION.

B. Systems, which require functional and physical interface coordination, may include, but are not limited to:

1. Drainage Systems
2. Existing Underground Utilities
3. Traffic Maintenance during Construction and Traffic Signalization
4. Power and Energy Management System
5. Mechanical Systems
6. Plumbing Systems
7. Electrical Systems
8. Communications Systems including Voice and Data
9. CCTV
10. Automatic Train Control
11. Traction Power System
12. Elevators and Escalators

C. Interface and compatibility requirements within various other interfaces for the Communications Systems include:

1. Ancillary and Remote Facilities: Coordinate provisions for Fire and Intrusion Alarm System and wayside telephones.
2. Local Fire Jurisdictional Authorities: Coordinate provisions for fire detection, alarm, and suppression to ensure compliance.

D. Interface and compatibility requirements for the Utility systems:

1. Coordinate equipment location and drain inlets and pipes. Coordinate new drain inlets and pipes with existing manholes, drain inlets, and pipes. Coordinate new sanitary sewer pipes with existing manholes and pipes.
2. Coordinate electrical power requirements and location of equipment, feeders, and ductbanks.

E. Interface and compatibility requirements for the Public Telephone system:

1. Right-of-Way: Coordinate required changes to telephone company facilities affected by construction.

F. Develop a Systems Interface Points matrix, which shall identify all system interfaces and describe in detail the functional and physical interfaces between new and existing systems. The descriptions shall include interface locations, operating parameters, and applicable test points. The Systems Interface Points matrix shall:

1. Assign primary and secondary responsibilities to the providers of the interfaced systems and provide assurances that the systems provided under this Contract are fully compatible and that interface connections will not degrade, be compromised, or otherwise interfere with the normal operations of either of the interfaced systems.

2. Provide assurances that the systems provided under this Contract are interfaced in a manner similar to existing WMATA systems performing the same functions. Differences in the manner in which the systems are interfaced shall be clearly described and subject to the Approval of the Contracting Officer Representative.

3. Provide a direct reference to one or more test procedures contained in the Design-Builder's approved Systems Integration Plan, which will verify that each system interface fully satisfies the requirements described therein.

4. Be developed before or concurrent with the systems designs and shall be submitted for review along with each milestone design submittal.

G. Control systems installation, its current configuration, and provide appropriate documents to support system configuration. Issue engineering recalls, update installed material, and update support material such as test equipment and documentation.

END OF SECTION

SECTION 28 40 00

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) WORK FOR TRACTION POWER SYSTEM

PART 1 – GENERAL

1.01 SUMMARY

A. The scope of this section includes the design, furnishing, installation, integration and testing of SCADA equipment and network to support the addition of rectifiers and circuit breakers to existing traction power substations and tie breaker stations that are currently monitored/controlled by the Advanced Information Management System (AIM) and Automated Energy Management System (AEMS) in JGB/CTF OCC.

B. TPSS or TBS to host communications facilities are existing, and apart from relocation of cables and receptacles within TPSS and TBS if necessary, communications work is not anticipated as part of this contract. A description of the communications facilities is included in this document as information.

C. Integrate the new equipment furnished under this contract with the existing SCADA system. This work includes running and terminating control and indication wiring, and such data communications connections between IEDs and the existing SCADA equipment as is necessary.

D. The SCADA system inside TPSS and TBS will control and/or monitor as applicable High voltage AC switchgear, Rectifier Transformer units, Auxiliary transformers, DC switchgear, Digital trace recorders, Low Voltage AC switchgear, uninterruptable power supplies (UPS), battery cycle monitor, negative switchboards, emergency trip system, contact rail heating system, feeder cable shield monitor, and ancillary equipment installed inside the station.

E. Related Sections:
   1. Section 28 40 08 - Wire, Cable and Termination Panel for SCADA System
   2. Section 28 40 07 - Human Machine Interface (HMI) Panel for Traction Power
   3. Section 28 40 02 - RTU for Traction and AC room Systems.
   4. Section 28 40 03 - DC Digital Trace Recorder for Traction Power.
   5. Section 28 40 04 - Network Switch for SCADA and Automation Systems
   6. Section 28 40 05 - Distributed input output (DIO) module for Traction Power
   7. Section 28 40 06 - SCADA Systems Site Acceptance Test Plan

These sections generally specify an entirely new SCADA system. For the Potomac Yard Metrorail Station project, equip the new traction power equipment being furnished and installed as part of this project with the input-output devices called for in these specifications, and connect and test to the existing SCADA system using the products and methods described in these specifications.

1.02 REFERENCES

A. Drawings: This specification should be read in conjunction with the following design directive drawings;
   1. Contract drawings.

B. Tables:
   1. Existing SCADA Point Assignment Charts (PACs)

C. Codes and Regulations:
   1. Authority Having Jurisdiction (AHJ).
   2. Applicable NEC version.
   3. ANSI C37.2 Electrical Power System Device Function Numbers and Contact Designation.
   4. IEEE 802.3 Standard for LAN interfaces and protocols.
   5. IEEE std. 1815-2010 Standard for Electric Power Systems Communications - Distributed Network Protocol (DNP3)
   6. NFPA 130, 2003.
   7. WMATA Information Technology/ Network & Communications Services (IT/NCS) specification section: Infrastructure design & wiring standards

1.03 DEFINITIONS AND ABBREVIATIONS

ANALOG: A variable quantity represented numerically

CPU: Central Processing Unit

CONTRACTOR: Supplier of SCADA equipment and Devices

DNP3: Distributed Network Protocol – a communications protocol in current use in the SCADA industry. DNP is an open and public protocol, creating interoperability between master stations and RTUs.

DIGITAL: A quantity with two discrete states: ON or OFF. This term is often used in conjunction with physical input and output states.

DIO: Distributed input output module

DTR: Digital Trace Recorder

IEC 61850: International Electro-Technical Commission standard protocol for the design of electrical substation automation. This protocol can run over TCP/IP networks or substation LANs using high speed switched Ethernet to obtain the necessary response times below four milliseconds for protective relaying.

IED: Intelligent Electronic Device, such as a PLC, protection relay, Distributed Input Output modules or an RTU.

INTERNET PROTOCOL: Communication protocols and applications from the TCP/IP suite, used in Internet and Intranet local area and wide area communication architectures.

I/O: Input/ Output

LED: Light Emitting Diode

MASTER STATION: - Refers to multiple servers and distributed software applications connected to the SCADA system network and intended to communicate with the RTUs.

MODBUS: A communication protocol developed by Modicon in 1979 and now managed by the Modbus Organization

PLC: Programmable Logic Controller

PAC: Point Assignment Chart

PHYSICAL POINTS: RTU internal representation of electrical terminations on a Main RTU Unit or Remote I/O Unit.

POINT: an entity of data within an RTU corresponding to a physical or derived quantity

PAC: Point Assignment Chart - point address list in the RTU point database

PROTOCOL: communication description shared by multiple devices permitting interchange of information

RTU: Remote Terminal Unit device responsible for communicating with a SCADA Master or Peer RTUs, executing user applications and controlling Remote I/O.

Computer: Industrial Type computer running applications except RTU applications.

SCADA: Supervisory Control and Data Acquisition

SUBSTATION: Traction Power Substation, Tie Breaker Station and other electrical locations that might contain RTUs.

SUPPLIER: The supplier of SCADA equipment including RTU, HMI, DIO, DTR and other IEDs

SYSTEM INTEGRATOR: The manufacturer of the RTU or their authorized representative responsible for the design, implementation and integration of the SCADA systems.

TCP/IP (TCP) and the (IP)

1.04 QUALITY ASSURANCE

A. Develop a quality assurance program to ensure that:

   a. Wiring performed under this contract is complete, free of unintended grounds or

connections to other points, and tight.

b. HMI displays at the TPSS or TBS accurately control and report status of the new equipment installed under this contract.

c. HMI displays at the TPSS or TBS concerning existing equipment are not upset or disturbed in any way.

d. Log files, audit trails, and other SCADA records are accurate and complete regarding the new equipment, and are not upset or disturbed in any way regarding the existing equipment.

1.05 SUBMITTALS

A. Shop Drawings:

1. Shop drawing submittals shall be in accordance with the requirements of the Contract Documents.
2. Shop Drawings preparation shall not commence until after the Pre-Submittal Conference specified below.
3. Manufacturing of the SCADA components shall not commence until related submittals have been approved by the WMATA.
4. Shop Drawings shall be submitted in complete packages grouped to permit review of related items.
5. Review of Shop Drawings will be for conformance with Contract Documents and with regard to functional requirements.
6. Final and approved copies of all Shop Drawings shall be provided in AutoCAD format on a CD-ROM.

B. Pre-Submittal Meeting :

1. CONTRACTOR shall arrange and conduct a Pre-Submittal meeting on the SCADA System.
2. Purpose of the Pre-Submittal meeting shall be to review the manner in which the SCADA System Supplier intends to respond to the requirements of the Contract Documents before any submittals are prepared.
3. CONTRACTOR shall prepare the items listed below for presentation at the Pre-Submittal meeting. The information shall be submitted to WMATA three weeks prior to the date of the meeting.
    a. List of equipment and materials required for the SCADA System and the brand and model, which CONTRACTOR proposes to use for each item.
    b. List of proposed exceptions to the Contract Documents along with a brief explanation of each. Approval shall be subject to a formal submittal.

c. Sample of each type of submittal specified herein. The samples may be submittals prepared for other projects.
d. General outline of the type of tests to be performed to verify that all sensors/transducers, instruments and digital processing equipment are functioning properly.
e. Outline of system integration and testing.

4. Product information for all RTU, MPR's, IED's and other solid state devices selected to be used for the remote control and monitoring purpose along with their configuration information (control/status mapping).
5. Submit SCADA design drawings including but not limited to layout drawings, riser diagrams, cable schedules, assembly drawings, cable tray layouts, interconnection diagrams, and termination diagrams for approval by WMATA.
6. Submit PDF copy of the As-built drawings of the newly installed SCADA system for approval. On approval, submit three copies of as-built drawings in electronic format (AutoCAD and pdf) and paper format (11X17).
7. Provide software, licenses and documentation required for the configuration and integration of the newly installed SCADA system inclusive of each Intelligent Electronic Device provided.
8. Provide spare parts list.
9. Submit Integration Test procedure and test report for installations. Fiber test report are reviewed and approved by WMATA IT network group only.
10. Submit MPR's, IED's mapping document to comply with WMATA approved Point Assignment Chart.

C. Operation and maintenance (O & M) manuals:

1. Operation manuals should contain information pertaining to the operation of the facility. The maintenance manual shall be a compilation of all the technical information related to the maintenance of the facility, equipment, and/or system. Included should be information pertaining to equipment identification, location, data summary, preventive maintenance instruction parts lists, recommended spare parts, wiring diagrams, shop drawings, special tools, test equipment , factory and field test data and reports.
2. Operating and Maintenance Manuals and other supporting documentation shall be provided on CD, virus checked, in MS WORD format and PDF format with a 'Read Me' file containing instructions.
3. Preventive Maintenance Instructions and other supporting documentation shall be provided on a separate folder on the CD, virus checked, in MS WORD format and PDF format. All photographs, drawings shall be provided in subfolders in native format (JPEG,

DWG etc.).

4. Following the acceptance of the equipment shop drawing, the equipment manufacturer shall submit the associated O&M documentation for review and approval.
5. After approval, the Contractor prepares and delivers the Contract specified number of copies of the O&M manuals for each site.

D. Preventive Maintenance Instructions:

1. The Operations and Maintenance (O&M) Manual provided for contractually furnished or installed equipment shall include a Preventive Maintenance Instruction (PMI) section, to ensure the continued safe and reliable operation of the specific system or equipment. The O&M shall specify any maintainer's training requirement and when specified the training curriculum shall be included in the appropriate PMI. The PMI shall recommend the minimum number of maintainers that will be required along with the lowest level of skill sets requirements. If a section contains more than one PMI procedure then the section shall begin with a Table of Contents.
2. PMI procedures shall be written in language easily understood by every maintainer skill level recommended in the PMI. Prior to acceptance, clarity and effectiveness of each PMI procedure shall be demonstrated in coordination with WMATA's maintenance department using the recommended minimum number and level of maintainers. The maintenance team or individual must be able to understand and successfully perform the draft PMI without intervention by the contractors or engineers. Each procedure shall be formatted similar to standard PMI formatting as currently approved by the WMATA maintenance discipline responsible for the maintenance of the equipment, including a standard approval signature cover sheet. Sample PMI, formats, may be obtained from the appropriate maintenance discipline after contract award. Each procedure shall contain:
    a. A recommended performance frequency (interval) that is adjusted to the installed environment and expected level of use.
    b. The maintenance crew size and average time for performance of the PMI
    c. The system-specific and/or equipment-specific objectives of the PMI
    d. Lists of:
        1) Prerequisites
        2) Required reference documents
        3) Industry standards or regulations governing the performance of the maintenance action
        4) Necessary tools and test equipment
3. Definitions and graphics, as much as practical to clarify the instructions.

4. Warnings, Cautions, and Safety Notices, plentifully and prominently interspersed to prevent injury, damage, or unsafe operating conditions before any procedure step to which they apply.
5. Data sheets and checklists, for data collection regarding conditions that are measured and to ensure that important steps are not skipped.
6. Step-by-step instructions to verify and document that the tested mechanism or circuit or subsystem functions within design parameters.
7. Step-by-step instructions, types of solvents, cleansers, and lubricants with intervals for lubrication and cleaning of mechanisms to prevent or minimize grime, corrosion, and wear.
8. Step-by-step instructions to verify the adjustment of the system, equipment, or circuit which will allow it to operate properly (safely, reliably, and without causing excessive wear) until the next scheduled PMI.
9. Step-by-step instructions to verify the integrity of all fasteners, couplings, electrical connections, etc. which may fail or loosen between scheduled maintenance intervals.
10. Step-by-step instructions to document the measured condition of the equipment or circuit, to be used for abatement of deterioration, future failure analysis, and in case of catastrophe.
11. Step-by-step detailed adjustment instructions for any mechanism or circuit found to be out-of-adjustment.

1.06 SUBMITTALS SOFTWARE & DOCUMENTATIONS

A. Programming Software:
   1. For each programmable Intelligent Electronic Device, provide configuration software, configuration file and manuals on disks licensed to WMATA six weeks prior to the start of any factory acceptance tests. Provide and submit proof that the software packages are licensed to WMATA when the software is delivered to the WMATA. Provide and submit proof that a two-year software maintenance/upgrade package has been purchased for the Owner.
   2. Equipment and devices configuration files shall be submitted to WMATA for review and approval prior to the start of any site acceptance tests.
   3. All configuration files shall be in their native formats, shall become property of WMATA and shall not include any copyright license or any license terms that require permissions from the vendor for modifications to the files.
   4. Site as built configuration files shall be provided two weeks prior to SCI.
   5. Software Licenses: Three (3) fully licensed versions of programming software. This

software shall allow for the modification, the re-programming and the reinstallation of the configuration files for each type of device. The software shall be the manufacturer version that is the most current on the day of system commissioning.

B. Chain of custody:
   1. A chain of custody shall be used and maintained for all software, configuration files and documentations transferred listed above in this specification section 28 40 00 (16051D). The chain of custody shall be maintained at all times to ensure these items reach WMATA's SCADA engineering group. The contractor shall be responsible for ensuring that the above documentation, configuration files, and software are conveyed to the WMATA project manager. The WMATA project manager shall ensure that the deliverables get submitted to the WMATA SCADA engineering.

1.07 SCADA SYSTEM FACTORY TESTING

A. CONTRACTOR shall provide all labor, materials, software, equipment, engineering and incidentals, specified and required to perform factory testing, before shipment, at the manufacturer's facility to verify that system components are functioning properly and that they meet the functional and performance requirements of the Contract Documents.
B. CONTRACTOR shall submit information on factory testing procedures to verify that testing shall fulfill the requirements as specified herein. Submittal shall be made at least two months in advance of any scheduled testing and shall include dates of scheduled tests.
C. CONTRACTOR shall notify WMATA, in writing, at least three weeks before expected initiation of tests. WMATA may elect to be present at CONTRACTOR'S facilities during operational test of system equipment, either for individual units or as an integrated system. Presence of WMATA representative during testing does not relieve CONTRACTOR from conforming to the requirements of the Contract Documents and shall in no way imply acceptance of the equipment.
D. Factory Testing shall not begin until all related Supervisory Control and Data Acquisition (SCADA) System shop drawings have been submitted and approved.

1.08 SCADA RTU COMPATIBILITY TESTS

A. RTU provided under this contract shall be tested for compatibility with the WMATA system servers. Compatibility tests shall be conducted at the WMATA SCADA engineering LAB where the provided RTU shall be connected to WMATA AIM and SCADA servers.

B. CONTRACTOR shall provide all labor, materials, software, configuration, equipment, engineering

and incidentals required to perform system compatibility tests.

C. The RTU shall be tested for the complete ultimate size point counts.

D. The RTU shall be tested per requirements in PART 2- Execution, Functional Performance Test and Continuous Operation Test of Specification 28 40 06 (16606).

E. Communication between the RTU and all servers shall be monitored and analyzed by WMATA IT group.

F. All issues revealed shall be addressed by the contractor.

1.09

1.10 DELIVERY, STORAGE AND HANDLING

A. Deliver a fully tested network of microprocessor-based devices, switches, cables and other devices which provide a remote control/monitoring system for Traction Power system equipment.

B. Licenses for any software used in for the setup and configuration of devices and equipment shall be provided.

C. Store network of microprocessor-based devices, switches, and temperature sensitive equipment in a dry, climate controlled area before field installation.

1.11 SCADA SYSTEM DESCRIPTION

A. The SCADA system provides for remote control and monitoring of the Traction Power systems from the Operational Control Centre (OCC) and from the Automated Energy Management System (AEMS) located in the Jackson Graham Building and Carmen Turner Facility (JGB/CTF). Refer to Block diagrams of the SCADA architecture in the contract documents and also in the SCADA system design criteria section.

B. Dedicated fiber optic WAN connects the SCADA master station at the JGB/CTF to SCADA systems at remote sites.

C. At each site a SCADA RTU is provided to act as a data concentrator. Network Switches are also provided to connect all fiber and Ethernet cables from traction power equipment also serves as a

gateway to connect the site LAN to the SCADA WAN router.

D. Through the SCADA system, each remote site equipment can be accessed, monitored and/or controlled as applicable from the SCADA Master Station, OCC Master Station, engineer/Maintenance consoles, and locally from HMI panels installed adjacent to access doors where possible. Control and monitoring of the Traction Power equipment will be carried out by multi-purpose protection relays, control I/O modules, PLCs and other intelligent electronic devices, described in other Specifications, connected directly through Ethernet Switch.

E. RTU provided for installation at TPSS and TBS are tested for compatibility with WMATA current SCADA systems.

F. WMATA established Point Assignment Chart is used to develop the RTU configuration files to ensure full compatible to tie in to the existing Advanced Information Management System (AIM) and Automated Energy Management System (AEMS) using DNP3 communication protocol.

G. At TPSS where the existing AC or DC switchgear is to remain, the switchgear is retrofitted to install new Microprocessor relay and DIOs. Refer to the SCADA equipment schedule drawing for switchgears scheduled for retrofits and the type of equipment required.

H. At each TPSS an interface panel is installed to reroute legacy equipment status points and alarms. The interface panel with DIOs will be installed adjacent to the existing annunciator panel and connected to the network switch by fiber cable. All wiring between the interface panel and the existing annunciator panel will be done by WMATA.

I. At TPSS where the existing DC switchboard is not replaced, the switchboard is retrofitted to install current shunts and transducers for the DTR

J. Digital Trace Recorders are installed at TPSS and TBS to record DC systems operating currents, voltages and disturbances.

K. Intelligent Electronic devices installed in the facilities to provide remote monitoring, control and protection of the power systems are connected to the substation network switches by fiber optical cables.

L. All hard-wired connections to the SCADA system are made through the SCADA RTU.

M. All Ethernet (fiber or copper) connections to the SCADA are made through the Network Switches.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Select devices and equipment specified in their related specification sections.

B. All devices to communicate with the SCADA RTU either through a direct hard-wire connection or using the DNP 3.0, IEC61850 or Modbus TCP protocols over TCP/IP Ethernet or RS485 serial connection.

C. Devices on the LAN/WAN shall use assigned IP addresses provided by WMATA. Use of Dynamic Host Configuration Protocol (DHCP) is not permitted.

D. Devices to operate from 125V DC power supply.

2.02 PRODUCT FEATURE REQUIREMENTS

A. SCADA equipment provided by the contractor :

1. All equipment required to connect the new rectifiers, circuit breakers, and related equipment furnished under this contract to the existing SCADA system and digital trace recorder.

2.03 DEVICE CONTROL AND INDICATION REQUIREMENTS (Refer to Table 4.0)

Alarms, indications and control functions available to the SCADA system, HMI panel and the OCC master stations are listed in Part 4 tables. The tables detail the SCADA points for the following facilities:

A. TRACTION POWER SUBSTATION (TPSS)

B. TIE BREAKER STATIONS (TBS)

2.04 DEVICE MEASURING AND MONITORING REQUIREMENTS

A. The SCADA system shall be capable of displaying meter values concerning traction power and station power equipment at the SCADA/AEMS Master Stations, AIM, and at individual HMI panels on demand as described in individual equipment specifications and as listed in Section 4 (Tables) of this specification.

PART 3 – EXECUTION

3.01 GENERAL REQUIREMENTS

A. The contract shall furnish and install equipment as specified for each facility listed in the SCADA equipment schedule matrix. The contractor is responsible for the programming and integration of each SCADA equipment.

B. CONTRACTOR shall retain the services of the RTU manufacturers or their authorized representatives to be the system integrators.

C. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on contract drawings or specified in the contract documents.

D. Equipment IED communicating with Modbus protocol over RS485, shall also be hard wired to the RTU for all points monitored by OCC.

E. WMATA shall provide, configure and install network switches and routers in network switch cabinet at each TPSS.

F. WMATA shall provide, configure and install network switches and routers in network switch in RTU cabinet at each TBS.

G. IEDs associated with high voltage switchgear, DC Switchgear, Rectifiers, Transformers, Track Heater Master Controller, Cable Shield Monitors shall connect to the Network Switches using Multimode Optical Fibers type OM3 50/125µm and shall be provided with 100 Base FX Ethernet ports.

H. Equipment communicating with SCADA using Modbus protocol over RS485 shall have all OCC alarm points hard wired to the facility RTU in addition to the RS485 cable connection.

I. CONTRACTOR shall provide and install pre-fabricated jumper fiber cables between patch panels and end devices including the network switches.

J. The CONTRACTOR shall provide software and licenses for IED provided by the contractors.

3.02 EXISTING TPSS ANNUNCIATOR PANEL INTERFACE CABINET:

A. The Contractor shall expand the existing annunciator panel to include the new equipment furnished under this contract.

3.03 POINT ASSIGNMENT CHART FORMAT

A. RTU Point Assignment Chart (PAC) is the listing of the input (status), output (control), and spare data points for each type of facility. The standard WMATA RTU PAC shall be used for all RTU configuration to ensure compatibility with SCADA servers. All DNP3, IEC61850 and Modbus control, status and other point addresses must be the same as the existing system addresses for compatibility. Any modifications or change to the PAC must be evaluated and approved by SCADA engineering before implementation.

B. The contractor system integrator is responsible for the development of the PAC for each type of RTU provided.

C. The RTU PAC shall include as a minimum all points included in the SCADA points listed in table 4.0 in this Specifications and shall include any additions, corrections or revisions necessary to provide complete control and indication coverage of all support facilities within the respective RTU control areas, based on the latest information available.

D. The Contractor shall coordinate with the Traction Power Substation, Mechanical & Electrical Sub Contractors for additional Control and Status points to be Monitored and Controlled.

E. IED provided and installed by the contractor in AC/DC switchgears, Transformers, rectifiers, UPS and other equipment provided by the contractor, shall be configured by the contractor to communicate with the SCADA system and shall be mapped in accordance with the WMATA standard Point Assignment Chart (PAC). The PAC shall be provided to the contractor upon request.

3.04 INTEGRATION WITH OCC SCADA SYSTEM

A. The contractor shall conduct end to end testing at each facility where new equipment has been added to the existing SCADA system. It is the contractor responsibility to schedule and conduct the point to point tests.

B. WMATA SCADA engineers shall coordinate the point to point tests with OCC.

3.08 SCADA SYSTEM START-UP AND FIELD TESTING

A. CONTRACTOR shall provide all labor, materials, software, equipment, engineering and incidentals as shown, specified and required to furnish and install all new equipment and coordinate all activities necessary to perform system testing, start-up and commissioning.

B. CONTRACTOR shall retain the services of the SCADA RTU manufacturer to be the system integrator, supervise and/or perform check-out and start-up of all new system components. As part of these services, the contractor shall include for those equipment items not manufactured by the RTU manufacturer, the services of an authorized manufacturers' representative to test the equipment installation and place the equipment in operation. The manufacturers' representative shall be thoroughly knowledgeable about the installation, operation and maintenance of the equipment.

C. CONTRACTOR, under the supervision of the SCADA System integrator and other manufacturers' representative shall perform the following:
   1. Inspect and approve the installation of all new SCADA System components and all cable and wiring connections between the various system components prior to placing the various processes and equipment into operation.
   2. Conduct a complete system checkout and adjustment, including calibration of all instruments, tuning of control loops, program algorithms and logic operations, checking operation functions, and testing of final control actions. When there are future operational functions included in this work, they should be included in the system checkout. All problems encountered shall be documented and promptly corrected to prevent any delays in start-up of the various unit processes. The WMATA representative may witness any or all of this checkout and testing.
   3. Upon completion, complete documentation for this checkout and testing shall be submitted.
   4. CONTRACTOR shall provide all test equipment and software necessary to perform the testing during system checkout and start-up. CONTRACTOR shall transfer all test equipment and software to the WMATA SCADA Engineering after all final testing and commissioning.
   5. CONTRACTOR and SCADA System integrator shall be responsible for initial operation of monitoring and control system and shall make any required changes, adjustment or replacements for operation, monitoring and control of the various processes and equipment necessary to perform the functions intended.

6. CONTRACTOR shall furnish to the WMATA certified calibration reports for field instruments and devices specified in Section 28 40 06 (16606) and other sections as soon as calibration is completed.
7. CONTRACTOR shall furnish WMATA an installation inspection report certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by authorized representatives of both the Contractor and the System integrator.
8. CONTRACTOR shall provide all software and licenses required to configure, operate, troubleshoot, maintain and repair the new SCADA systems or a component part of it including the software for the devices that communicate with SCADA RTU provided under this specification.
9. The Contractor shall produce SCADA System Test Procedures and submit it to the WMATA for approval. A minimum of 30 calendar days after submittal shall be allowed for the initial Test Procedure submittal review and a minimum of 10 calendar days for review after submittal for each revision thereafter. These test procedures are applicable for the SCADA system integrated field tests.
10. Following the SCADA System checkout and initial operation, CONTRACTOR, under the supervision of the SCADA System integrator, shall perform a complete system point to point test to verify that all equipment and programmed software is operating properly as a fully integrated system, and that the intended monitoring and control functions are fully implemented and operational. The test shall be witnessed by WMATA. Any defects or problems found during the test shall be corrected by Contractor and then retested to demonstrate proper operation.
11. Following successful SCADA system integrated field testing, the SCADA System including field sensors/transducers and instruments shall be running and fully operational for a continuous 48-hour period. The Operational Availability Demonstration specified below shall not begin until the continuous 48-hour integrated system test has been successfully completed.

4.0 – TABLES
TABLE 4.1 TPSS SCADA ASSIGNMENT POINTS

WMATA reserves the right to add or remove points as necessary to provide a comprehensive remote monitoring and control system.

		TPSS SCADA ASSIGNMENT POINTS		Control			Indication				
Equipment	Item	Point description	Signal Type	Local HMI	OCC	SCADA SERVER	Local HMI	OCC	SCADA SERVER	WEB Access	IED type/Protocol
DC S/G Cathode Breaker (Typical QTY =3)	1	D.C SWGR Cathode Breaker No. 2XOpen Control	Ethernet	x							DC SWITCHGEAR DIO (DNP3)
	2	D.C SWGR Cathode Breaker No. 2X Close Control	Ethernet	x							
	3	D.C SWGR Cathode Breaker No. 2X Open Indication	Ethernet				x	x	x	x	
	4	D.C SWGR Cathode Breaker No. 2X Closed Indication	Ethernet				x	x	x	x	
	5	D.C SWGR Cathode Breaker No. 2X DIO Communication Failure	Ethernet				x	x	x	x	
	6	D.C SWGR Cathode Breaker No. 2X Rack Out	Ethernet				x	x	x	x	
	7	D.C SWGR Cathode Breaker No. 2X Test Position	Ethernet				x		x	X	
	8	D.C SWGR Cathode Breaker No. 2X Manual Position	Ethernet				x		x	x	
	9	D.C SWGR Cathode Breaker No. 2X Relay 201C	Ethernet				x		x	x	
	10	D.C SWGR Cathode Breaker No. 2X Relay 201T	Ethernet				x		x	x	
	11	D.C SWGR Cathode Breaker No. 2X Lockout (86) (where available)	Ethernet				x		x	x	
	12	D.C SWGR Cathode Breaker No. 2X Loss of Control Power	Ethernet				x	x	x	x	
	13	D.C SWGR Cathode Breaker No. 2X Rack In	Ethernet				x		x	x	
	14	D.C SWGR Energized Structure (64DX)	Ethernet				x		x	x	
	15	D.C SWGR Cathode Breaker No. 2X MPR Critical Failure	Ethernet				x		x	x	
	16	NDC Control Module Trip Circuit Supervision Failure	Ethernet				x		x	x	
	17	NDC Controller Failure	Ethernet				x		x	x	
	18	D.C SWGR Cathode Breaker No. 2X Reverse Current 32 Device	Ethernet				x		x	x	
	19	D.C SWGR Grounded Structure (64DY)	Ethernet				x		x	x	
	20	D.C SWGR Cathode Breaker No.2X DIO Local	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
DC S/G Cathode Breaker (Typical QTY=3)	1	D.C SWGR Cathode Breaker No. 2X MPR Communication Failure	Ethernet				x	x	x	x	DC MPR (DNP3, MODBUS, IEC61850) NOTE: CATHODE BREAKER CURRENTS ARE MAPPED TO THE HMI ONELINE DISPLAY
	2	D.C SWGR Cathode Breaker No. 2X Instantaneous Over Current	Ethernet				x		x	x	
	3	D.C SWGR Cathode Breaker No. 2X Inverse Time Over Current	Ethernet				x		x	x	
	4	D.C SWGR Cathode Breaker No. 2X Extreme Inverse Over Current	Ethernet				x		x	x	
	5	D.C SWGR Cathode Breaker No. 2X Reverse Current	Ethernet				x		x	x	
	6	D.C SWGR Cathode Breaker No. 2X Straight Time Over Current	Ethernet				x		x	x	
	7	D.C SWGR Cathode Breaker No. 2X Current	Ethernet				x		x	x	
	8	D.C SWGR Cathode Breaker No. 2X Rectifier Voltage	Ethernet				x		x	x	
	9	D.C SWGR Cathode Breaker No. 2X Bus Voltage	Ethernet				x		x	x	
	10	D.C SWGR Cathode Breaker No. 2X Setting Violation Alarm	Ethernet				x		x	x	
	10	D.C SWGR Cathode Breaker No. 2X Setting Violation Alarm	Ethernet				x		x	x	
DC S/G Feeder Breaker (Typical QTY=7)	1	D.C SWGR Feeder Breaker No. 3X Open Control	Ethernet	x	x						DC SWITCHGEAR DIO/(DNP3)
	2	D.C SWGR Feeder Breaker No. 3X Close Control	Ethernet	x	x						
	3	D.C SWGR Feeder Breaker No. 3X Open Indication	Ethernet				x	x	x	x	
	4	D.C SWGR Feeder Breaker No. 3X Close Indication	Ethernet				x	x	x	x	
	5	D.C SWGR Feeder Breaker No. 3X DIO Communication Failure	Ethernet				x	x	x	x	
	6	D.C SWGR Feeder Breaker No. 3X Rack Out	Ethernet				x	x	x	x	
	7	D.C SWGR Feeder Breaker No. 3X Test Position	Ethernet				x		x	x	
	8	D.C SWGR Feeder Breaker No. 3X Local Position	Ethernet				x		x	x	
	9	D.C SWGR Feeder Breaker No. 3X Relay 201C	Ethernet				x		x	x	
	10	D.C SWGR Feeder Breaker No. 3X Relay 201T	Ethernet				x		x	x	
	11	D.C SWGR Feeder Breaker No. 3X Lockout (86) (where available)	Ethernet				x		x	x	
	12	D.C SWGR Feeder Breaker No. 3X Loss of Control Power	Ethernet				x	x	x	x	
	13	D.C SWGR Feeder Breaker No. 3X Rack In	Ethernet				x		x	x	
	14	D.C SWGR Feeder Breaker No. 3X 51BX	Ethernet				x		x	x	
	15	D.C SWGR Feeder Breaker No. 3X MPR Failure	Ethernet				x		x	x	
	16	NDC Control Module Trip Circuit Supervision Failure	Ethernet				x		x	x	
	17	NDC Controller Failure	Ethernet				x		x	x	
	18	NDC Controller Overload Operation	Ethernet				x		x	x	
	19	D.C SWGR Cathode Breaker No.31 DIO Local	Ethernet				x		x	X	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
DC S/G Feeder Relay (Typical QTY=7)	1	D.C SWGR Feeder Breaker No. 3X MPR Communication Failure	Ethernet				x	x	x	x	DC FEEDER MPR (DNP3, MODBUS, IEC61850) NOTE: FEEDER BREAKER CURRENTS ARE MAPPED TO THE HMI ONELINE DISPLAY
	2	D.C SWGR Feeder Breaker No. 3X Instantaneous Over Current	Ethernet				x		x	x	
	3	D.C SWGR Feeder Breaker No. 3X Inverse time Over Current	Ethernet				x		x	x	
	4	D.C SWGR Feeder Breaker No. 3X Extreme Inverse Over current	Ethernet				x		x	x	
	5	D.C SWGR Feeder Breaker No. 3X Low Level fault	Ethernet				x		x	x	
	6	D.C SWGR Feeder Breaker No. 3X Current Rate Of Rise	Ethernet				x		x	x	
	7	D.C SWGR Feeder Breaker No. 3X Straight Time Over Current	Ethernet				x		x	x	
	8	D.C SWGR Feeder Breaker No. 3X Long Time Over Current Fault	Ethernet				x		x	x	
	9	D.C SWGR Feeder Breaker No. 3X Load Measuring/Reclosing Timeout	Ethernet				x		x	x	
	10	D.C SWGR Feeder Breaker No. 3X Contact Rail Potential	Ethernet				x		x	x	
	11	D.C SWGR Feeder Breaker No. 3X Bus Potential	Ethernet				x		x	x	
	12	D.C SWGR Feeder Breaker No. 3X Feeder Current	Ethernet				x		x	x	
	13	D.C SWGR Feeder Breaker No. 3X Setting Violation Alarm	Ethernet				x		x	x	
AC S/G Incoming Line (Typical QTY=2) X = 1 & 2	1	SWGR. Inc. line Breaker No. X Open Control	Ethernet	x	x						AC SWITCHGEAR INCOMING BREAKER DIO/(DNP3)
	2	SWGR. Inc. line Breaker No. X Close Control	Ethernet	x	x						
	3	SWGR. Inc. line Breaker No. X Open Indication	Ethernet				x	x	x	x	
	4	SWGR. Inc. line Breaker No. X Closed Indication	Ethernet				x	x	x	x	
	5	SWGR. Inc. line Breaker No. X DIO Communication Failure	Ethernet				x	x	x	x	
	6	SWGR. Inc. line Breaker No. X (86 Lockout)	Ethernet				x	x	x	x	
	7	SWGR. Inc. line Breaker No. X 27/59 (Under/Over Volt)	Ethernet				x	x	x	x	
	8	SWGR. Inc. line Breaker No. X Rack Out	Ethernet				x	x	x	x	
	9	SWGR. Inc. line Breaker No. X Rack-In	Ethernet				x		x	x	
	10	SWGR. Inc. line Breaker No. X Local Position	Ethernet				x		x	x	
	11	SWGR. Inc. line Breaker No. X Relay 201C	Ethernet				x		x	x	
	12	SWGR. Inc. line Breaker No. X Relay 201T	Ethernet				x		x	x	
	13	SWGR. Inc. line Breaker No. X 27DC Loss of Control Power	Ethernet				x	x	x	x	
	14	SWGR. Inc. line Breaker No. X MPR Critical Failure	Ethernet				x		x	x	
	15	SWGR. Inc. line Breaker No. X DIO Local	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
AC S/G Incoming Line (Typical QTY=2) X= 1 & 2	1	SWGR. Inc. line Breaker No. X MPR Communication Failure	Ethernet				x	x	x	x	AC SWITCHGEAR MPR (DNP3 & IEC61850)
	2	SWGR. Inc. line Breaker No. X (86-1) Lockout Reset Indication	Ethernet				x		x	x	
	3	SWGR. Inc. line Breaker No. X (86-1) Lockout Trip Indication	Ethernet				x		x	x	
	4	SWGR. Inc. line Breaker No. X (27) Under-voltage Abnormal Indication	Ethernet				x		x	x	
	5	SWGR. Inc. line Breaker No. X (59-1) Over voltage Abnormal Indication	Ethernet				x		x	x	
	6	SWGR. Inc. line No. X MPR Relay Failure	Ethernet				x	x	x	x	
	7	SWGR. Inc. line No. X 50/51 Phase A	Ethernet				x		x	x	
	8	SWGR. Inc. line No. X 50/51 Phase B	Ethernet				x		x	x	
	9	SWGR. Inc. line No. X 50/51 Phase C	Ethernet				x		x	x	
	10	SWGR. Inc. line Breaker No. X 50/51 N	Ethernet				x		x	x	
AC S/G Incoming Line (Typical QTY= 2 X= 1 & 2	1	SWGR. Inc. line No. X Meter Communication Failure	Ethernet				x		x	**x**	AC PQM (DNP3, IEC61850)
	2	SWGR. Inc. line No. X RMS current phase A	Ethernet				x		x	**x**	
	3	SWGR. Inc. line No. X RMS current phase B	Ethernet				x		x	**x**	
	4	SWGR. Inc. line No. X RMS current phase C	Ethernet				x		x	x	
	5	SWGR. Inc. line No. X RMS Voltage Line A-B	Ethernet				x		x	x	
	6	SWGR. Inc. line No. X RMS Voltage Line B-C	Ethernet				x		x	x	
	7	SWGR. Inc. line No. X RMS Voltage Line C-A	Ethernet				x		x	x	
	8	SWGR. Inc. line No. X RMS Voltage Line C-A	Ethernet				x		x	x	
AC S/G BUS TIE (Typical QTY=1	1	SWGR. Bus Tie Breaker Open Indication	Ethernet				x	x	x	x	AC SWITCHGEAR BUS TIE DIO/(DNP3)
	2	SWGR. Bus Tie Breaker Closed Indication	Ethernet				x	x	x	x	
	3	SWGR. Bus Tie Breaker DIO Communication Failure	Ethernet				x	x	x	x	
	4	SWGR. Bus Tie Breaker 86 Lockout	Ethernet				x		x	x	
	5	SWGR. Bus Tie Breaker Rack Out	Ethernet				x	x	x	x	
	6	SWGR. Bus Tie Breaker Rack-In	Ethernet				x		x	x	
	7	SWGR. Bus Tie Breaker Local Position	Ethernet				x		x	x	
	8	SWGR. Bus Tie Breaker Relay 201C	Ethernet				x		x	x	
	9	SWGR. Bus Tie Breaker Relay 201T	Ethernet				x		x	x	
	10	SWGR. Bus Tie Breaker 27DC Loss of Control Power	Ethernet				x	x	x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	Item	Point description	Signal Type	Local HMI	OCC	SCADA SERVER	Local HMI	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
	11	SWGR. Bus Tie Breaker MPR Critical Failure	Ethernet				x		x	x	
	12	SWGR. Bus Tie Breaker DIO Local	Ethernet				x		x	x	
AC S/G BUS TIE (Typical QTY=1	1	SWGR. Bus Tie Breaker MPR Communication Failure	Ethernet				x		x	x	AC SWITCHGEAR MPR (DNP3 & IEC61850)
	4	SWGR. Bus Tie Breaker 50/51 Phase A	Ethernet				x		x	x	
	5	SWGR. Bus Tie Breaker 50/51 Phase B	Ethernet				x		x	x	
	6	SWGR. Bus Tie Breaker 50/51 Phase C	Ethernet				x		x	x	
	7	SWGR. Bus Tie Breaker 50/51 N	Ethernet				x		x	x	
	8	SWGR. Bus Tie Breaker (86-BT) Lockout Reset Indication	Ethernet				x		x	x	
	9	SWGR. Bus Tie Breaker (86/BT) Lockout Trip Indication	Ethernet				x		x	x	
	10	SWGR. Bus Tie Breaker MPR Relay Failure	Ethernet				x		x	x	
AC S/G Aux Trans (Typical QTY=2)	1	35kV SWGR Aux. Transf. Breaker No. A1 Open Control	Ethernet	x	x						AC SWITCHGEAR AUX TRANS. DIO/(DNP3)
	2	35kV SWGR Aux. Transf. Breaker No. A1 Close Control	Ethernet	x	x						
	3	35kV SWGR Aux. Transf. Breaker No. A1 Open Indication	Ethernet				x	x	x	x	
	4	35kV SWGR Aux. Transf. Breaker No. A1 Closed Indication	Ethernet				x	x	x	x	
	5	35kV SWGR Aux. Transf. Breaker No. A1 DIO Communication Failure	Ethernet				x	x	x	x	
	5	35kV SWGR Aux. Transf. Breaker No. A1 86 Lockout	Ethernet				x		x	x	
	6	35kV SWGR Aux. Transf. Breaker No. A1 Rack out	Ethernet				x	x	x	x	
	7	35kV SWGR Aux. Transf. Breaker No. A1 Rack In	Ethernet				x		x	x	
	8	35kV SWGR Aux. Transf. Breaker No. A1 Local Position	Ethernet				x		x	x	
	9	35kV SWGR Aux. Transf. Breaker No. A1 Relay 201C	Ethernet				x		x	x	
	10	35kV SWGR Aux. Transf. Breaker No. A1 Relay 201T	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control	Indication	

Equipment	Item	Point description	Signal Type	Local HMI	OCC	SCADA SERVER	Local HMI	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
AC S/G Incoming Line (Typical QTY=2) X= 1 & 2	1	SWGR. Inc. line Breaker No. X MPR Communication Failure	Ethernet				x	x	x	x	AC SWITCHGEAR MPR (DNP3 & IEC61850)
	2	SWGR. Inc. line Breaker No. X (86-1) Lockout Reset Indication	Ethernet				x		x	x	
	3	SWGR. Inc. line Breaker No. X (86-1) Lockout Trip Indication	Ethernet				x		x	x	
	4	SWGR. Inc. line Breaker No. X (27) Under-voltage Abnormal Indication	Ethernet				x		x	x	
	5	SWGR. Inc. line Breaker No. X (59-1) Over voltage Abnormal Indication	Ethernet				x		x	x	
	6	SWGR. Inc. line No. X MPR Relay Failure	Ethernet				x	x	x	x	
	7	SWGR. Inc. line No. X 50/51 Phase A	Ethernet				x		x	x	
	8	SWGR. Inc. line No. X 50/51 Phase B	Ethernet				x		x	x	
	9	SWGR. Inc. line No. X 50/51 Phase C	Ethernet				x		x	x	
	10	SWGR. Inc. line Breaker No. X 50/51 N	Ethernet				x		x	x	
AC S/G Incoming Line (Typical QTY= 2 X= 1 & 2	1	SWGR. Inc. line No. X Meter Communication Failure	Ethernet				x		x	**x**	AC PQM (DNP3, IEC61850)
	2	SWGR. Inc. line No. X RMS current phase A	Ethernet				x		x	**x**	
	3	SWGR. Inc. line No. X RMS current phase B	Ethernet				x		x	**x**	
	4	SWGR. Inc. line No. X RMS current phase C	Ethernet				x		x	x	
	5	SWGR. Inc. line No. X RMS Voltage Line A-B	Ethernet				x		x	x	
	6	SWGR. Inc. line No. X RMS Voltage Line B-C	Ethernet				x		x	x	
	7	SWGR. Inc. line No. X RMS Voltage Line C-A	Ethernet				x		x	x	
	8	SWGR. Inc. line No. X RMS Voltage Line C-A	Ethernet				x		x	x	
AC S/G BUS TIE (Typical QTY=1	1	SWGR. Bus Tie Breaker Open Indication	Ethernet				x	x	x	x	AC SWITCHGEAR BUS TIE DIO/(DNP3)
	2	SWGR. Bus Tie Breaker Closed Indication	Ethernet				x	x	x	x	
	3	SWGR. Bus Tie Breaker DIO Communication Failure	Ethernet				x	x	x	x	
	4	SWGR. Bus Tie Breaker 86 Lockout	Ethernet				x		x	x	
	5	SWGR. Bus Tie Breaker Rack Out	Ethernet				x	x	x	x	
	6	SWGR. Bus Tie Breaker Rack-In	Ethernet				x		x	x	
	7	SWGR. Bus Tie Breaker Local Position	Ethernet				x		x	x	
	8	SWGR. Bus Tie Breaker Relay 201C	Ethernet				x		x	x	
	9	SWGR. Bus Tie Breaker Relay 201T	Ethernet				x		x	x	
	10	SWGR. Bus Tie Breaker 27DC Loss of Control Power	Ethernet				x	x	x	x	
	11	SWGR. Bus Tie Breaker MPR Critical Failure	Ethernet				x		x	x	
	12	SWGR. Bus Tie Breaker DIO Local	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
AC S/G BUS TIE (Typical QTY=1	1	SWGR. Bus Tie Breaker MPR Communication Failure	Ethernet				x		x	x	AC SWITCHGEAR MPR (DNP3 & IEC61850)
	2	SWGR. Bus Tie Breaker 50/51 Phase A	Ethernet				x		x	x	
	3	SWGR. Bus Tie Breaker 50/51 Phase B	Ethernet				x		x	x	
	4	SWGR. Bus Tie Breaker 50/51 Phase C	Ethernet				x		x	x	
	5	SWGR. Bus Tie Breaker 50/51 N	Ethernet				x		x	x	
	6	SWGR. Bus Tie Breaker (86-BT) Lockout Reset Indication	Ethernet				x		x	x	
	7	SWGR. Bus Tie Breaker (86/BT) Lockout Trip Indication	Ethernet				x		x	x	
	8	SWGR. Bus Tie Breaker MPR Relay Failure	Ethernet				x		x	x	
	9	SWGR. Bus Tie Breaker MPR Communication Failure	Ethernet				x		x	x	
	10	SWGR. Bus Tie Breaker 50/51 Phase A	Ethernet				x		x	x	
AC S/G Aux Trans (Typical QTY=2) X=1, 2	1	SWGR Aux. Transf. Breaker No. AX Open Control	Ethernet	x	x						AC SWITCHGEAR AUX DIO/(DNP3)
	2	SWGR Aux. Transf. Breaker No. AX Close Control	Ethernet	x	x						
	3	SWGR Aux. Transf. Breaker No. AX Open Indication	Ethernet				x	x	x	x	
	4	SWGR Aux. Transf. Breaker No. AX Closed Indication	Ethernet				x	x	x	x	
	5	SWGR Aux. Transf. Breaker No. AX DIO Communication Failure	Ethernet				x	x	x	x	
	5	SWGR Aux. Transf. Breaker No. AX 86 Lockout	Ethernet				x		x	x	
	6	SWGR Aux. Transf. Breaker No. AX Rack out	Ethernet				x	x	x	x	
	7	SWGR Aux. Transf. Breaker No. AX Rack In	Ethernet				x		x	x	
	8	SWGR Aux. Transf. Breaker No. AX Local Position	Ethernet				x		x	x	
	9	SWGR Aux. Transf. Breaker No. AX Relay 201C	Ethernet				x		x	x	
	10	SWGR Aux. Transf. Breaker No. AX Relay 201T	Ethernet				x		x	x	
	11	SWGR Aux. Transf. Breaker No. AX Loss of Control Power Ind.	Ethernet				x	x	x	x	
	12	SWGR Aux. Transf. Breaker No. AX MPR Failure	Ethernet				x		x	x	
	13	SWGR Aux. Transf. Breaker No. AX DIO Local	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
AC S/G Aux Trans (Typical QTY=2)	1	SWGR. Aux. Transf. Breaker No. A1 MPR Communication Failure	Ethernet				x		x	x	AC SWITCHGEAR MPR (DNP3 & IEC61850)
	2	SWGR. Aux. Transf. Breaker No. A1 50/51 Phase A	Ethernet				x		x	x	
	3	SWGR. Aux. Transf. Breaker No. A1 50/51 Phase B	Ethernet				x		x	x	
	4	SWGR. Aux. Transf. Breaker No. A1 50/51 Phase C	Ethernet				x		x	x	
	5	SWGR. Aux. Transf. Breaker No. A1 50/51 N	Ethernet				x		x	x	
	6	SWGR. Aux. Transf. Breaker No. A1 (86) Lockout Reset Indication	Ethernet				x		x	x	
	7	SWGR. Aux. Transf. Breaker No. A1 (86) Lockout Trip Indication	Ethernet				x		x	x	
	8	SWGR. Aux. Transf. Breaker No. A1 MPR Relay Failure	Ethernet				x		x	x	
AC S/G Aux Trans (Typical QTY=2) X=1,2	1	SWGR Aux Transformer AX RMS current phase A	Ethernet				x		x	x	DPM (DNP3, IEC61850)
	2	SWGR Aux Transformer AX RMS current phase B	Ethernet				x		x	x	
	3	SWGR. Aux Transformer AX RMS current phase C	Ethernet				x		x	x	
	5	SWGR. Aux Transformer AX RMS Voltage phase A	Ethernet				x		x	x	
	6	SWGR, Aux Transformer AX RMS Voltage phase B	Ethernet				x		x	x	
	7	SWGR. Aux Transformer AX RMS Voltage phase C	Ethernet				x		x	x	
AC S/G Rect. Trans (Typical QTY=3) X=1,2,3 OR 4	1	SWGR. Rect. Trans No. 1X Feeder Breaker Open Control	Ethernet	x	x						AC SWITCHGEAR REC.TRANSF. DIO/(DNP3)
	2	SWGR. Rect. Trans No. 1X Feeder Breaker Close Control	Ethernet	x	x						
	3	SWGR. Rect. Trans No. 1X Feeder Breaker Open Indication	Ethernet				x	x	x	x	
	4	SWGR. Rect. Trans No. 1X Feeder Breaker Closed Indication	Ethernet				x	x	x	x	
	5	SWGR. Rect. Trans No. 1X Feeder Breaker DIO Communication Failure	Ethernet				x	x	x	x	
	6	SWGR. Rect. Trans No. 1X Feeder Breaker 86 Lockout	Ethernet				x	x	x	x	
	7	SWGR. Rect. Trans No. 1X Feeder Breaker Rack Out	Ethernet				x	x	x	x	
	8	SWGR. Rect. Trans No. 1X Feeder Breaker Rack-In	Ethernet				x		x	x	
	9	SWGR. Rect. Trans No. 1X Feeder Breaker Local Position	Ethernet				x		x	x	
	10	SWGR. Rect. Trans No. 1X Feeder Breaker Relay 201C	Ethernet				x		x	x	
	11	SWGR. Rect. Trans No. 1X Feeder Breaker Relay 201T	Ethernet				x		x	x	
	12	SWGR. Rect. Trans No. 1X Feeder Breaker Loss of Control Power Ind.	Ethernet				x	x	x	x	
	13	SWGR. Rect. Trans No. 1X Feeder Breaker 51BX	Ethernet				x		x	x	
	14	SWGR. Rect. Trans No. 1X Feeder Breaker MPR Failure	Ethernet				x		x	x	
	15	SWGR. Rect. Trans No. 1X Feeder Breaker DIO Local	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	Item	Point description	Signal Type	Local HMI	OCC	SCADA SERVER	Local HMI	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
AC S/G Rect Trans (Typical QTY=3) X=1,2,3 OR 4	1	SWGR. Rect. Trans No. 1X Feeder Breaker MPR Communication Failure	Ethernet				x		x	x	AC SWITCHGEAR REC.TRANSF MPR (DNP3 & IEC61850)
	2	SWGR. Rect. Trans No. 1X Feeder Breaker 50/51 Phase A	Ethernet				x		x	x	
	3	SWGR. Rect. Trans No. 1X Feeder Breaker 50/51 Phase B	Ethernet				x		x	x	
	4	SWGR. Rect. Trans No. 1X Feeder Breaker 50/51 Phase C	Ethernet				x		x	x	
	5	SWGR. Rect. Trans No. 1X Feeder Breaker 51A Phase A	Ethernet				x		x	x	
	6	SWGR. Rect. Trans No.1X Feeder Breaker 51A Phase B	Ethernet				x		x	x	
	7	SWGR. Rect. Trans No. 1X Feeder Breaker 51A Phase C	Ethernet				x		x	x	
	8	SWGR. Rect. Trans No. 1X Feeder Breaker 51B Phase A	Ethernet				x		x	x	
	9	SWGR. Rect. Trans No. 1X Feeder Breaker 51B Phase B	Ethernet				x		x	x	
	10	SWGR. Rect. Trans No. 1X Feeder Breaker 51B Phase C	Ethernet				x		x	x	
	11	SWGR. Rect. Trans No. 1X Feeder Breaker 50/51N	Ethernet				x		x	x	
	12	SWGR. Rect. Trans No.1X Feeder Breaker (86) Lockout Reset Ind.	Ethernet				x		x	x	
	13	SWGR. Rect. Trans No.1X Feeder Breaker (86) Lockout Trip Ind.	Ethernet				x		x	x	
	14	SWGR. Rect. Trans No. 1X Feeder Breaker RMS Voltage Phase A	Ethernet				x		x	x	
	15	SWGR. Rect. Trans No. 1X Feeder Breaker RMS Voltage Phase B	Ethernet				x		x	x	
	16	SWGR. Rect. Trans No. 1X Feeder Breaker RMS Voltage Phase C	Ethernet				x		x	x	
	17	SWGR Rect. Trans No. 1X RMS current phase A	Ethernet				x		x	x	
	18	SWGR Rect. Trans No. 1X RMS current phase B	Ethernet				x		x	x	
	19	SWGR. Rect. Trans No. 1X RMS current phase C	Ethernet				x		x	x	
	20	SWGR. Rect. Trans No. 1X RMS Voltage Phase A	Ethernet				x		x	x	
	21	SWGR, Rect. Trans No. 1X RMS Voltage Phase B	Ethernet				x		x	x	
	22	SWGR. Rect. trans No. 1X RMS Voltage Phase C	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
AC RECTIFIER TRANSFORMER OIL (Typical QTY=3) X=1,2,3 OR 4	1	Rect Xfrmer #X Communication Failure	Ethernet				x			**x**	OIL TRANSFORMER MONITOR (DNP3)
	2	Rect Xfrmer #X Sudden pressure Abnormal (63SP)	Ethernet				x			**x**	
	3	Rect Xfrmer #X Oil Level Abnormal (63QL)	Ethernet				x	~~x~~		**x**	
	4	Rect Xfrmer #X Oil Temp Stage 1 Abnormal (Dev 26T1)	Ethernet				x	x		x	
	5	Rect Xfrmer #X Oil temp stage 2 Abnormal (26T2)	Ethernet				x	x	x	x	
	6	Rect Xfrmer #X wind. Temp. Stage one Abnormal (49T1)	Ethernet				x	x	x	x	
	7	Rect Xfrmer #X Wind. Temp Stage 2 Abnormal (49T2)	Ethernet				x	x	x	x	
	8	Rect Xfrmer #X Tank Bottom Oil Temp Abnormal (Dev26 T1)	Ethernet				x		x	x	
	9	Rect Xfrmer #X Tank Top Oil Temp Abnormal (Dev26 T1)	Ethernet				x		x	x	
	10	Rect Xfrmer #X Dissolve Gases in Oil Abnormal	Ethernet				x		x	x	
	11	Rect Xfrmer #X Explosion Diaphragm Abnormal (63MR)	Ethernet				x		x	x	
	12	Rect Xfrmer #X wind. Temp phase A (Analog value)	Ethernet				x		x	x	
	13	Rect Xfrmer #X wind. Temp phase B (Analog value)	Ethernet				x		x	x	
	14	Rect Xfrmer #X wind. Temp phase C (Analog value)	Ethernet				x		x	x	
	15	Rect Xfrmer #X wind. MAX Temp Phase A (Analog value)	Ethernet				x		x	x	
	16	Rect Xfrmer #X wind. MAX Temp Phase B (Analog value)	Ethernet				x		x	x	
	17	Rect Xfrmer #X wind. MAX Temp Phase C (Analog value)	Ethernet				x		x	x	
	18	Rect Xfrmer #X Top Oil Tem (Analog value)	Ethernet				x		x	x	
	19	Rect Xfrmer #X Bottom Oil Temp (Analog value)	Ethernet				x		x	x	
AC RECTIFIER TRANSFORMER DRY (Typical QTY=3) X=1,2	1	Aux. Xformer#X Communication Failure	Ethernet				x	~~x~~	x	x	DRY TRANSFORMER MONITOR (DNP3)
	2	Aux. Xformer#X Wind. Temp. Abnormal Stage 2 (Dev 49T2)	Ethernet				x	~~x~~	x	x	
	3	Aux. Xformer#X Wind. Temp. Abnormal Stage 1 (Dev 49T1)	Ethernet				x	~~x~~	x	x	
	4	Aux. Xformer#X wind. Temp phase 1 (Analog value)	Ethernet				x		x	x	
	5	Aux. Xformer#X wind. Temp phase 2 (Analog value)	Ethernet				x		x	x	
	6	Aux. Xformer#X wind. Temp phase 3 (Analog value)	Ethernet				x		x	x	
	7	Aux. Xformer#X wind. MAX Temp phase (Analog value)	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
SMART RECTIFIER (Typical QTY=3) X=1,2,3 OR 4	1	Rectifier #X SEL Communication Failure	Ethernet				x		x	x	RECTIFIER SEL 2411 (DNP3)
	2	Rectifier #X Over- temp. Stage 1(26RT1)	Ethernet				x	x	x	x	
	3	Rectifier #X Over- temp. Stage 1(26RT2)	Ethernet				x	x	x	x	
	4	Rect #X diode Failure Stage 1(Dev 95)	Ethernet				x	x	x	x	
	5	Rect #X diode Failure Stage 2 (Dev 95)	Ethernet				x	x	x	x	
	6	Rectifier #X Ground Structure(Dev64X)	Ethernet				x		x	x	
	7	Rectifier #X Energized Structure (Dev 64C)	Ethernet				x		x	x	
	8	Rectifier #X Door Open(Dev33)	Ethernet				x		x	x	
	9	Rectifier #X Door Close (Dev 33)	Ethernet				x		x	x	
	10	Rectifier #X Negative switch open (89N)	Ethernet				x	x	x	x	
	1	Rectifier #X Diode String 1 Heat sink Temp	Ethernet				x		x	x	RECTIFIER SEL 2600 CONNECTED T0 SEL 2411 (GOOSE)
	2	Rectifier #X Diode String 2 Heat sink Temp	Ethernet				x		x	x	
	3	Rectifier #X Diode String 3 Heat sink Temp	Ethernet				x		x	x	
	4	Rectifier #X Diode String 4 Heat sink Temp	Ethernet				x		x	x	
	5	Rectifier #X Diode String 5 Heat sink Temp	Ethernet				x		x	x	
	6	Rectifier #X Diode String 6 Heat sink Temp	Ethernet				x		x	x	
	7	Rectifier #X Diode String 7 Heat sink Temp	Ethernet				x		x	x	
	8	Rectifier #X Diode String 8 Heat sink Temp	Ethernet				x		x	x	
	9	Rectifier #X Diode String 9 Heat sink Temp	Ethernet				x		x	x	
	10	Rectifier #X Diode String 10 Heat sink Temp	Ethernet				x		x	x	
	11	Rectifier #X Diode String 11 Heat sink Temp	Ethernet				x		x	x	
	12	Rectifier #X Diode String 12 Heat sink Temp	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	Item	Point description	Signal Type	Local HMI	OCC	SCADA SERVER	Local HMI	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
SMART RECTIFIER (Typical QTY=3) X=1,2,3 OR 4	11	Rect #X diode No 11 Failure (Dev 95)	Ethernet				x		x	x	RECTIFIER SEL 2440 CONNECTED T0 SEL 2411 OOSE)
	12	Rect #X diode No 12 Failure (Dev 95)	Ethernet				x		x	x	
	13	Rect #X diode No 13 Failure (Dev 95)	Ethernet				x		x	x	
	14	Rect #X diode No 14 Failure (Dev 95)	Ethernet				x		x	x	
	15	Rect #X diode No 15 Failure (Dev 95)	Ethernet				x		x	x	
	16	Rect #X diode No 16 Failure (Dev 95)	Ethernet				x		x	x	
	17	Rect #X diode No 17 Failure (Dev 95)	Ethernet				x		x	x	
	18	Rect #X diode No 18 Failure (Dev 95)	Ethernet				x		x	x	
	19	Rect #X diode No 19 Failure (Dev 95)	Ethernet				x		x	x	
	20	Rect #X diode No 20 Failure (Dev 95)	Ethernet				x		x	x	
	21	Rect #X diode No 21 Failure (Dev 95)	Ethernet				x		x	x	
	22	Rect #X diode No 22 Failure (Dev 95)	Ethernet				x		x	x	
	23	Rect #X diode No 23 Failure (Dev 95)	Ethernet				x		x	x	
	24	Rect #X diode No 24 Failure (Dev 95)	Ethernet				x		x	x	
	25	Rect #X diode No 25 Failure (Dev 95)	Ethernet				x		x	x	
	26	Rect #X diode No 26 Failure (Dev 95)	Ethernet				x		x	x	
	27	Rect #X diode No 27 Failure (Dev 95)	Ethernet				x		x	x	
	28	Rect #X diode No 28 Failure (Dev 95)	Ethernet				x		x	x	
	29	Rect #X diode No 29 Failure (Dev 95)	Ethernet				x		x	x	
	30	Rect #X diode No 30 Failure (Dev 95)	Ethernet				x		x	x	
	31	Rect #X diode No 31 Failure (Dev 95)	Ethernet				x		x	x	
	32	Rect #X diode No 32 Failure (Dev 95)	Ethernet				x		x	x	
	33	Rect #X diode No 33 Failure (Dev 95)	Ethernet				x		x	x	
	34	Rect #X diode No 34 Failure (Dev 95)	Ethernet				x		x	x	
	35	Rect #X diode No 35 Failure (Dev 95)	Ethernet				x		x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
SMART RECTIFIER (Typical QTY=3) X=1,2,3 OR 4	36	Rect #X diode No 36 Failure (Dev 95)	Ethernet				x		x	x	RECTIFIER SEL 2440 CONNECTED T0 SEL 2411 (GOOSE)
	37	Rect #X diode No 37 Failure (Dev 95)	Ethernet				x		x	x	
	38	Rect #X diode No 38 Failure (Dev 95)	Ethernet				x		x	x	
	39	Rect #X diode No 39 Failure (Dev 95)	Ethernet				x		x	x	
	40	Rect #X diode No 40 Failure (Dev 95)	Ethernet				x		x	x	
	41	Rect #X diode No 41 Failure (Dev 95)	Ethernet				x		x	x	
	42	Rect #X diode No 42 Failure (Dev 95)	Ethernet				x		x	x	
	43	Rect #X diode No 43 Failure (Dev 95)	Ethernet				x		x	x	
	44	Rect #X diode No 44 Failure (Dev 95)	Ethernet				x		x	x	
	45	Rect #X diode No 45 Failure (Dev 95)	Ethernet				x		x	x	
	46	Rect #X diode No 46 Failure (Dev 95)	Ethernet				x		x	x	
	47	Rect #X diode No 47 Failure (Dev 95)	Ethernet				x		x	x	
	48	Rect #X diode No 48 Failure (Dev 95)	Ethernet				x		x	x	
UPS	1	UPS Communication Failure	Ethernet				x		x	x	UPS HARDWIRE CONNECTED TO RTU
	2	Battery Charger NOR./IND	Hardwired				x	*	x	x	
	3	Battery Charger ABN. /IND	Hardwired				x	*	x	x	
	4	Inv. Transfer SW Position NOR./IND	Hardwired				x	*	x	x	
	5	Inv. Transfer SW Position ABN. /IND	Hardwired				x	*	x	x	
	6	Inverter Output NOR./IND	Hardwired				x	*	x	x	
	7	Inverter Output ABN. /IND	Hardwired				x	*	x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
UPS	8	Input AC Voltage L-L, L-N for phase A	Ethernet				x		x	x	UPS NETWORK MANAGEMENT INTERFACE TO NETWORK SWITCH
	9	Input AC Voltage L-L, L-N for phase B	Ethernet				x		x	x	
	10	Input AC Voltage L-L, L-N for phase C	Ethernet				x		x	x	
	11	Input AC Current Phase A	Ethernet				x		x	x	
	12	Input AC Current Phase B	Ethernet				x		x	x	
	13	Input AC Current Phase C	Ethernet				x		x	x	
	14	Input Frequency	Ethernet				x		x	x	
	15	DC bus Voltage	Ethernet				x		x	x	
	16	Output AC Voltage L-L, L-N for phase A	Ethernet				x		x	x	
	17	Output AC Voltage L-L, L-N for phase B	Ethernet				x		x	x	
	18	Output AC Voltage L-L, L-N for phase C	Ethernet				x		x	x	
	19	Output AC Current Phase A	Ethernet				x		x	x	
	20	Output AC Current Phase B	Ethernet				x		x	x	
	21	Output AC Current Phase C	Ethernet				x		x	x	
	22	Output Frequency	Ethernet				x		x	x	
	23	Bypass AC Voltage L-L, L-N for phase A	Ethernet				x		x	x	
	24	Bypass AC Voltage L-L, L-N for phase B	Ethernet				x		x	x	
	25	Bypass AC Voltage L-L, L-N for phase C	Ethernet				x		x	x	
ANCILARY	1	Fire Alarm	Hard Wired				x	x	x	x	TO RTU
	2	Unauthorized Entrance Summary	Hard Wired				x	x	x	x	
	3	TPSS Room Temperature	Hard Wired				x	x	x	x	
	4	RTU in Local	Hard Wired				x	x	x	x	
Battery Room	1	Battery Room Exhaust Fan Normal	Hard Wired				x	x	x		TO RTU
	2	Battery Room Exhaust Fan Abnormal	Hard Wired				x	x	x		
	3	Room Temperature	Hard Wired				x		x		

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
Battery Monitor (BM)	1	Battery Communication Failure	Ethernet				x		x	x	BM TO NETWORK SWITCH ETHERNET COPPER (DNP3 OR MODBUS)
	2	Individual Cell Resistance	Ethernet							x	
	3	Individual Cell Voltage	Ethernet							x	
	4	Individual Inter-cell Resistance	Ethernet							x	
	5	Electrolyte Level (Optional)	Ethernet							x	
	6	String current (Charge/Discharge/Float)	Ethernet							x	
	7	Battery Failure alarm	Ethernet				x	x		x	
	8	Ripple Current (Optional)	Ethernet							x	
	9	Ambient Temperatures	Ethernet							x	
	10	Ground Fault Currents (Optional)	Ethernet							x	
	11	Battery Float Voltage	HARD WIRED				x	x	x	x	TO RTU STATUS & ANALOG MODULES
	12	Battery Low Voltage Alarm							x	x	
Zone Heater Control Panel	1	Contact rail heater TRk1 On (control)	Ethernet	x	x	-					MASTER STATION IED (DNP3)
	2	Contact rail heater TRk1 Off (control)	Ethernet	x	x	-					
	3	Contact rail heater TRk1 On (indication)	Ethernet				x	x	x	x	
	4	Contact rail heater TRk1 Off (indication)	Ethernet				x	x	x	x	
	5	Contact rail heater TRk1 Local/Remote (indication)	Ethernet				x	x	x	x	
	6	Contact rail heater Trk2 On (control)	Ethernet	x	x	-					
	7	Contact rail heater TRk2 Off (control)	Ethernet	x	x	-					
	8	Contact rail heater TRk2 On (indication)	Ethernet				x	x	x	x	
	9	Contact rail heater TRK2 Off (indication)	Ethernet				x	x	x	x	
	10	Contact rail heater TRk2 Local/Remote (indication)	Ethernet				x	x	x	x	
	11	Contact rail heater TRk3 On (control) (Where available)	Ethernet	x	x	-					
	12	Contact rail heater TRk3 Off (control) (Where available)	Ethernet	x	x	-					
	13	Contact rail heater TRk3 On (indication) (Where available)	Ethernet				x	x	x	x	
	14	Contact rail heater TRk3 Off (indication) (Where available)	Ethernet				x	x	x	x	
	15	Contact rail heater TRk3 Local/Remote (indication) (Where provided)	Ethernet				x	x	x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
ETS Relay Cabinet	1	ETS Trip Circuit Normal TRk1 Inbound	hardwired				x	x	x	x	RELAY CONTACTS TO RTU
	2	ETS Trip Circuit Trip TRk1 Inbound	hardwired				x	x	x	x	
	3	ETS Trip Circuit Normal TRk2 Inbound	hardwired				x	x	x	x	
	4	ETS Trip Circuit Trip TRk2 Inbound	hardwired				x	x	x	x	
	5	ETS Trip Circuit Normal TRk1 Outbound	hardwired				x	x	x	x	
	6	ETS Trip Circuit Trip TRk1 Outbound	hardwired				x	x	x	x	
	7	ETS Trip Circuit Normal TRk2 Outbound	hardwired				x	x	x	x	
	8	ETS Trip Circuit Trip TRk2 Outbound	hardwired				x	x	x	x	
	9	ETS Trip Circuit Normal TRk3 (Where available)	hardwired				x	x	x	x	
	10	ETS Trip Circuit Trip TRk3 (Where available)	hardwired				x	x	x	x	
ETS Remote Monitor	1	ETS Pushbutton operated	RS485				x	x	x	x	WAYSIDE DIO (DNP3)
	2	Amber Light ON	RS485			x		x	x	x	
	3	Amber Light OFF	RS485			x		x	x	x	
	4	Amber Light ABN/IND	RS485					x	x	x	
	5	Blue Light ABN/IND	RS485				x	x	x	x	
	6	Communications ABN/IND	RS485				x	x	x	x	
	7	DC trip circuit A ABN/IND	RS485				x	x	x	x	
	8	DC trip circuit B ABN/IND	RS485				x	x	x	x	
Cable Shield Monitor	1	Cable Shield Monitor Communication Failure	Ethernet				x		x	x	Cable Shield Monitor (MODBUS, DNP3 OR IEC61850)
	2	Cable Shield Monitor Healthy/Fail	Ethernet				x		x	x	
	3	Cable Shield Overvoltage	Ethernet				x		x	x	
	4	Cable Shield Leakage Current	Ethernet				x		x	x	
	5	Cable Shield Low Resistance to Ground	Ethernet				x		x	x	
	6	Broken connection from cable Shield to SCM	Ethernet				x		x	x	
	7	SCM sensor	Ethernet				x		x	x	
	8	Cable Shield Common Alarm	Ethernet				x	x	x	x	

		TPSS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
POS SWG DTR	1	DTR Communication Failure	Ethernet				x		x		DTR TO COMPUTER ETHERNET
	2	DC Bus Voltage	Ethernet				x		x		
	3	D.C SWGR Cathode Breaker No. 21 Current Measurement	Ethernet				x		x		
	4	D.C SWGR Cathode Breaker No. 22 Current Measurement	Ethernet				x		x		
	5	D.C SWGR Cathode Breaker No. 23 Current Measurement	Ethernet				x		x		
	6	D.C SWGR Feeder Breaker No. 31 Current Measurement	Ethernet				x		x		
	7	D.C SWGR Feeder Breaker No. 32 Current Measurement	Ethernet				x		x		
	8	D.C SWGR Feeder Breaker No. 33 Current Measurement	Ethernet				x		x		
	9	D.C SWGR Feeder Breaker No. 34 Current Measurement	Ethernet				x		x		
	10	D.C SWGR Feeder Breaker No. 35 Current Measurement	Ethernet				x		x		
	11	D.C SWGR Feeder Breaker No. 36 Current Measurement	Ethernet				x		x		
	12	D.C SWGR Feeder Breaker No. 37 Current Measurement	Ethernet				x		x		
	13	D.C SWGR Cathode Breaker No. 21 Relay Trigger Contact	Ethernet				x		x		
	14	D.C SWGR Cathode Breaker No. 22 Relay Trigger Contact	Ethernet				x		x		
	15	D.C SWGR Cathode Breaker No. 23 Relay Trigger Contact	Ethernet				x		x		
	16	D.C SWGR Feeder Breaker No. 31 Relay Trigger Contact	Ethernet				x		x		
	17	D.C SWGR Feeder Breaker No. 32 Relay Trigger Contact	Ethernet				x		x		
	18	D.C SWGR Feeder Breaker No. 33 Relay Trigger Contact	Ethernet				x		x		
	19	D.C SWGR Feeder Breaker No. 34 Relay Trigger Contact	Ethernet				x		x		
	20	D.C SWGR Feeder Breaker No. 35 Relay Trigger Contact	Ethernet				x		x		
	21	D.C SWGR Feeder Breaker No. 36 Relay Trigger Contact	Ethernet				x		x		
	22	D.C SWGR Feeder Breaker No. 37 Relay Trigger Contact	Ethernet				x		x		
NEG. SWG DTR	1	D.C Neg. SWBD Track 1 Negative return Current Measurement	Ethernet				x		x		DTR TO COMPUTER ETHERNET
	2	D.C Neg. SWBD Track 2 Negative return Current Measurement	Ethernet				x		x		
	3	D.C Neg. SWBD Track 1 to earth voltage Measurement	Ethernet				x		x		
	4	D.C Neg. SWBD Track 2 to earth voltage Measurement	Ethernet				x		x		

Table 4.2 TBS SCADA ASSIGNMENT POINTS

WMATA reserves the right to add or remove points as necessary to provide a comprehensive remote monitoring and control system. WMATA standard Point assignment charts shall be used by the contractor for the protocol mapping of the IEDs and for points to be simulated and tested during the SCADA system integration.

		TBS SCADA ASSIGNMENT POINTS		Control			Indication				
Equipment	Item	Point description	Signal Type	Local HMI	OCC	SCADA SERVER	Local HMI	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
	2	D.C SWGR Feeder Breaker No. 4X Close Control	Ethernet	x	x						
	3	D.C SWGR Feeder Breaker No. 4X Open Indication	Ethernet				x	x	x	x	
	4	D.C SWGR Feeder Breaker No. 4X Close Indication	Ethernet				x	x	x	x	
	5	D.C SWGR Feeder Breaker No. 4X DIO Communication Failure	Ethernet				x	x	x	x	
	6	D.C SWGR Feeder Breaker No. 4X Rack Out	Ethernet				x	x	x	x	
	7	D.C SWGR Feeder Breaker No. 4X Test Position	Ethernet				x		x	x	
	8	D.C SWGR Feeder Breaker No. 4X Local Position	Ethernet				x		x	x	
	9	D.C SWGR Feeder Breaker No. 4X Relay 201C	Ethernet				x		x	x	
	10	D.C SWGR Feeder Breaker No. 4X Relay 201T	Ethernet				x		x	x	
	11	D.C SWGR Feeder Breaker No. 4X Lockout (86) (where available)	Ethernet				x		x	x	
	12	D.C SWGR Feeder Breaker No. 4X Loss of Control Power	Ethernet				x	x	x	x	
	13	D.C SWGR Feeder Breaker No. 4X Rack In	Ethernet				x		x	x	
	14	D.C SWGR Feeder Breaker No. 4X MPR Failure	Ethernet				x		x	x	
	15	NDC Control Module Trip Circuit Supervision Failure	Ethernet				x		x	x	
	16	NDC Controller Failure	Ethernet				x		x	x	
	17	NDC Controller Overload Operation	Ethernet				x		x	x	
	18	D.C SWGR Cathode Breaker No.4X DIO Local	Ethernet				x		x	x	

		TBS SCADA ASSIGNMENT POINTS		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
DC S/G Feeder Relay (Typical QTY=6) X=1 TO QTY	1	D.C SWGR Cathode Breaker No. 4X MPR Communication Failure	Ethernet				x	x	x	x	DC MPR (DNP3, MODBUS, IEC61850)
	2	D.C SWGR Feeder Breaker No. 4X Instantaneous Over Current	Ethernet				x		x	x	
	3	D.C SWGR Feeder Breaker No. 4X Inverse time Over Current	Ethernet				x		x	x	
	4	D.C SWGR Feeder Breaker No. 4X Extreme Inverse Over current	Ethernet				x		x	x	
	5	D.C SWGR Feeder Breaker No. 4X Low Level fault	Ethernet				x		x	x	
	6	D.C SWGR Feeder Breaker No. 4X Current Rate Of Rise	Ethernet				x		x	x	
	7	D.C SWGR Feeder Breaker No. 4X Straight Time Over Current	Ethernet				x		x	x	
UPS	1	UPS Communication Failure	Ethernet				x		x	x	DC MPR (DNP3, MODBUS, IEC61850)
	2	Battery Charger NOR./IND	Hardwired				x	*	x	x	
	3	Battery Charger ABN. /IND	Hardwired				x	*	x	x	
	4	Inv. Transfer SW Position NOR./IND	Hardwired				x	*	x	x	
	5	Inv. Transfer SW Position ABN. /IND	Hardwired				x	*	x	x	
	6	Inverter Output NOR./IND	Hardwired				x	*	x	x	
	7	Inverter Output ABN. /IND	Hardwired				x	*	x	x	
	1	Input AC Voltage L-L, L-N for phase A	Ethernet				x		x	x	UPS NETWORK MANAGEMENT INTERFACE TO NETWORK SWITCH
	2	Input AC Voltage L-L, L-N for phase B	Ethernet				x		x	x	
	3	Input AC Voltage L-L, L-N for phase C	Ethernet				x		x	x	
	4	Input AC Current Phase A	Ethernet				x		x	x	
	5	Input AC Current Phase B	Ethernet				x		x	x	
	6	Input AC Current Phase C	Ethernet				x		x	x	
	7	Input Frequency	Ethernet				x		x	x	
	8	DC bus Voltage	Ethernet				x		x	x	
	9	Output AC Voltage L-L, L-N for phase A	Ethernet				x		x	x	
	10	Output AC Voltage L-L, L-N for phase B	Ethernet				x		x	x	

		TBS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
UPS	11	Output AC Voltage L-L, L-N for phase C	Ethernet				x		x	x	
	12	Output AC Current Phase A	Ethernet				x		x	x	
	13	Output AC Current Phase B	Ethernet				x		x	x	
	14	Output AC Current Phase C	Ethernet				x		x	x	
	15	Output Frequency	Ethernet				x		x	x	
	17	Bypass AC Voltage L-L, L-N for phase A	Ethernet				x		x	x	
	18	Bypass AC Voltage L-L, L-N for phase B	Ethernet				x		x	x	
	19	Bypass AC Voltage L-L, L-N for phase C	Ethernet				x		x	x	
Battery Monitor (BM)	1	Battery Communication Failure	Ethernet				x		x	x	BM TO NETWORK SWITCH ETHERNET COPPER
	2	Battery Float Voltage	Ethernet				x	x	x	x	
	3	Individual Cell Resistance	Ethernet							x	
	4	Individual Cell Voltage	Ethernet							x	
	5	Individual Inter-cell Resistance	Ethernet							x	
	6	Electrolyte Level (Optional)	Ethernet							x	
	7	String current (Charge/Discharge/Float)	Ethernet							x	
	8	Battery Failure alarm	Ethernet				x	x		x	
	9	Ripple Current (Optional)	Ethernet							x	
	10	Ambient Temperatures	Ethernet							x	
	11	Ground Fault Currents (Optional)	Ethernet							x	
	12	Battery Low Voltage Alarm	Ethernet						x	x	
	13	Battery Float Voltage	Hard Wired				x	x	x	x	TO RTU STATUS AND ANALOG MODULES
	14	Battery Low Voltage Alarm					x	x	x	x	
Battery Room	1	Battery Room Exhaust Fan Normal	Hard Wired				x	x	x		TO RTU
	2	Battery Room Exhaust Fan Abnormal	Hard Wired				x	x	x		
	3	Room Temperature	Hard Wired				x		x		

		TBS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
Zone Heater Control Panel	1	Contact rail heater TRk1 On (control)	Ethernet	x	x	-					ZONE HEATER CONTROLLER
	2	Contact rail heater TRk1 Off (control)	Ethernet	x	x	-					
	3	Contact rail heater TRk1 On (indication)	Ethernet				x	x	x	x	
	4	Contact rail heater TRk1 Off (indication)	Ethernet				x	x	x	x	
	5	Contact rail heater TRk1 Local/Remote (indication)	Ethernet				x	x	x	x	
	6	Contact rail heater Trk2 On (control)	Ethernet	x	x	-					
	7	Contact rail heater TRk2 Off (control)	Ethernet	x	x	-					
	8	Contact rail heater TRk2 On (indication)	Ethernet				x	x	x	x	
	9	Contact rail heater TRK2 Off (indication)	Ethernet				x	x	x	x	
	10	Contact rail heater TRk2 Local/Remote (indication)	Ethernet				x	x	x	x	
	11	Contact rail heater TRk3 On (control) (Where available)	Ethernet	x	x	-					
	12	Contact rail heater TRk3 Off (control) (Where available)	Ethernet	x	x	-					
	13	Contact rail heater TRk3 On (indication) (Where available)	Ethernet				x	x	x	x	
	14	Contact rail heater TRk3 Off (indication) (Where available)	Ethernet				x	x	x	x	
	15	Contact rail heater TRk3 Local/Remote (indication) (Where available)	Ethernet				x	x	x	x	
ETS Relay Cabinet	1	ETS Trip Circuit Normal TRk1 Inbound	hardwired				x	x	x	x	RELAY CONTACTS TO RTU
	2	ETS Trip Circuit Trip TRk1 Inbound	hardwired				x	x	x	x	
	3	ETS Trip Circuit Normal TRk2 Inbound	hardwired				x	x	x	x	
	4	ETS Trip Circuit Trip TRk2 Inbound	hardwired				x	x	x	x	
	5	ETS Trip Circuit Normal TRk1 Outbound	hardwired				x	x	x	x	
	6	ETS Trip Circuit Trip TRk1 Outbound	hardwired				x	x	x	x	
	7	ETS Trip Circuit Normal TRk2 Outbound	hardwired				x	x	x	x	
	8	ETS Trip Circuit Trip TRk2 Outbound	hardwired				x	x	x	x	
	9	ETS Trip Circuit Normal TRk3 (Where available)	hardwired				x	x	x	x	
	10	ETS Trip Circuit Trip TRk3 (Where available)	hardwired				x	x	x	x	

		TBS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
ETS Remote Monitor	1	ETS Pushbutton operated	RS485				x	x	x	x	WAYSIDE DIO with DNP3 PROTOCOL
	2	Amber Light ON	RS485			x		x	x	x	
	3	Amber Light OFF	RS485			x		x	x	x	
	4	Amber Light ABN/IND	RS485					x	x	x	
	5	Blue Light ABN/IND	RS485				x	x	x	x	
	6	Communications ABN/IND	RS485				x	x	x	x	
	7	DC trip circuit A ABN/IND	RS485				x	x	x	x	
	8	DC trip circuit B ABN/IND	RS485				x	x	x	x	
Cable Shield Monitor	1	Cable Shield Monitor Communication Failure	Ethernet				x		x	x	Cable Shield Monitor (MODBUS, DNP3 OR IEC61850)
	2	Cable Shield Monitor Healthy/Fail	Ethernet				x		x	x	
	3	Cable Shield Overvoltage	Ethernet				x		x	x	
	4	Cable Shield Leakage Current	Ethernet				x		x	x	
	5	Cable Shield Low Resistance to Ground	Ethernet				x		x	x	
	6	Broken connection from cable Shield to SCM	Ethernet				x		x	x	
	7	SCM sensor Over temperature	Ethernet				x		x	x	
	8	Cable Shield Common Alarm	Ethernet				x	x	x	x	
ANCILARY	1	Fire Alarm	Hard Wired				x	x	x	x	TO RTU
	2	Unauthorized Entrance Summary	Hard Wired				x	x	x	x	
	3	TPSS Room Temperature	Hard Wired				x	x	x	x	
	4	RTU in Local	Hard Wired				x	x	x	x	

		TBS SCADA ASSIGNMENT POINTS CONTINUED		Control			Indication				
Equipment	**Item**	**Point description**	**Signal Type**	**Local HMI**	**OCC**	**SCADA SERVER**	**Local HMI**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
POS SWG DTR	1	DTR Communication Failure	Ethernet				x		x	x	TO INDUSTRIAL COMPUTER
	2	DC Bus Voltage	Ethernet				x		x	x	
	3	D.C SWGR Feeder Breaker No. 41 Current Measurement	Ethernet				x		x	x	
	4	D.C SWGR Feeder Breaker No. 42 Current Measurement	Ethernet				x		x	x	
	5	D.C SWGR Feeder Breaker No. 43 Current Measurement	Ethernet				x		x	x	
	6	D.C SWGR Feeder Breaker No. 44 Current Measurement	Ethernet				x		x	x	
	7	D.C SWGR Feeder Breaker No. 45 Current Measurement	Ethernet				x		x	x	
	8	D.C SWGR Feeder Breaker No. 46 Current Measurement	Ethernet				x		x	x	
	9	D.C SWGR Feeder Breaker No. 47 Current Measurement	Ethernet				x		x	x	
	10	D.C SWGR Feeder Breaker No. 41 Relay Trigger Contact	Ethernet				x		x	x	
	11	D.C SWGR Feeder Breaker No. 42 Relay Trigger Contact	Ethernet				x		x	x	
	12	D.C SWGR Feeder Breaker No. 43 Relay Trigger Contact	Ethernet				x		x	x	
	13	D.C SWGR Feeder Breaker No. 44 Relay Trigger Contact	Ethernet				x		x	x	
	14	D.C SWGR Feeder Breaker No. 45 Relay Trigger Contact	Ethernet				x		x	x	
	15	D.C SWGR Feeder Breaker No. 46 Relay Trigger Contact	Ethernet				x		x	x	
	16	D.C SWGR Feeder Breaker No. 47 Relay Trigger Contact	Ethernet				x		x	x	

END OF SECTION

SECTION 28 40 00.1

PASSENGER STATIONS AC ROOMS

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) WORK

PART 1 – GENERAL

1.01 SUMMARY

A. The scope of this section includes the design, furnishing, installation, integration and testing of SCADA equipment and network to support the protection, control and monitoring of the passenger station (AC Switchboard Room) that are currently monitored/controlled by the Advanced Information Management System (AIM) and Automated Energy Management System (AEMS) in JGB/CTF OCC.

B. AC room to host communications facilities are existing, and apart from relocation of cables and receptacles within AC rooms if necessary, communications work is not anticipated as part of this contract. A description of the communications facilities is included in this document as information.

C. Integrate the new equipment furnished under this contract with the existing SCADA system. This work includes running and terminating control and indication wiring, and such data communications connections between IEDs and the existing SCADA equipment as is necessary.

D. The SCADA system inside AC rooms will mainly control and/or monitor as applicable Medium voltage AC switchgear, transformers, Low Voltage AC switchgear, uninterruptable power supplies (UPS), battery cycle monitor, escalators, elevators, lighting and HVAC and ancillary equipment installed inside the station

E. Related Sections:
1. Section 26 33 53 - Uninterruptible Power System
2. Section 26 22 00 – Medium Voltage Transformers
3. Section 26 13 26 – Medium Voltage Switchgear
4. Section 26 11 13 – Unit Substation
5. Section 26 24 13 - Low-Voltage switchgear and switchboard
6. Section 26 24 14 – Programmable Logic Controller (PLC) and Human Machine Interface (HMI) for Electrical Systems
7. Section 28 40 02 – Remote Terminal Unit for Power System SCADA
8. Section 28 40 04 - Network Switch for SCADA and Automation Systems
9. Section 28 40 06.1 - SCADA Systems Integration Testing and Documentation for AC Rooms

These sections generally specify an entirely new SCADA system. For the Potomac Yard Metrorail Station project, equip the new AC power equipment being furnished and installed as part of this project with the input-output devices called for in these specifications, and connect and test to the existing SCADA system using the products and methods described in these specifications.

1.02 REFERENCES

A. Drawings: This specification should be read in conjunction with the following design directive drawings;

1. Contract drawings.

B. Tables:

1. Existing SCADA Point Assignment Charts (PACs)

C. Codes and Regulations:

1. Authority Having Jurisdiction (AHJ).
2. Applicable NEC version.
3. ANSI C37.2 Electrical Power System Device Function Numbers and Contact Designation.
4. IEEE 802.3 Standard for LAN interfaces and protocols.
5. IEEE std. 1815-2010 Standard for Electric Power Systems Communications - Distributed Network Protocol (DNP3)
6. NFPA 130, 2003.
7. WMATA Information Technology/ Network & Communications Services (IT/NCS) specification section: Infrastructure design & wiring standards

1.03 DEFINITIONS AND ABBREVIATIONS

ANALOG: A variable quantity represented numerically

CPU: Central Processing Unit

CONTRACTOR: Supplier of SCADA equipment and Devices

CONFIGURATION FILE: Programming file created for a specific device that contends information required for the proper operation of the device as intended, also to build, modify, or restore the device to the proper operation state.

DNP3: Distributed Network Protocol – a communications protocol in current use in the SCADA industry. DNP is an open and public protocol, creating interoperability between master stations and RTUs.

DIGITAL: A quantity with two discrete states: ON or OFF. This term is often used in conjunction with physical input and output states.

IEC 61850: International Electro-Technical Commission standard protocol for the design of electrical substation automation. This protocol can run over TCP/IP networks or substation LANs using high speed switched Ethernet to obtain the necessary response times below four milliseconds for protective relaying.

IED: Intelligent Electronic Device, such as a PLC, protection relay, Distributed Input Output modules or an RTU.

INTERNET PROTOCOL: Communication protocols and applications from the TCP/IP suite, used in Internet and Intranet local area and wide area communication architectures.

I/O: Input/ Output

LED: Light Emitting Diode

MASTER STATION: - Refers to multiple servers and distributed software applications connected to the SCADA system network and intended to communicate with the RTUs.

MODBUS: A communication protocol developed by Modicon in 1979 and now managed by the Modbus Organization

PLC: Programmable Logic Controller

PAC: Point Assignment Chart

PHYSICAL POINTS: RTU internal representation of electrical terminations on a Main RTU Unit or Remote I/O Unit.

POINT: an entity of data within an RTU corresponding to a physical or derived quantity

PAC: Point Assignment Chart - point address list in the RTU point database

PROTOCOL: communication description shared by multiple devices permitting interchange of information

RTU: Remote Terminal Unit device responsible for communicating with a SCADA Master or Peer RTUs, executing user applications and controlling Remote I/O.

Computer: Industrial Type computer running applications except RTU applications.

SCADA: Supervisory Control and Data Acquisition

STATION: Electrical Facilities.

SUPPLIER: The supplier of SCADA equipment including RTU, HMI, DIO, DTR and other IEDs

SYSTEM INTEGRATOR: The manufacturer of the RTU or their authorized representative responsible for the design, implementation and integration of the SCADA systems.

1.04 QUALITY ASSURANCE

A. The SCADA System shall be furnished by a single Supplier who shall assume responsibility for providing a complete and integrated system.

B. The supplier of SCADA equipment shall demonstrate that the provided RTU is designed and configured in such a way that it is fully compatible to tie into the existing Advanced Information Management System (AIM) and SCADA server using DNP3 communication protocol.

C. The Supplier shall supply its company's Quality Assurance Plan, and for components that are not of its manufacture, the component manufacturer's Quality Assurance Plan. The plans shall include but not necessarily be limited to: method of testing, methods of documentation, station control, "Burn-In", final tests and serialization coding and packaging.

D. Supplier Minimum Qualifications:

1. At least five years' continuous experience in designing, implementing, supplying and supporting instrumentation and control systems that are comparable to the SCADA System in terms of hardware, software and complexity.
2. Manufactured and supported standard lines of microprocessor based control and monitoring equipment and application software continuously for the last five years.
3. In existence at the time of bid, experienced engineering and technical staff capable of designing, implementing, supplying and supporting the SCADA System and handling the SCADA System submittal and training requirements.
4. Can provide system hardware components and software packages of fully developed, field proven standardized designs that are readily available; with minimal uniqueness and limited customization
5. Has a minimum of five years of experience in hardware application and programming of Remote Terminal Units and data highway systems.
6. Provides standard course offerings in general control applications and in operation, programming and maintenance of the control system and equipment.
7. Has a system of traceability of the manufactured units, of "Burn-In" for all components and available supportive documentation to demonstrate the equipment meets all of the manufacturer's testing codes and standards, operational, functional, environmental (physical and electrical) and configuration requirements of these specifications.
8. Has a demonstrable record of prompt response to field device failure inquiries

and has an established program for failure analysis.

9. Has excellent record for prompt shipping in accordance with contract obligations required in previous projects.
10. Has at the time of bid, a certificate from an independent testing company that the RTU software IEC 61850 stack has been tested and has not shown to be non-conforming to IEC 61850 communication networks and systems in substation.

E. Technical Requirements:

1. Have at least three completed utility or transit projects utilizing RTU and control equipment identical to or similar to that specified. Indicate owner, value, completion date, names and phone numbers of owner's representative familiar with each project.
2. Provide a general system configuration drawing and include designations for model numbers and types of the proposed SCADA System and all other proposed system components.
3. Provide descriptive literature and manufacturer's catalog information covering all aspects of the hardware design, functions and capabilities of the specific system proposed for the SCADA System.
4. Provide certifications for IEC61850 protocol compliance utilized in the proposed system components.
5. Describe the complete software packages proposed, including any customized software required to meet the functional intent of the system specifications. Descriptions, abundantly accompanied by display screen captures shall address the following:
   a. Overview of system software including the functions, organization and interrelationship of the major software modules provided.
   b. Designed memory requirements to accomplish the specified graphic display, logging, reporting and alarm function requirements.
   c. Real-time data logging and reporting software features and capabilities including examples of logs and reports, procedures for automatic reporting and logging file setups; raw data sampling frequency limits; computing speed and data throughput capabilities, hardware platform requirements; data acquisition and logging data structures and byte sizes; log files and available utilities for reporting, modifications and file

maintenance.

d. Software alarm handling features and capabilities methods of defining alarms and alarm files, automatic print queuing of alarms, acknowledgements and return to normal conditions, chronological sorting and time-tagging of alarms, and alarm file maintenance utilities.

e. SCADA system programming and documentation software features and capabilities with fully annotated and cross-referenced ladder diagram and ladder and function block elements.

f. RTU programming including database creation and automating tools for RTU to SCADA server communication.

g. All RTU programs and software configuration documents, features and capabilities.

h. System level diagnostics for monitoring the performance and detecting and reporting of faults associated with the SCADA.

F. Successful completion of Prototype Testing that proves that the equipment functions properly when connected to the AIM and SCADA servers located in JGB/CTF. This testing shall be done at the WMATA engineering LAB.

G. RTU and Distributed Input Output modules (DIO) acceptance testing shall be done at the manufacturer's facility and witnessed by WMATA representative. The contractor shall provide to WMATA a twenty- one (21) days minimum advance notice date of testing.

H. Specification language related to RTU, MPR, PLC, IED's, Ethernet switches, server devices and other solid state devices will be located in the equipment specification sections in which they appear.

I. Training: Provide information and literature of proposed training. Indicate the qualifications of the manufacturer's training staff.

J. Start-Up and Field Testing: Indicate how the availability demonstration will be accomplished.

K. Maintenance: Provide the following information:

1. Location of service facility along with indication of the expected longest response time.

2. Location of parts facility with available shipping methods and expected delivery time indication for each.

L. Contractor Responsibility:

1. Design, fabrication, integration and Testing of the SCADA and all subsystems in accordance with the Contract Documents and all referenced standards and codes.
2. Proper interfacing of the SCADA System hardware, software, field devices and panels, including required interfacing with electrical equipment, and devices furnished and installed by other equipment suppliers.
3. Supervision of the installation of SCADA System, instruments, panels, RTU cabinets, wiring and other components required.
4. Calibration; inspection, confirmation and documentation of configuration settings; testing and start-up of the SCADA System.
5. Training of OWNER'S personnel in operation and maintenance of the SCADA system,
6. Handling of all warranty obligations for the SCADA system components.
7. Programming and configuration of the RTU's used in the SCADA System in accordance with the approved control descriptions provided by the Contractor.

1.05 SUBMITTALS

A. Shop Drawings:

1. Shop drawing submittals shall be in accordance with the requirements of the Contract Documents.
2. Shop Drawings preparation shall not commence until after the Pre-Submittal Conference specified below.
3. Manufacturing of the SCADA components shall not commence until related submittals have been approved by the WMATA.
4. Shop Drawings shall be submitted in complete packages grouped to permit review of related items as generally outlined below.
5. Review of Shop Drawings will be for conformance with Contract Documents and with regard to functional requirements.

6. Final and approved copies of all Shop Drawings shall be provided in AutoCAD format on a CD-ROM.

B. Pre-Submittal Meeting :

1. CONTRACTOR shall arrange and conduct a Pre-Submittal meeting on the SCADA System.
2. Purpose of the Pre-Submittal meeting shall be to review the manner in which the SCADA System Supplier intends to respond to the requirements of the Contract Documents before any submittals are prepared.
3. CONTRACTOR shall prepare the items listed below for presentation at the Pre-Submittal meeting. The information shall be submitted to WMATA three weeks prior to the date of the meeting.
   a. List of equipment and materials required for the SCADA System and the brand and model, which CONTRACTOR proposes to use for each item.
   b. List of proposed exceptions to the Contract Documents along with a brief explanation of each. Approval shall be subject to a formal submittal.
   c. Sample of each type of submittal specified herein. The samples may be submittals prepared for other projects.
   d. General outline of the type of tests to be performed to verify that all sensors/transducers, instruments and digital processing equipment are functioning properly.
   e. Outline of system integration and testing.
4. Product information for all RTU, MPR's, IED's and other solid state devices selected to be used for the remote control and monitoring purpose along with their configuration information (control/status mapping).
5. Submit SCADA design drawings including but not limited to layout drawings, riser diagrams, cable schedules, assembly drawings, cable tray layouts, interconnection diagrams, and termination diagrams for approval by WMATA.
6. Submit PDF copy of the As-built drawings of the newly installed SCADA system for approval. On approval, submit three copies of as-built drawings in electronic format (AutoCAD and pdf) and paper format (11X17)
7. Provide software, licenses and documentation required for the configuration and integration of the newly installed SCADA system inclusive of each Intelligent Electronic Device provided.

8. Provide spare parts list.
9. Submit Integration Test procedure and test report for installations. Fiber test report are reviewed and approved by WMATA IT network group only.
10. Submit MPR's, IED's mapping document to comply with WMATA approved Point Assignment Chart.

C. Operation and maintenance (O & M) manuals:

1. Operation manuals should contain information pertaining to the operation of the facility. The maintenance manual shall be a compilation of all the technical information related to the maintenance of the facility, equipment, and/or system. Included should be information pertaining to equipment identification, location, data summary, preventive maintenance instruction parts lists, recommended spare parts, wiring diagrams, shop drawings, special tools, test equipment , factory and field test data and reports.
2. Operating and Maintenance Manuals and other supporting documentation shall be provided on CD, virus checked, in MS WORD format and PDF format with a Read.me file containing instructions.
3. Preventive Maintenance Instructions and other supporting documentation shall be provided on a separate folder on the CD, virus checked, in MS WORD format and PDF format. All photographs, drawings shall be provided in subfolders in native format (JPEG, DWG etc.).
4. Following the acceptance of the equipment shop drawing, the equipment manufacturer shall submit the associated O&M documentation for review and approval.
5. After approval, the Contractor prepares and delivers the Contract specified number of copies of the O&M manuals for each site.

D. Preventive Maintenance Instructions:

1. The Operations and Maintenance (O&M) Manual provided for contractually furnished or installed equipment shall include a Preventive Maintenance Instruction (PMI) section, to ensure the continued safe and reliable operation of the specific system or equipment. The O&M shall specify any maintainer's training requirement and when specified the training curriculum shall be included in the appropriate PMI. The PMI shall recommend the minimum number of

maintainers that will be required along with the lowest level of skill sets requirements. If a section contains more than one PMI procedure then the section shall begin with a Table of Contents.

2. PMI procedures shall be written in language easily understood by every maintainer skill level recommended in the PMI. Prior to acceptance, clarity and effectiveness of each PMI procedure shall be demonstrated in coordination with WMATA's maintenance department using the recommended minimum number and level of maintainers. The maintenance team or individual must be able to understand and successfully perform the draft PMI without intervention by the contractors or engineers. Each procedure shall be formatted similar to standard PMI formatting as currently approved by the WMATA maintenance discipline responsible for the maintenance of the equipment, including a standard approval signature cover sheet. Sample PMI, formats, may be obtained from the appropriate maintenance discipline after contract award. Each procedure shall contain:
    a. A recommended performance frequency (interval) that is adjusted to the installed environment and expected level of use.
    b. The maintenance crew size and average time for performance of the PMI
    c. The system-specific and/or equipment-specific objectives of the PMI
    d. Lists of:
        1) Prerequisites
        2) Required reference documents
        3) Industry standards or regulations governing the performance of the maintenance action
        4) Necessary tools and test equipment
3. Definitions and graphics, as much as practical to clarify the instructions.
4. Warnings, Cautions, and Safety Notices, plentifully and prominently interspersed to prevent injury, damage, or unsafe operating conditions before any procedure step to which they apply.
5. Data sheets and checklists, for data collection regarding conditions that are measured and to ensure that important steps are not skipped.
6. Step-by-step instructions to verify and document that the tested mechanism or circuit or subsystem functions within design parameters.

7. Step-by-step instructions, types of solvents, cleansers, and lubricants with intervals for lubrication and cleaning of mechanisms to prevent or minimize grime, corrosion, and wear.
8. Step-by-step instructions to verify the adjustment of the system, equipment, or circuit which will allow it to operate properly (safely, reliably, and without causing excessive wear) until the next scheduled PMI.
9. Step-by-step instructions to verify the integrity of all fasteners, couplings, electrical connections, etc. which may fail or loosen between scheduled maintenance intervals.
10. Step-by-step instructions to document the measured condition of the equipment or circuit, to be used for abatement of deterioration, future failure analysis, and in case of catastrophe.
11. Step-by-step detailed adjustment instructions for any mechanism or circuit found to be out-of-adjustment.

1.06 SUBMITTALS SOFTWARE & DOCUMENTATIONS

A. Programming Software:

1. For each programmable Intelligent Electronic Device, provide configuration software, configuration file and manuals on disks licensed to WMATA six weeks prior to the start of any factory acceptance tests. Provide and submit proof that the software packages are licensed to WMATA when the software is delivered to the WMATA. Provide and submit proof that a two-year software maintenance/upgrade package has been purchased for the Owner.
2. Equipment and devices configuration files shall be submitted to WMATA for review and approval prior to the start of any site acceptance tests.
3. All configuration files shall be in their native formats, shall become property of WMATA and shall not include any copyright license or any license terms that require permissions from the vendor for modifications to the files.
4. Site as built configuration files shall be provided two weeks prior to SCI.
5. Software Licenses: Three (3) fully licensed versions of programming software. This software shall allow for the modification, the re-programming and the reinstallation of the configuration files for each type of device. The software shall be the manufacturer version that is the most current on the day of system commissioning.

B. Chain of custody:

1. A chain of custody shall be used and maintained for all software, configuration files and documentations transferred listed above in this specification. The chain of custody shall be maintained at all times to ensure these items reach WMATA's SCADA engineering group. The contractor shall be responsible for ensuring that the above documentation, configuration files, and software are conveyed to the WMATA project manager. The WMATA project manager shall ensure that the deliverables get submitted to the WMATA SCADA engineering.

1.07 SCADA SYSTEM FACTORY TESTING

A. CONTRACTOR shall provide all labor, materials, software, equipment, engineering and incidentals, specified and required to perform factory testing, before shipment, at the manufacturer's facility to verify that system components are functioning properly and that they meet the functional and performance requirements of the Contract Documents.

B. CONTRACTOR shall submit information on factory testing procedures to verify that testing shall fulfill the requirements as specified herein. Submittal shall be made at least two months in advance of any scheduled testing and shall include dates of scheduled tests.

C. CONTRACTOR shall notify WMATA, in writing, at least three weeks before expected initiation of tests. WMATA may elect to be present at CONTRACTOR'S facilities during operational test of system equipment, either for individual units or as an integrated system. Presence of WMATA representative during testing does not relieve CONTRACTOR from conforming to the requirements of the Contract Documents and shall in no way imply acceptance of the equipment.

D. Factory Testing shall not begin until all related Supervisory Control and Data Acquisition (SCADA) System shop drawings have been submitted and approved.

1.08 SCADA RTU COMPATIBILITY TESTS

A. First Article RTU provided under this contract shall be tested for compatibility with the WMATA system servers. Compatibility tests shall be conducted at the WMATA SCADA

engineering LAB where the provided RTU shall be connected to WMATA AIM and SCADA servers.

B. CONTRACTOR shall provide all labor, materials, software, configuration, equipment, engineering and incidentals required to perform system compatibility tests.

C. The RTU shall be tested for the complete ultimate size point counts.

D. The RTU shall be tested per requirements in PART 2- Execution, Functional Performance Test and Continuous Operation Test of Specification 28 40 06.1.

E. Communication between the RTU and all servers shall be monitored and analyzed by WMATA IT group.

F. All issues revealed shall be addressed by the contractor.

1.09 NOT USED

1.10 DELIVERY, STORAGE AND HANDLING

A. Deliver a fully tested network of microprocessor-based devices, switches, cables and other devices which provide a remote control/monitoring system for AC Power system equipment.

B. Licenses for any software used in for the setup and configuration of devices and equipment shall be provided.

C. Store network of microprocessor-based devices, switches, and temperature sensitive equipment in a dry, climate controlled area before field installation.

1.11 SCADA SYSTEM DESCRIPTION

A. The SCADA system provides for remote control and monitoring of the Electrical Power systems from the Operational Control Centre (OCC) and from the Automated Energy Management System (AEMS) located in the Jackson Graham Building and Carmen Turner Facility (JGB/CTF). Refer to Block diagrams of the SCADA architecture in the contract documents and also in the SCADA system design criteria section.

B. Dedicated fiber optic WAN connects the SCADA master station at the JGB/CTF to SCADA systems at remote sites.

C. At each site a SCADA RTU is provided to act as a data concentrator. Network Switches are also provided to connect all fiber and Ethernet cables from electrical power equipment also serves as a gateway to connect the site LAN to the SCADA WAN router.

D. Through the SCADA system, each remote site equipment can be accessed, monitored and/or controlled as applicable from the SCADA Master Station, OCC Master Station, engineer/Maintenance consoles, and locally from HMI panels installed adjacent to access doors where possible. Control and monitoring of the electrical Power equipment will be carried out by multi-purpose protection relays, control I/O modules, PLCs and other intelligent electronic devices, described in other Specifications, connected directly through Ethernet Switch.

E. RTU provided for installation at AC rooms are tested for compatibility with WMATA current SCADA systems.

F. WMATA established Point Assignment Chart is used to develop the RTU configuration files to ensure full compatible to tie in to the existing Advanced Information Management System (AIM) and Automated Energy Management System (AEMS) using DNP3 communication protocol.

G. Intelligent Electronic devices installed in the facilities to provide remote monitoring, control and protection of the power systems are connected to the substation network switches by fiber optical cables.

H. All hard-wired connections to the SCADA system are made through the SCADA RTU.

I. All Ethernet (fiber or copper) connections to the SCADA are made through the Network Switches.

PART 2 – PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Select devices and equipment specified in their related specification sections.

B. All devices to communicate with the SCADA RTU either through a direct hard-wire connection or using the DNP 3.0, IEC61850 or Modbus TCP protocols over TCP/IP Ethernet or RS485 serial connection.

C. Devices on the LAN/WAN shall use assigned IP addresses provided by WMATA. Use of Dynamic Host Configuration Protocol (DHCP) is not permitted.

D. Devices to operate from 125V DC power supply.

2.02 PRODUCT FEATURE REQUIREMENTS

This section lists the features required for products to form part of the remote control and monitoring system and the SCADA system.

A. SCADA equipment provided by the contractor :

1. All equipment required to connect the new circuit breakers, IEDs, and all other related equipment furnished under this contract to the existing SCADA system.

2.03 DEVICE CONTROL AND INDICATION REQUIREMENTS (Refer to Table 4.0)

Alarms, indications and control functions available to the SCADA system and the OCC master stations are listed in Part 4 tables. The tables detail the SCADA points for the following facilities:

A. PASSENGER STATION AC ROOM

2.04 DEVICE MEASURING AND MONITORING REQUIREMENTS

A. The SCADA system shall be capable of displaying meter values concerning electrical power and station power equipment at the SCADA/AEMS Master Stations and AIM on demand as described in individual equipment specifications and as listed in Section 4 (Tables) of this specification.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Contractor shall refer to drawing ST-SCDA-AC-022 for AC room SCADA equipment to be provided under the contract.

B. The contract shall furnish and install equipment as specified for each facility listed in the SCADA equipment schedule matrix. The contractor is responsible for the programming and integration of each SCADA equipment.

C. CONTRACTOR shall retain the services of the RTU manufacturer or their authorized representatives to be the system integrators.

D. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on contract drawings or specified in the contract documents.

E. Work associated with AIM and AEMS servers is by others.

F. Contractor shall provide an Ethernet based system of RTU, MPRs, IEDs and other devices with integrated web server functionality for status and analog measurement data through Windows Internet Explorer for remote control and monitoring using Ethernet Switch and SCADA RTU.

G. AC Room RTUs will be furnished and installed by the Contractor. Refer to SCADA equipment schedule drawing for the type and brand of RTU to be provided. The programming and integration of the RTU's will be done by the manufacturer of the RTU or the contractor system integrator.

H. The CONTRACTOR shall furnish, install and terminate two six pair single-mode fiber optic cables between the immediate adjacent passenger station communication room and the network switch patch panel installed at the AC room. Fiber cable shall be installed per section 28 40 08.

I. The CONTRACTOR shall provide and install network switch cabinet and accessories as specified in the technical specification 28 40 04.

J. WMATA shall provide, configure and install the network switches in network switch cabinet at the AC rooms.

K. IEDs associated with high voltage switchgear, Transformers and LV switchgears shall connect to the Network Switches using Multimode Optical Fibers type OM3 50/125µm and shall be provided with 100 Base FX Ethernet ports.

L. CONTRACTOR shall provide and install pre-fabricated jumper fiber cables between patch panels and end devices including the network switches.

M. The contractor shall configure the utility grade digital power quality meters to communicate with WMATA energy monitoring server located at JGB.

N. The CONTRACTOR shall provide software and licenses for IED provided by the contractors.

O. The CONTRACTOR shall provide and install conduits for the routing of the Fiber optical cable, CAT6 cable, RS-485 cables and other communication cables used for SCADA purpose as specified in Section 28 40 08.

P. The CONTRACTOR shall provide wiring to connect the UPS as follows:
   1. Form “C” contacts hard wired to the SCADA RTU.
   2. Ethernet copper to network switch.

Q. Battery Charger, Inverter and HVAC system communication module shall connect to the SCADA RTU using RS-485 and form “C” contacts hard wired to the SCADA RTU.

R. For each facility, the contractor shall provide a room temperature sensor type: Rotronic Hygroflex3 HF32 Type W. Two sensors shall be provided for two levels facilities.

S. The contractor shall provide and install copper wire between the Intrusion system and the RTU.

T. The contractor shall provide and install copper wire between Fire Alarm system and the RTU.

U. The contractor shall provide and install copper wire between existing the AC room ventilation HOA switches and the RTU.

V. The contractor shall provide and install copper wire between lighting contactors and the RTU.

W. For location where utility meters are installed, the contractor shall installed wire between the utility meters and the RTU.

X. The contractor shall provide and install copper wire between Battery exhaust fan and the RTU

3.02 POINT ASSIGNMENT CHART FORMAT

A. AC ROOM RTU Point Assignment Chart (PAC) is the listing of the input (status), output (control), and spare data points for each type of facility. The standard WMATA RTU PAC shall be used for all RTU programming to ensure compatibility with SCADA servers. All DNP3, IEC61850 and Modbus control, status and other point addresses must be the same as the existing system addresses for compatibility. Any modifications or change to the PAC must be evaluated and approved before implementation.

B. The contractor system integrator is responsible for the development of the PAC for each type of RTU provided.

C. The RTU PAC shall include as a minimum all points included in the SCADA points listed in table 4.0 in this Specifications and shall include any additions, corrections or revisions necessary to provide complete control and indication coverage of all support facilities within the respective RTU control areas, based on the latest information available.

D. The Contractor shall coordinate with the Mechanical & Electrical Sub Contractors for additional Control and Status points to be Monitored and Controlled.

E. IED provided and installed by the contractor in AC MV switchgears, LV Switchgear, Transformers, UPS and other equipment provided by the contractor, shall be configured by the contractor to communicate with the SCADA system and shall be mapped in accordance with the WMATA standard Point Assignment Chart (PAC). The PAC shall be provided to the contractor upon request.

3.03 INTEGRATION WITH OCC SCADA SYSTEM

A. New RTU type/brand that has not been previously tested for compatibility with WMATA servers, shall be tested for compatibility with the WMATA system servers. Compatibility tests shall be conducted at the WMATA engineering LAB where the provided RTU shall be connected to WMATA AIM and SCADA servers for tests. Refer to Section 28 40 06.1 for the compatibility test requirements.

B. CONTRACTOR shall provide all labor, materials, software, configuration, equipment, engineering and incidentals required to perform the system compatibility tests.

C. The contractor shall conduct end to end testing at each facility where all I/O points listed on the approved point assignment chart shall be tested by physically operating the devices or equipment. It is the contractor responsibility to schedule and conduct the point to point tests.

D. Contractor shall coordinate the point to point tests with WMATA.

3.04 SCADA SYSTEM START-UP AND FIELD TESTING

A. CONTRACTOR shall provide all labor, materials, software, equipment, engineering and incidentals as shown, specified and required to furnish and install all new equipment and coordinate all activities necessary to perform system testing, start-up and commissioning.

B. CONTRACTOR shall retain the services of the SCADA RTU manufacturer to be the system integrator, supervise and/or perform check-out and start-up of all new system components. As part of these services, the contractor shall include for those equipment items not manufactured by the RTU manufacturer, the services of an authorized manufacturers' representative to test the equipment installation and place the equipment in operation. The manufacturers' representative shall be thoroughly knowledgeable about the installation, operation and maintenance of the equipment.

C. CONTRACTOR, under the supervision of the SCADA System integrator and other manufacturers' representative shall perform the following:

1. Inspect and approve the installation of all new SCADA System components and all cable and wiring connections between the various system components prior to placing the various processes and equipment into operation.
2. Conduct a complete system checkout and adjustment, including calibration of all instruments, tuning of control loops, program algorithms and logic operations, checking operation functions, and testing of final control actions. When there are future operational functions included in this work, they should be included in the system checkout. All problems encountered shall be documented and promptly corrected to prevent any delays in start-up of the various unit processes. The WMATA representative may witness any or all of this checkout and testing.
3. Upon completion, complete documentation for this checkout and testing shall be submitted.
4. CONTRACTOR shall provide all test equipment and software necessary to perform the testing during system checkout and start-up. CONTRACTOR shall

transfer all test equipment and software to the WMATA SCADA Engineering after all final testing and commissioning.

5. CONTRACTOR and SCADA System integrator shall be responsible for initial operation of monitoring and control system and shall make any required changes, adjustment or replacements for operation, monitoring and control of the various processes and equipment necessary to perform the functions intended.
6. CONTRACTOR shall furnish to the WMATA certified calibration reports for field instruments and devices specified in Section 28 40 06.1 and other sections as soon as calibration is completed.
7. CONTRACTOR shall furnish WMATA an installation inspection report certifying that all equipment has been installed correctly and is operating properly. The report shall be signed by authorized representatives of both the Contractor and the System integrator.
8. CONTRACTOR shall provide all software and licenses required to configure, operate, troubleshoot, maintain and repair the new SCADA systems or a component part of it including the software for the devices that communicate with SCADA RTU provided under this specification.
9. The Contractor shall produce SCADA System Test Procedures and submit it to the WMATA for approval. A minimum of 30 calendar days after submittal shall be allowed for the initial Test Procedure submittal review and a minimum of 10 calendar days for review after submittal for each revision thereafter. These test procedures are applicable for the SCADA system integrated field tests.
10. Following the SCADA System checkout and initial operation, CONTRACTOR, under the supervision of the SCADA System integrator, shall perform a complete system point to point test to verify that all equipment and programmed software is operating properly as a fully integrated system, and that the intended monitoring and control functions are fully implemented and operational. Any defects or problems found during the test shall be corrected by Contractor and then retested to demonstrate proper operation.
11. Following successful SCADA system integrated field testing, the SCADA System including field sensors/transducers and instruments shall be running and fully operational for a continuous 48-hour period. The Operational Availability Demonstration specified below shall not begin until the continuous 48-hour integrated system test has been successfully completed.

4.0 – TABLES

Table 4.1 FACILITY AC ROOM SCADA ASSIGNMENT POINTS

WMATA reserves the right to add or remove points as necessary to provide a comprehensive remote monitoring and control system.

		AC ROOM SCADA ASSIGNMENT POINTS		Control			Status			
Equipment	**Item**	**Point description**	**Signal Type**		**OCC**	**SCADA SERVER**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
AC S/G Incoming Line (Typical QTY=2) Line 1- X=1 Line 2 X=2	1	COMM OK (MPR)	Ethernet					x	x	AC SWITCHGEAR MPR /DNP3 & IEC61850
	2	AC Incoming Line Primary Breaker No. X "Trip indication"	Hard Wired				x	x	x	
	3	AC Incoming Line Primary Breaker No. X "Closed Indication"	Hard Wired				x	x	x	
	4	AC Incoming Line Primary Breaker No. X "Open Control"	Ethernet							
	5	AC Incoming Line Primary Breaker No. X "Closed Control"	Ethernet							
	6	Bus No. X- 50/51 Phase A Time & Instantaneous Overcurrent	Ethernet					x	x	
	7	Bus No. X- 50/51 Phase B Time & Instantaneous Overcurrent	Ethernet					x	x	
	8	Bus No. X- 50/51 Phase C Time & Instantaneous Overcurrent	Ethernet					x	x	
	9	Bus No. X- 50N/51N Neutral Time & Instantaneous Overcurrent	Ethernet					x	x	
	10	Bus No. X- 27 Undervoltage	Ethernet				x	x	x	
	11	Bus No. X- 59 Overvoltage	Ethernet				x	x	x	
	12	AC Incoming Line Primary Breaker No. X -86 Lockout	Hard Wired				x	x	x	
	13	Primary Breaker No. X trip circuit availability / operability	Ethernet					x	x	
	14	Primary Breaker No. X trip circuit "open-circuit"	Ethernet					x	x	
	15	Primary Breaker No. X relay self-supervision fault "alarm"	Hard Wired				x	x	x	
	16	AC Incoming Line No. X Loss of Control Power	Ethernet				x	x	x	
	17	Local/Remote switch	Hard Wired`					x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control	Status

Equipment	Item	Point description	Signal Type		OCC	SCADA SERVER	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
AC S/G Incoming Line PQM (Typical QTY=2) Line 1- X=1 Line 2 X=2	1	COMM OK (PQM)	Ethernet					x	x	AC SWITCHGEAR PQM /DNP3 & IEC61850
	2	Incoming line No. X RMS current phase A	Ethernet					x	x	
	3	Incoming line No. X RMS current phase B	Ethernet					x	x	
	4	Incoming line No. X RMS current phase C	Ethernet					x	x	
	5	Incoming line No. X RMS current average	Ethernet					x	x	
	6	Incoming line No. X RMS residual current	Ethernet					x	x	
	7	Incoming line No. X RMS Voltage phase A	Ethernet					x	x	
	8	Incoming line No. X RMS Voltage phase B	Ethernet					x	x	
	9	Incoming line No. X RMS Voltage phase C	Ethernet					x	x	
	10	Incoming line No. X RMS Voltage average	Ethernet					x	x	
	11	Incoming line No. X RMS Voltage phase AB	Ethernet					x	x	
	12	Incoming line No. X RMS Voltage phase BC	Ethernet					x	x	
	13	Incoming line No. X RMS Voltage phase CA	Ethernet					x	x	
	14	Incoming line No. X kVA Total	Ethernet					x	x	
	15	Incoming line No. X kW Total	Ethernet					x	x	
	16	Incoming line No. X Instantaneous kW demand	Ethernet					x	x	
	17	Incoming line No. X kVAR Total	Ethernet					x	x	
	18	Incoming line No. X Power Factor	Ethernet					x	x	
	19	Incoming line No. X Frequency	Ethernet					x	x	
	20	Unbalance Values (I UNB)	Ethernet					x	x	
	21	Incoming line No. X kWh Delivered (Accumulators)	Ethernet					x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control			Status			
Equipment	Item	Point description	Signal Type		OCC	SCADA SERVER	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol

Transformer #1	1	COMM OK	Ethernet					x	x	TRANSFORMER IED (DNP3)
	2	Xformer TX 1 - Winding 1, 2, 3 OverTemperature - Alarm	Ethernet				x	x	x	
	3	Xformer TX 1 - Winding 1, 2, 3 OverTemperature - Trip	Ethernet				x	x	x	
	4	MV -480V Transformer TX1 – FAN ON	Ethernet					x	x	
	5	MV -480V Transformer TX1 - Winding No. 1 Temperature (degF)	Ethernet					x	x	
	6	MV -480V Transformer TX1 - Winding No. 2 Temperature (degF)	Ethernet					x	x	
	7	MV -480V Transformer TX1 - Winding No. 3 Temperature (degF)	Ethernet					x	x	
	8	MV -480V Transformer TX1 - Winding MAX Temperature (degF)	Ethernet					x	x	
Transformer #2	1	COMM OK	Ethernet					x	x	TRANSFORMER IED (DNP3)
	2	Xformer TX 2 - Winding 1, 2, 3 OverTemperature - Alarm	Ethernet				x	x	x	
	3	Xformer TX 2 - Winding 1, 2, 3 OverTemperature - Trip	Ethernet				x	x	x	
	4	MV -480V Transformer TX 2 – FAN ON	Ethernet					x	x	
	5	MV -480V Transformer TX 2 - Winding No. 1 Temperature (degF)	Ethernet					x	x	
	6	MV -480V Transformer TX 2 - Winding No. 2 Temperature (degF)	Ethernet					x	x	
	7	MV -480V Transformer TX 2 - Winding No. 3 Temperature (degF)	Ethernet					x	x	
	8	MV -480V Transformer TX 2 - Winding MAX Temperature (degF)	Ethernet					x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control			Status			
Equipment	**Item**	**Point description**	**Signal Type**		**OCC**	**SCADA SERVER**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**

LV SWG PLC #1 (HOT STANDBY PRIMARY)	1	COMM OK (SWG PLC-1)	Ethernet				x	x	x	LV SWITCHGEAR PLC-1 (DNP3, IEC61850 OR MODBUS)
	2	LV BUS TIE PLC Failure status	Hard Wired				x	x	x	
	3	Secondary Main Power CB No.1 "TRIPPED"'	Ethernet				x	x	x	
	4	Secondary Main Power CB No.1 "CLOSED"	Ethernet				x	x	x	
	5	Secondary Main Power CB No.2 "TRIPPED"'	Ethernet				x	x	x	
	6	Secondary Main Power CB No.2 "CLOSED"	Ethernet				x	x	x	
	7	Tie Breaker No.1 "TRIPPED"	Ethernet				x	x	x	
	8	Tie Breaker No.1 "CLOSED"	Ethernet				x	x	x	
	9	Tie Breaker No.2 "TRIPPED"	Ethernet				x	x	x	
	10	Tie Breaker No.2 "CLOSED"	Ethernet				x	x	x	
	11	PLC Alarm Log	Ethernet				x	x	x	
LV SWG PLC #2 (HOT STANDBY PRIMARY)	1	COMM OK (SWBD PLC)	Ethernet				x	x	x	LV SWITCHGEAR PLC-2 (DNP3, IEC61850 OR MODBUS)
	2	LV BUS TIE PLC Failure status	Hard Wired				x	x	x	
	3	Secondary Main Power CB No.1 "TRIPPED"'	Ethernet				x	x	x	
	4	Secondary Main Power CB No.1 "CLOSED"	Ethernet				x	x	x	
	5	Secondary Main Power CB No.2 "TRIPPED"'	Ethernet				x	x	x	
	6	Secondary Main Power CB No.2 "CLOSED"	Ethernet				x	x	x	
	7	Tie Breaker No.1 "TRIPPED"	Ethernet				x	x	x	
	8	Tie Breaker No.1 "CLOSED"	Ethernet				x	x	x	
	9	Tie Breaker No.2 "TRIPPED"	Ethernet				x	x	x	
	10	Tie Breaker No.2 "CLOSED"	Ethernet				x	x	x	
	11	PLC Alarm Log	Ethernet				x	x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control			Status			
Equipment	Item	Point description	Signal Type		OCC	SCADA SERVER	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
LVAC SWGR Secondary Main Power CB #1	1	COMM OK	Ethernet					x	x	GATEWAY #1 /DNP3
	2	Secondary Main Power CB No.1 Long Time Overcurrent Trip	Ethernet					x	x	
	3	Secondary Main Power CB No.1 Short Time Overcurrent Trip	Ethernet					x	x	
	4	Secondary Main Power CB No.1 Instantaneous Overcurrent Trip	Ethernet					x	x	
	5	Secondary Main Power CB No.1 Time-Coordinated Ground Fault	Ethernet					x	x	
	6	Secondary Main Power CB No. 1 - TRIPPED	Ethernet				-	x	x	
	7	Secondary Main Power CB No. 1 - "CLOSED"	Ethernet				-	x	x	
	8	Secondary Main Power CB No. 1 - RMS Current Phase A	Ethernet					x	x	
	9	Secondary Main Power CB No. 1 - RMS Current Phase B	Ethernet					x	x	
	10	Secondary Main Power CB No. 1 - RMS Current Phase C	Ethernet					x	x	
	11	Secondary Main Power CB No. 1- RMS Current Average	Ethernet					x	x	
	12	Secondary Main Power CB No. 1 - RMS L-L Voltage Phase AB	Ethernet					x	x	
	13	Secondary Main Power CB No. 1 - RMS L-L Voltage Phase BC	Ethernet					x	x	
	14	Secondary Main Power CB No. 1 - RMS L-L Voltage Phase CA	Ethernet					x	x	
	15	Secondary Main Power CB No. 1 - RMS L-L Voltage Average	Ethernet					x	x	
	16	Secondary Main Power CB No. 1 - RMS L-N Voltage Phase AN	Ethernet					x	x	
	17	Secondary Main Power CB No. 1 - RMS L-N Voltage Phase BN	Ethernet					x	x	
	18	Secondary Main Power CB No. 1 - RMS L-N Voltage Phase CN	Ethernet					x	x	
	19	Secondary Main Power CB No. 1 - RMS L-N Voltage Average	Ethernet					x	x	
	20	Secondary Main Power CB No. 1 - Total kW	Ethernet					x	x	
	21	Secondary Main Power CB No. 1 - Total kVA	Ethernet					x	x	
	22	Secondary Main Power CB No. 1 - Total PF	Ethernet					x	x	
	23	Secondary Main Power CB No. 1 - Average Peak kW demand	Ethernet					x	x	
	24	Secondary Main Power CB No. 1 - Average Present kW demand	Ethernet					x	x	
	25	Secondary Main Power CB No. 1 - Frequency "Hz"	Ethernet					x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control			Status			
Equipment	**Item**	**Point description**	**Signal Type**		**OCC**	**SCADA SERVER**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
LVAC SWGR Secondary Main Power CB #2	1	COMM OK	Ethernet					x	x	GATEWAY #2 /DNP3
	2	Secondary Main Power CB No.2 Long Time Overcurrent Trip	Ethernet					x	x	
	3	Secondary Main Power CB No.2 Short Time Overcurrent Trip	Ethernet					x	x	
	4	Secondary Main Power CB No.2 Instantaneous Overcurrent Trip	Ethernet					x	x	
	5	Secondary Main Power CB No.2 Time-Coordinated Ground Fault	Ethernet					x	x	
	6	Secondary Main Power CB No. 2 - TRIPPED	Ethernet				-	x	x	
	7	Secondary Main Power CB No. 2 - "CLOSED"	Ethernet				-	x	x	
	8	Secondary Main Power CB No. 2 - RMS Current Phase A	Ethernet					x	x	
	9	Secondary Main Power CB No. 2 - RMS Current Phase B	Ethernet					x	x	
	10	Secondary Main Power CB No. 2 - RMS Current Phase C	Ethernet					x	x	
	11	Secondary Main Power CB No. 2 - RMS Current Average	Ethernet					x	x	
	12	Secondary Main Power CB No. 2 - RMS L-L Voltage Phase AB	Ethernet					x	x	
	13	Secondary Main Power CB No. 2 - RMS L-L Voltage Phase BC	Ethernet					x	x	
	14	Secondary Main Power CB No. 2 - RMS L-L Voltage Phase CA	Ethernet					x	x	
	15	Secondary Main Power CB No. 2 - RMS L-L Voltage Average	Ethernet					x	x	
	16	Secondary Main Power CB No. 2 - RMS L-N Voltage Phase AN	Ethernet					x	x	
	17	Secondary Main Power CB No. 2 - RMS L-N Voltage Phase BN	Ethernet					x	x	
	18	Secondary Main Power CB No. 2 - RMS L-N Voltage Phase CN	Ethernet					x	x	
	19	Secondary Main Power CB No. 2 - RMS L-N Voltage Average	Ethernet					x	x	
	20	Secondary Main Power CB No. 2 - Total kW	Ethernet					x	x	
	21	Secondary Main Power CB No. 2 - Total kVA	Ethernet					x	x	
	22	Secondary Main Power CB No. 2 - Total PF	Ethernet					x	x	
	23	Secondary Main Power CB No. 2 - Average Peak kW demand	Ethernet					x	x	
	24	Secondary Main Power CB No. 2 - Average Present kW demand	Ethernet					x	x	
	25	Secondary Main Power CB No. 1 - Frequency "Hz"	Ethernet					x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control			Status			
Equipment	Item	Point description	Signal Type		OCC	SCADA SERVER	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
LVAC SWGR Tie Power CB #1	1	COMM OK	Ethernet					x	x	GATEWAY #1 /DNP3
	2	Tie Power CB No. 1 Long Time Overcurrent Trip	Ethernet					x	x	
	3	Tie Power CB No. 1 Short Time Overcurrent Trip	Ethernet					x	x	
	4	Tie Power CB No. 1 Instantaneous Overcurrent Trip	Ethernet					x	x	
	5	Tie Power CB No. 1 Time-Coordinated Ground Fault	Ethernet					x	x	
	6	Tie Power CB No. 1 - TRIPPED	Ethernet				-	x	x	
	7	Tie Power CB No. 1 - "CLOSED"	Ethernet				-	x	x	
	8	Tie Power CB No. 1 - RMS Current Phase A	Ethernet					x	x	
	9	Tie Power CB No. 1 - RMS Current Phase B	Ethernet					x	x	
	10	Tie Power CB No. 1 - RMS Current Phase C	Ethernet					x	x	
	11	Tie Power CB No. 1 - RMS Current Average	Ethernet					x	x	
	12	Tie Power CB No. 1 - RMS L-L Voltage Phase AB	Ethernet					x	x	
	13	Tie Power CB No. 1 - RMS L-L Voltage Phase BC	Ethernet					x	x	
	14	Tie Power CB No. 1 - RMS L-L Voltage Phase CA	Ethernet					x	x	
	15	Tie Power CB No. 1 - RMS L-L Voltage Average	Ethernet					x	x	
	16	Tie Power CB No. 1 - RMS L-N Voltage Phase AN	Ethernet					x	x	
	17	Tie Power CB No. 1 - RMS L-N Voltage Phase BN	Ethernet					x	x	
	18	Tie Power CB No. 1 - RMS L-N Voltage Phase CN	Ethernet					x	x	
	19	Tie Power CB No. 1 - RMS L-N Voltage Average	Ethernet					x	x	
	20	Tie Power CB No. 1 - Total kW	Ethernet					x	x	
	21	Tie Power CB No. 1 - Total kVA	Ethernet					x	x	
	22	Tie Power CB No. 1 - Total PF	Ethernet					x	x	
	23	Tie Power CB No. 1 - Average Peak kW demand	Ethernet					x	x	
	24	Tie Power CB No. 1 - Average Present kW demand	Ethernet					x	x	
	25	Tie Power CB No. 1 - Frequency "Hz"	Ethernet					x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control	Status

Equipment	Item	Point description	Signal Type		OCC	SCADA SERVER	OCC	SCADA SERVER	WEB Access	IED Type/ Protocol
LVAC SWGR Tie Power CB #2	1	COMM OK	Ethernet					x	x	GATEWAY #2 /DNP3
	2	Tie Power CB No. 2 Long Time Overcurrent Trip	Ethernet					x	x	
	3	Tie Power CB No. 2 Short Time Overcurrent Trip	Ethernet					x	x	
	4	Tie Power CB No. 2 Instantaneous Overcurrent Trip	Ethernet					x	x	
	5	Tie Power CB No. 2 Time-Coordinated Ground Fault	Ethernet					x	x	
	6	Tie Power CB No. 2 - TRIPPED	Ethernet				-	x	x	
	7	Tie Power CB No. 2 - "CLOSED"	Ethernet				-	x	x	
	8	Tie Power CB No. 2 - RMS Current Phase A	Ethernet					x	x	
	9	Tie Power CB No. 2 - RMS Current Phase B	Ethernet					x	x	
	10	Tie Power CB No. 2 - RMS Current Phase C	Ethernet					x	x	
	11	Tie Power CB No. 2 - RMS Current Average	Ethernet					x	x	
	12	Tie Power CB No. 2 - RMS L-L Voltage Phase AB	Ethernet					x	x	
	13	Tie Power CB No. 2 - RMS L-L Voltage Phase BC	Ethernet					x	x	
	14	Tie Power CB No. 2 - RMS L-L Voltage Phase CA	Ethernet					x	x	
	15	Tie Power CB No. 2 - RMS L-L Voltage Average	Ethernet					x	x	
	16	Tie Power CB No. 2 - RMS L-N Voltage Phase AN	Ethernet					x	x	
	17	Tie Power CB No. 2 - RMS L-N Voltage Phase BN	Ethernet					x	x	
	18	Tie Power CB No. 2 - RMS L-N Voltage Phase CN	Ethernet					x	x	
	19	Tie Power CB No. 2 - RMS L-N Voltage Average	Ethernet					x	x	
	20	Tie Power CB No. 2 - Total kW	Ethernet					x	x	
	21	Tie Power CB No. 2 - Total kVA	Ethernet					x	x	
	22	Tie Power CB No. 2 - Total PF	Ethernet					x	x	
	23	Tie Power CB No. 2 - Average Peak kW demand	Ethernet					x	x	
	24	Tie Power CB No. 2 - Average Present kW demand	Ethernet					x	x	
	25	Tie Power CB No. 2 - Frequency "Hz"	Ethernet					x	x	

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control			Status			
Equipmen	Ite	Point description	Signal		OCC	SCADA	OCC	SCADA	WEB	IED Type/

t	m		Type			SERVER		SERVER	Access	Protocol
LV SWBD Breakers	1	COMM OK	Ethernet					X	x	GATEWAY /DNP3
	2	Feeder Breaker No.X Long Time Overcurrent Trip	Ethernet					x	x	
	3	Feeder Breaker No.X Short Time/ Instantaneous Overcurrent Trip	Ethernet					x	x	
	4	Feeder Breaker No.X Time-Coordinated Ground Overcurrent Trip	Ethernet					x	x	
	5	Feeder Breaker No.X OPEN/CLOSED Status	Ethernet					x	x	
	6	Feeder Breaker No.X TRIPPED Unit Status	Ethernet					x	x	
		NOTES: 1. SWITCHBOARD BREAKERS RATED 150A OR HIGHER SHALL BE MONITORED 2. No. X IS EACH FEEDER BREAKER MONITORED								
UPS	1	COMM OK	Ethernet						x	UPS TO RTU FORM "C" CONTACTS
	2	Battery Charger NOR./IND	Hard Wired				x	x	x	
	3	Battery Charger ABN./IND	Hard Wired				x	x	x	
	4	Inv. Transfer SW Position NOR./IND	Hard Wired				x	x	x	
	5	Inv. Transfer SW Position ABN./IND	Hard Wired				x	x	x	
	6	Inverter Output NOR./IND	Hard Wired				x	x	x	
	7	Inverter Output ABN./IND	Hard Wired				x	x	x	
		NOTES: 1. LV HMIs ARE FACTORY INSTALLED ON SWITCHGEAR TO DISPLAY AND CONTROL LV MTTM (MTM). 2. THESE HMIs SHOW ONLY THE LV ONE-LINE DIAGRAM.								

		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		Control			Status			
Equipmen	Ite	Point description	Signal		OCC	SCADA	OCC	SCADA	WEB	IED Type/

t	m		Type			SERVER		SERVER	Access	Protocol
UPS	1	Input AC Voltage L-L, L-N for phase A	Ethernet					x	x	UPS Network Management Interface
	2	Input AC Voltage L-L, L-N for phase B	Ethernet					x	x	
	3	Input AC Voltage L-L, L-N for phase C	Ethernet					x	x	
	4	Input AC Current phase A	Ethernet					x	x	
	5	Input AC Current phase B	Ethernet					x	x	
	6	Input AC Current phase C	Ethernet					x	x	
	7	Input Frequency	Ethernet					x	x	
	8	DC bus Voltage	Ethernet					x	x	
	9	Output AC Voltage L-L, L-N for phase A	Ethernet					x	x	
	10	Output AC Voltage L-L, L-N for phase B	Ethernet					x	x	
	11	Output AC Voltage L-L, L-N for phase C	Ethernet					x	x	
	12	Output AC Current phase A	Ethernet					x	x	
	13	Output AC Current phase B	Ethernet					x	x	
	14	Output AC Current phase C	Ethernet					x	x	
	15	Output Frequency	Ethernet					x	x	
	16	Bypass AC Voltage L-L, L-N for phase A	Ethernet					x	x	
	17	Bypass AC Voltage L-L, L-N for phase B	Ethernet					x	x	
	18	Bypass AC Voltage L-L, L-N for phase C	Ethernet					x	x	
Battery Cycle Monitor (BCM)	1	COMM OK (BCM)	Ethernet					x	x	Battery Cycle Monitor (BCM)/Modbus
	2	Battery Float Voltage	Ethernet				x	x	x	
	3	Individual Cell Resistance	Ethernet						x	
	4	Individual Cell Voltage	Ethernet						x	
	5	Individual Intercell Resistance	Ethernet						x	
	6	Electrolyte Level (Optional)	Ethernet						x	
	7	String current (Charge/Discharge/Float)	Ethernet						x	
	8	Battery Failure alarm	Ethernet				x		x	
	9	Ripple Current (Optional)	Ethernet						x	
	10	Ambient Temperatures	Ethernet						x	
	11	Ground Fault Currents (Optional)	Ethernet						x	
	12	Battery Low Voltage Alarm	Ethernet					x	x	
	13	Common Alarms	Ethernet					x	x	
		AC ROOM SCADA ASSIGNMENT POINTS CONTINUED		**Control**			**Status**			
Equipment	**Item**	**Point description**	**Signal Type**		**OCC**	**SCADA SERVER**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
AC Room	1	Battery Room Exhaust Fan Normal	Hard Wired				x	x	x	Hard Wire to RTU

ANCILLARY	2	Battery Room Exhaust Fan Abnormal	Hard Wired				x	x	x	
	3	Battery Room Ambient Temperature (RTD quantity)	Hard Wired					x	x	
	4	EUH #26 Unit Heater Status	Hard Wired					x	x	
	5	EUH #26 Unit Heater HOA Selector switch status (Auto/Hand)	Hard Wired					x	x	
	6	RTU Local/ Remote (SUPV)	Hard Wired					x	x	
	7	Air Handler Unit (AHU) Status	Hard Wired					x	x	
	8	Roof Top Unit (RTU) Status	Hard Wired					x	x	
	9	AC Room Ambient Temperature	Hard Wired					x	x	
	10	Fare Collection Intrusion	Hard Wired				x	x	x	
	11	Fire Alarm	Hard Wired				x	x	x	
	12	Unauthorized Entrance Summary	Hard Wired				x	x	x	
	13	Fire Alarm Ancillary Structure	Hard Wired				x	x	x	
	14	Unauthorized Entrance Alarm Ancillary Structure	Hard Wired				x	x	x	
	15	HVAC Station 1 Filter ABN/IND	Hard Wired					x	x	
	16	HVAC Station 1 HOA Selector switch status (Auto/Hand)	Hard Wired					x	x	
	17									
	18									
	1									
	2									
	3									
	4									
	5									
	6									
	7									
	8									
	9									
	10									
	11									
	12									
	13									
		AC ROOM SCADA ASSIGNMENT POINT -LIGHTING		**Control**			**Status**			
Equipment	**Item**	**Point description**	**Signal Type**		**OCC**	**SCADA SERVER**	**OCC**	**SCADA SERVER**	**WEB Access**	**IED Type/ Protocol**
LIGHTING	1	Station North Site Security Lighting Control	Hard Wired			x				Hard Wired to RTU modules/
	2	Station North Site Security Lighting Status	Hard Wired				x	x		

	3	Station North Site Non-Security Lighting HOA selector switch status	Hard Wired				x	x		HOA is 3 wire switch
	4	Station North Site Non-Security Lighting Control	Hard Wired			x				
	5	Station North Site Non-Security Lighting Status	Hard Wired				x	x		
	6	Station North Site Non-Security Lighting HOA selector switch status	Hard Wired				x	x		
	7	Station Platform Normal Lighting Control	Hard Wired			x				
	8	Station Platform Normal Lighting Status	Hard Wired				x	x		
	9	Station Platform Normal Lighting HOA selector switch status	Hard Wired				x	x		
	10	Station Platform Emergency Lighting Control	Hard Wired			x				
	11	Station Platform Emergency Lighting Status	Hard Wired				x	x		
	12	Station Platform Emergency Lighting HOA selector switch status	Hard Wired				x	x		
	13	Station Ground Normal Lighting Control	Hard Wired			x				
	14	Station Ground Normal Lighting Status	Hard Wired				x	x		
	15	Station Ground Normal Lighting HOA selector switch status	Hard Wired				x	x		
	16	Station Ground Emergency Lighting Control	Hard Wired			x				
	17	Station Ground Emergency Lighting Status	Hard Wired				x	x		
	18	Station Ground Emergency Lighting HOA selector switch status	Hard Wired				x	x		
	19	Station Mezzanine Normal Lighting Control	Hard Wired			x				
	20	Station Mezzanine Normal Lighting Status	Hard Wired				x	x		
	21	Station Mezzanine Normal Lighting HOA selector switch status	Hard Wired				x	x		
	22	Station Mezzanine Emergency Lighting Control	Hard Wired			x				
	23	Station Mezzanine Emergency Lighting Status	Hard Wired				x	x		
	24	Station Mezzanine Emergency Lighting HOA selector switch status	Hard Wired				x	x		
	25									

END OF SECTION

SECTION 28 40 01

SCADA SYSTEMS TRAINING

PART 1 – GENERAL

1.01 SUMMARY

A. This section specifies requirements for training of Authority personnel.

B. Training shall be conducted according to the following:
   1. Operations and maintenance (O&M) training, to include preventive maintenance instructions (PMI) and corrective maintenance and adjustment of all equipment in its anticipated installed environment.
   2. Engineering and technician training, for performing reliability-oriented inspection, maintenance, diagnostic tests, calibration, trouble-shooting and repair of electrical SCADA systems devices and equipment classes in accordance with applicable IEEE, ANSI, ASTM standards and applicable INETA test procedures. Engineering and technician training shall include training in utilization of diagnostic test equipment, Software tools and Applications in conjunction with appropriate test, simulators, measurement hardware to calibrate and test the operation of SCADA devices, Intelligent Electronic Devices (IED), microprocessor based systems and computer provided for monitoring and control.
   3. Engineering training shall include a complete configuration of each type of RTU, monitoring and control devices provided under this contract.
   4. Training aids shall be liberally employed where helpful to illustrate the devices and principles being described. Charts, transparencies and slides shall become the property of WMATA at the conclusion of the presentation of each course, the contractor's instructor shall cooperate with the WMATA in the videotaping of the course presentations.

1.01 SUBMITTALS

A. O&M training: Submit five copies of training course descriptions and syllabus, training plan, instructor’s guide, recommended class size, course provider’s qualifications and instructors’ resumes 2 months prior to commencement of training for Authority approval.

B. Engineering and test technician training:
   1. Submit electronic copy of training course descriptions and syllabus, training plan, instructor's guide, recommended class size, course provider's qualifications 2 months prior to commencement of training for the Authority's approval.
   2. Submit for approval plans, equipment lists, software, documentations relating to signal and wave form generators, metering and signal measuring equipment necessary to simulate and view input/outputs for the duration of the trainings.
   3. Submit the course length required for each of the engineering training.

1.03 QUALITY ASSURANCE

A. Standards: applicable industry standards of IEEE, ANSI, ASTM, and INETA (Inter National Electrical Testing Association).

B. Training shall be provided for each type of SCADA system equipment and device provided as part of the complete SCADA system.

C. Training, Course Provider and Instructor Qualifications:
   1. The course instructors shall have prior experience in providing trainings or instructions for the utility or industrial, setups, in the fields of power systems, control system, instrumentations, communications systems or IT and networking as they apply to the selected course:
   2. Preferred providers are:
      a. SCADA system equipment and devices manufacturers or their approved training companies.
      b. SCADA system integrator.

1.04 TRAINING SCOPE OF WORK

A. Training of SCADA System Engineers and maintainers in the design, operation and maintenance of the SCADA system equipment and devices shall be provided by the contractor for any new SCADA products and as a refresher course for both new and existing personnel.

B. The courses shall cover all aspects of the SCADA equipment and device design sufficient for the engineers and the maintainers to maintain the SCADA system over its design life. Contents shall include but not limited to the following:
   1. Development of Configuration file for each type of equipment and device.
   2. Operation and data communications protocols for each equipment and device.

3. Diagnostic tools provided with the each type of equipment and device.
4. Test equipment and or simulator provided with each type of each equipment and device.
5. Failure modes of each type equipment and device.
6. Configuration of each type of equipment or device.

C. The training courses shall be broken into individual days. Depending upon the availability of staff to attend, the courses may be conducted on single days or multiple days, with multiple days not necessarily being consecutive days. The contractor shall advise the period of notice required to be given for any training courses.

D. The contract shall provide training on the following SCADA system equipment and devices:
   1. Remote Terminal Unit (RTU)
   2. Human Machine Interface (HMI)
   3. Distributed Input Output Modules (DIO)
   4. Programmable Logic Controllers (PLC) (as applicable)
   5. Protective Relay
   6. Digital Trace Recorder (DTR)
   7. Transformer Monitor
   8. Rectifier IED
   9. Power Quality and Digital Power Meter.
   10. Any programmable devices provided as part of the SCADA monitoring system.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Original reproducible training material, shall be developed as specified herein. Training should be conducted using final manuals approved by the Authority and certified by the Contractor as being correct and conforming to as-manufactured, as-installed (and where appropriate, as-built and as-adjusted) conditions. Manuals shall become the property of the Authority at the end of program.

B. O&M Training Materials
   1. The following training materials for the course shall be developed:
      a. Instructor material: Instructor Guides, Student Manuals, and Power Point Presentations shall be created on each piece of installed equipment with the intention guiding the instructor provide detailed instruction with respect of maintenance of the equipment.

b. Instructor Guides: The instructor guide for the course shall include:
   1) Table of contents listing each topic and the time allotted.
   2) List of applicable documents.
   3) List of training materials.
   4) Course learning objectives including course length and recommended number of students.
   5) Course Outline.
   6) Lesson Plans.
   7) Each topic with a cover sheet listing topic, objective, time allotted, and training aids required.
   8) Copy of the Student Manual.
   9) Copy of the Power Point Presentations on CD in sleeve.

c. Student Manual: A student manual shall be created for each piece of installed equipment for the purpose of providing in-depth maintenance and troubleshooting information to the maintenance employees. The manuals shall each include theory of operation, detailed electrical and mechanical schematics and useful troubleshooting and maintenance information. The student manuals shall contain all of the supporting documents and information referenced in the Instructor Guides. A copy of the Student Manuals shall be provided to each student enrolled in the training.

d. Power Point Presentations: Power Point Presentations shall be made for each piece of installed equipment in line with the curriculum outlined in the Instructor Guide. Presentations shall be designed to accomplish the stated learning objectives on each piece of equipment when used in conjunction with the Student Manuals.

e. Course outline: A course outline with measurable learning objectives shall be provided. The course outline shall provide a topic outline for each item of equipment. Maintenance training shall include a section devoted to system fault analysis and trouble-shooting. The learning objectives shall be stated for each topic.

f. Lesson plans: A set of lesson plans shall be developed for each item of equipment corresponding to the topic outline and shall contain the following information: Lesson title, instruction time, objectives, training aids required, instructing sequence (outline), tests, and summary.

g. Training Aids: Power Point Presentations, impregnated with animated schematics or video clips, are required for any equipment which requires theoretical discussion. An Authority-approved substitute may be used after

permission from the authority is obtained in writing. Additionally, all mock-ups become the property of the Authority. All training aids shall be provided in an Authority specified electronic file format, the electronic files shall be provided to the Authority. Any drawings needed for the course of instruction shall be provided to the Authority in an Authority specified electronic file format.

h. Instructional material: The primary source of instructional material shall be the applicable equipment operation and maintenance manuals, as-built equipment drawings and as-built power and control circuit schematic drawings, and the student manuals developed from said references. The Contractor shall develop student manuals for each piece of installed equipment containing such additional drawings, descriptive information and procedures necessary to ensure that all learning objectives are met in an orderly and timely manner. Student Manual Material shall be arranged to coordinate with the Instructor Guides written order of instruction outline.

C. Engineer Training Materials

1. Engineer Training Materials shall include requirements listed in the O&M Training Material section.
2. Student Manual shall include all materials necessary for student interaction in the learning process as outlined by the Instructor's Guide. It will include theory of operation, ladder logics, flow diagrams and any SCADA schematics and useful troubleshooting and maintenance information. The student manuals will contain all of the supporting documents and information referenced in the Instructor Guides, and may serve as a field reference at the conclusion of the course. A copy of the Student manual shall be provided to each participant enrolled in training classes and three copies shall be provided to OPERATION TRAINING for archival purposes. It shall contain, at a minimum:
    a. Program Overview / Introduction
    b. Statement of overall course goals
    c. Learning Objectives, stated in measurable terms that describe desired skills or knowledge to be obtained.
    d. Prose treatment, not outline format, of a fully developed content presentation, developed in the same modular format as the instructor's guide.
    e. Illustrations, charts, graphics and duplication of visual aids used during the course presentation in order to enhance content presentation and provide a course reference during later field use.
    f. Applicable Electronic and Mechanical Schematics.

g. A Problems or Frequently Asked Questions section related to lesson content, as appropriate.

2.02 O&M COURSE OF INSTRUCTION:

A. The course of instruction shall be developed and conducted by the Contractor to those individuals designated by the Authority. It shall consist of in-depth instruction on the fundamentals involved in the design of the complete system combined with practical aspects of operation, troubleshooting, and maintenance of each individual type of installed equipment. It shall also include the following:

1. Practical exercises that require the trainees to make use of the operation and maintenance manuals and parts identifiers.
2. Familiarization with the assembly, subassembly and components that make up a total system. This part of the course shall include instruction and practical exercises in trouble-shooting at a level higher than that performed by equipment operators.
3. Use and replacement of original assemblies, subassemblies and components with compatible assemblies, subassemblies and components manufactured by others where applicable.
4. The course shall include preventive maintenance operations on the equipment and hands-on trouble-shooting of all installed subsystems.
5. Handouts to all trainees that include information drawings, shop drawings, catalog cuts, manufacturer's literature, and equipment maintenance check lists and other literature describing the total system.
6. Power Point Presentations showing system installation, operation, trouble-shooting, maintenance, module removal and replacement.
7. Tools and test equipment necessary to conduct operation and equipment maintenance and trouble-shooting.

B. Supplemental Training: In the event the Contractor changes or performs modifications to the equipment subsequent to the training that impact form, fit and/or function, the Contractor shall provide supplementary training to the Authority's training instructors on a one-time basis.

2.03 SCADA TECHNICIAN COURSE OF INSTRUCTION

A. The course of instruction shall be developed and conducted by the contractor or the contractor's approved representative to those individuals designated by the Authority. It shall consist of in-depth instruction of the fundamentals involved in the design of the complete SCADA system combined with practical aspects of operation, maintenance, testing and calibration. In addition to the O&M Training, the SCADA Technician training shall be expanded to include installation,

programming and testing of equipment and devices provided under the pertinent specification. At the conclusion of the course the students should be able to:

1. Recognize and correct IED, RTU operating problems, program IEDs and RTUs.
2. Obtain measurements on operating AC and DC switchgear using laptop PC based measurement software and associated hardware.
3. Setup ED devices; retrieve store data using laptop PC based software.
4. Understand communication protocol and system integration for SCACA and remote monitoring.
5. Instruction shall include practical exercises that require the trainees to make use of software provided for each type of IED to program, access, retrieve and manipulate settings.
6. Familiarization with the assembly, subassembly and components that make up a total traction power system, Tie Breaker System and Passenger Station system.
7. Familiarization with the provided protocol simulator and communication analysis software for troubleshooting communication issues.
8. Handouts to all trainees that include information drawings, shop drawings, catalog cuts, manufacturer's literature, equipment maintenance and calibration check lists, parts lists and other literature describing the total system
9. Power Point Presentations, potentially impregnated with video clips, showing system installation, operation, trouble-shooting, maintenance, module removal and replacement
10. Recommended tools and test equipment necessary to conduct operation and equipment maintenance trouble-shooting both in the field and at the bench.

2.04 SCADA ENGINEER CONCEPT OF TRAINING

A. Provide on the Owner's premises, for SCADA engineering personnel, courses of classroom and hands-on instruction in the operation of the SCADA system, the programming of the Remote Terminal Units (RTU), MV Protective Relays (MPR), Power Quality Meter (PQM), Human Machine Interface (HMI), and other Intelligent Electronic Devices (IED) installed as part of the SCADA system. The presentation of the course shall accommodate the number of engineers specified in part 3.

1. This instruction shall cover all aspects of the programming, operating and maintenance of the SCADA equipment and devices installed as part of the SCADA system. It shall include, but not be limited to the following:
    a. Programming Techniques.
    b. Setting and Erasing Memory Devices.
    c. Locating Defective Board Components.

d. System Operation.
e. Trouble Shooting.
f. Diagnostic Routines.
g. Maintenance Procedures.

2. Classroom instruction shall be designed to cover, in detail, the following procedures and design criteria:
   a. Development of RTU configuration file for a typical AC and traction power systems.
   b. Development of HMI configuration files for a typical AC and traction power systems.
   c. Development of DIO configuration files for a typical breaker.
   d. Programming, calibration and testing of DTR.
   e. Programming, calibration and testing of AC, PQM and DC Microprocessor based relays.
   f. Programming and testing of PLC (as applicable).
   g. Programming, calibration and testing of all other type of IEDs provided.
3. At the conclusion of the course, the engineers should be able to:
   a. Recognize and correct IED, RTU operating problems, program IEDs and RTU.
   b. Obtain measurements on operating AC and DC switchgear using laptop PC based measurement software and associated hardware.
   c. Setup IEDs, retrieve store data using laptop PC based provided software.
   d. Understand communication protocol and system integration for SCACA and remote monitoring.
   e. Program AC/DC MPRs
   f. Program Rectifier IEDs
   g. Develop HMI screens for control and monitoring.
4. Training courses shall be conducted on Authority property. Necessary training material, mockups/simulator, IEDs and contractor-supplied test equipment may be shipped to and stored at the training facility in coordination with the Authority.

2.05 O&M TRAINING EQUIPMENT

A. Installed equipment shall be used in the course of instruction.

B. Training shall include practical exercises that permit the trainees to perform hands-on work using installed equipment under normal operating conditions.

C. Training equipment: Any special tools required for maintenance training shall be supplied by the Contractor and delivered to the SCADA engineering after completion of the course.

D. Test equipment: Test equipment required for maintenance training shall be supplied by the Contractor and delivered to the SCADA engineering after completion of the course.

2.06 ENGINEERING AND TECHNICIAN TRAINING EQUIPMENT

A. The contractor shall provide the following equipment and devices for the engineer and technician training. The material provided under the scope of this work shall become property of WMATA and shall be shipped to the SCADA Lab for future refresher courses.

1. RTU System with the following component mounted on an open rack
    a. Data Concentrator
    b. One Digital Input Module
    c. One Analog Input Module
    d. One Digital Output Module.
    e. 125VAC to 24V DC power supply
    f. One Industrial Computer.
    g. One Display Monitor.
2. One AC Relay
3. One DC Relay.
4. One Power Quality Meter
5. One Digital Power Meter
6. One PLC
7. One set of Rectifier Monitoring IEDs
8. One Transformer Monitor IED.
9. One DTR Digital and Analog input module or system.

B. Training shall include practical exercises that permit the trainees to perform hands-on work using contractor-supplied equipment.

C. Any specialized tools, laptop/notebook computers specified in the contract, device application software, equipment configuration files, connection and interface devices required for training shall be supplied by the contractor.

PART 3 – EXECUTION

3.01 RTU SYSTEM TRAINING

A. OPERATION AND MAINTENANCE TRAINING:

1. Operation and Maintenance Training is required. Training shall be based on training format in this specification.
2. Instructional Period: Three sessions, one day per session.

B. TRAINING OF SCADA TECHNICIAN:

1. Instruction Period: Three sessions, One day per session.
2. The training courses shall be broken into individual days. Each course session shall cover different topics with the three sessions not necessarily being consecutive days.

C. ENGINEERS' TRAINING COURSE:

1. Instruction Period: Refer to SCADA TRAINING SUMMARY TABLE

SCADA TRAINING SUMMARY TABLE

Course Title		Course Length	Class size (in persons)	Number of Courses	Total number of course hours per person per class
O&M Training		8 hours	12	3	24
SCADA Technician Training		8 hours	12	3	24
Engineering Training	RTU	24 hours	10	1	24
	HMI	16 hours	10	2	32
	DTR	8 hours	10	1	8
	DIO	8 hours	10	1	8

END OF SECTION

SECTION 28 40 02

REMOTE TERMINAL UNIT (RTU) FOR POWER SCADA SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. This section provides requirements for vendors who will design, manufacture, supply, install and configure Remote Terminal Units (RTU) required for Supervisory Control and Data Acquisition (SCADA).

B. The specification also defines requirements for Remote Terminal Unit, establishes functional and performance requirements for selection and system design of RTUs to be incorporated into the WMATA electrical SCADA network.

C. This specification applies to all RTU equipment, RTU cabinet, accessories, power distribution and associated software required to remotely control and monitor a substation/ part of substation or any related equipment.

D. This specification excludes Network switches and radio modems that are covered by other existing specification documents.

E. This specification is applicable to all new SCADA system RTU and to those that are replacing existing RTUs.

F. The RTU interfaces to the electrical, mechanical equipment and devices in a passenger station, TBS, TPSS and monitor the status of the system via digital and analogue inputs. This data is transferred to the master stations located at the Carmen Turner Facility (CTF) and Jackson Graham Building (JGB) using DNP3 communication protocol over fiber optics cable.

G. The provided RTU shall be capable of working with the following relevant DNP3, Modbus and IEC 61850 family of protocols for direct data transmission through permanent direct links with devices in substations and DNP3 protocol for data transmission between RTU and Master Stations through TCP/IP.

H. Provide at the time of bid, a certificate from an independent testing company that the RTU software IEC61850 stack has been tested and has not shown to be non-conforming to IEC 61850 communication networks and systems in substation.

I. RTU provided shall be configured as a Data Concentrator where the RTU manages the communications and polling regimes to other remote devices. The SCADA masters communicate with only the data concentrator. The data concentrator acts an intermediate between the master stations and the end devices.

J. In addition, an industrial computer is provided with the RTU to run the Human Machine Interface (HMI) software, the Digital Trace Recorder (DTR) and other application software.

K. Related Sections:
   1. Section 28 40 00 – SCADA Work for Traction Power Systems
   2. Section 28 40 01 – SCADA Systems Training
   3. Section 28 40 08 - Wire, Cable, Cable Tray and Termination Panel for SCADA System
   4. Section 28 40 07 - Human Machine Interface for Traction Power SCADA systems
   5. Section 28 40 03 - DC Digital Trace Recorder
   6. Section 28 40 04 – Network Switch for SCADA and Automation Systems
   7. Section 28 40 05 – DIO for New Traction Power Switchgear.
   8. Section 28 40 05.1 – DIO for Retrofitted Traction Power Switchgear.
   9. Section 28 40 06 - SCADA Systems Integration Testing and Documentation for TPSS & TBS.
   10. Section 28 40 06.1 - SCADA Systems Integration Testing and Documentation for AC Rooms.

L. Design Standards
   1. The RTUs shall be designed in accordance with applicable International Electro-Technical Commission (IEC), Institute of Electrical and Electronics Engineer (IEEE), American National Standards Institute (ANSI), and National Equipment Manufacturers association (NEMA) standards, unless otherwise specified in this Technical specification. In all cases the provisions of the latest edition or revision of the applicable standards in effect shall apply.
   2. The RTU shall be designed around microprocessor technology. For easy maintenance the architecture shall support pluggable modules on backplane. The field wiring shall be terminated such that these are easily detachable from the I/O module.

M. Operating Requirements
   1. Designed for continuous, unattended operation to perform:
      a. Analog, digital and pulse data acquisition.
      b. Digital control.

N. Power Requirements
   1. 120 Volts AC power for RTU light and receptacle.
   2. 125 Volts DC for Data Concentrator, Modules and Computer

1.02 REFERENCES

A. Code, Regulations, Reference Standards and Specifications
   1. Code and Regulation of jurisdictional authorities
   2. NEC
   3. NEMA 250, ICS-6, WC8, 12
   4. ANSI C37.90, Z55.1, C12
   5. EIA: RS 232.C
   6. ASTM: B138
   7. ASHRAE/ANSI : 135P
   8. ICEA: S-68-516

1.03 Acronyms and Abbreviations

RTU	Remote terminal unit
IED	Intelligent Electronic Devices
DTR	Digital Trace Recorder
DIO	Distributed Input Output
PAC	Point Assignment Charts
OPC	Object Linking and Embedding for Process Control
SOE	sequence of events

1.04 QUALITY ASSURANCE

A. RTU shall be of proven design and suited for SCADA applications in electrical and Traction power and Electric power systems.

B. The RTU point mapping shall comply in every respect with the RTU Point Assignment Charts (PAC) in section 28 40 00 (16051D) and of any supplements thereto that become effective before this Contract is awarded.

C. The Contractor shall certify that the entire microprocessor system type being furnished under this contract has been tested to successfully operate in high electric background noise environment. The system shall comply with the requirements of with IEEE C37.90.1.

D. The RTU and all associated equipment/devices including communications equipment installed inside the RTU cabinet shall operate continuously without damage, mis-operation, or data corruption under the environmental conditions of –40 degrees F to 160 degrees F and humidity levels of 5% to 95%, noncondensing, without the need of any external environment controls.

E. No failure of any component of the RTU shall cause the system to falsely or erroneously maintain for any reason a trip state of equipment.

F. No software or hardware locking mechanisms that restrict the user from copying the application software source code or compiled executable code from the storage media shall be employed.

G. The RTU shall be designed and configured to communicate with Master Stations using DNP3 protocol.

H. The RTUs shall be designed in accordance with applicable Institute of Electrical and Electronics Engineer (IEEE), American National Standards Institute (ANSI), and National Equipment Manufacturers association (NEMA), International Electro-technical Commission (IEC) standards, unless otherwise specified in this Technical specification. In all cases the provisions of the latest edition or revision of the applicable standards in effect shall apply.

I. The RTU vendor shall guarantee to support all system hardware, firmware, and software with spare parts and services for a period of ten (10) years from the system delivery date or as defined in the contract or purchase order for all proprietary components and software; and a period of five (5) years for all commercial off-the-shelf products and software supplied as part of the RTU system. This support shall not be contingent on the customer upgrading to later releases of software or hardware unless this upgrade is supplied at no additional cost.

1.05 SUBMITTALS:

A. General: Refer to Division 1 for Shop Drawings, Product Data, and Samples submittal requirements and procedures.

B. Provide at the time of bid, a certificate from an independent testing company that the RTU software IEC61850 stack has been tested and has not shown to be non-conforming to IEC 61850 communication networks and systems in substation.

C. Submit the following drawings, data, and procedures for approval prior to furnishing and installing the equipment:

1. Complete system data flow and software architecture diagrams for all modules of the system and all interfaces to the system.
2. Complete circuit drawings and systems diagrams, in a manner as hereinafter specified, for all system and subsystem interfaces, including interconnections of all hardware to the system.
3. Complete power distribution circuit drawings and schematics, as hereinafter specified.
4. Complete input and output modules wiring drawings.
5. Complete rack layout and arrangement plans.
6. Complete equipment plans and installation drawings showing all components of the system. These drawings shall include complete keyed parts lists for all components of the system, racks, terminal boards, plug connectors, cable boots, mounting hardware, and all other rack mounted equipment and hardware.
7. All physical dimensions and measurements shall be identified in both the “International System of Units” (SI), as well as by conventional “English” units. Non-critical dimensions may be rounded off to the nearest practical value.
8. Drawings showing details of interconnecting cables, plug couplers, terminal boards, and other interconnecting devices complete with keyed parts lists and cable assembly instructions.
9. The following standard documents shall be provided as part of the RTU documentation package: installation, operating instructions, maintenance instructions, test records, complete schematics/logic diagrams, and the RTU application software.
10. Electronic documentation shall be supplied with the RTU. The document management system shall include graphics, and text string search.
11. Complete predicted Reliability and Maintainability calculations. Actual performance data for a like system for which reliability records have been maintained for a period of not less than three (3) years, may be used to support or substantiate the submitted predicted calculations.
12. Complete power calculations for all power sources energizing the controllers. Where manufacturer's specific ripple or regulation specifications exist for the controllers or associated equipment relying upon these power sources, compliance with such ripple or regulation specifications shall be demonstrated to the satisfaction of the Engineer.
13. Factory Test Procedures designed to demonstrate that the manufactured system will be tested to verify that it performs all functions in accordance with these specifications, section 28 40 06 (16606) and in accordance with the approved plans.
14. Subsequent to Factory Testing, certified factory test reports.

15. Complete and comprehensive Installation and Inspection Procedures.
16. Field Test Procedures in accordance with the testing section of these Specifications to verify that the installed system meets all safety and operational requirements of these Specifications, section 28 40 06 (16606) and that it has been installed in accordance with the final approved plans.
17. Field Test Reports complete with data results.
18. End to End Test Procedures in accordance with the testing section of these Specifications to verify that the installed system meets all safety and operational requirements of these Specifications, section 28 40 06 (16606) and that it has been installed in accordance with the final approved plans.
19. The Contractor shall provide on electronic media six weeks prior to the start of any factory acceptance testing a complete sets of application, service, and development system manuals, including manuals covering all software and hardware provided as part of the application software development system required as part of this Contract.
20. Submit as-built drawings of all the works done under this specification for approval.
21. Operation and maintenance (O & M) manuals (Refer to 28 40 00 (16051D))
22. Preventive Maintenance Instructions (Refer to 28 40 00 (16051D))
23. Spare Parts:
    a. Recommended spare parts shall be detailed and listed for each RTU.
    b. Unit prices shall be supplied.
    c. The list shall include the following:
    d. Item identification
    e. Recommended spares quantities
    f. Base price
    g. Spare Part Quantity: 20%
24. Certification:
    a. Certified test results for the specified tests on the Remote Terminal Unit or provide certified test reports on identical unit.
    b. Certificates from manufacturers verifying that equipment conforms to the specified requirements.
    c. Certificate for IEC 61850 compliance.

1.06 CLOSEOUT SUBMITTALS:

A. Software and Firmware Operational Documentation:

1. Program Software Backup: On electronic media or compact complete with data files.
2. All configuration files shall be in their native format and will become the property of

WMATA.

3. This shall not include any copyright or license terms that require permissions from the vendor for modifications to the files.
4. Device address list.
5. Printout of software application and graphic screens.

B. As-Built Documents: Prior to Substantial Completion develop as-built documents as follows:

1. Submit three (3) sets of approved as built drawings in both printed hard copies and digital copies on approved medium.
2. 11-inch by 17-inch printed copies of the interconnection wiring diagrams applicable to the specific location and or equipment shall additionally be provided in sufficient copies, laminated if required, to be stored in each RTU interface cabinet door pocket.
3. Approved copies of each submittal.
4. Provide As-built drawing in both AutoCAD and PDF formats on CD in sleeves.

1.07 TRAINING:

A. Refer to Section 28 40 01 (16053D) –SCADA systems Training.

1.08 DELIVERY, STORAGE, AND HANDLING

A. The Supplier shall deliver RTUs to the address as indicated in the schedules. Full street address shall be confirmed at time of shipping.

B. RTUs shall be suitably packed to prevent damage during loading, unloading and transport. Equipment sub-assembly which could get damaged due to vibration shall be removed from assembly & packed separately for transport.

C. Each RTU and associated equipment shall be labelled as specified in the contract.

PART 2 – PRODUCTS

2.01 GENERAL:

A. The following are acceptable RTU manufacturers or an approved equal. The proposed equipment shall meet all the requirements in this specification.

1. Schweitzer Engineering Laboratories (SEL)
2. Novatech

B. RTU FUNCTIONS

All functional capability described herein shall be provided by the Contractor even if a function is not initially implemented. As a minimum, the RTUs shall be capable of performing the following functions:

1. Collecting and processing the digital status inputs, analog inputs, accumulated values and transmitting to at least four master stations.
2. Receiving and processing digital & analog control commands from at least four master stations.
3. Accepting polling messages from at least four master stations simultaneously using separate logical databases for each master station.
4. Application software shall be backward compatible and shall be able to run the same features under new releases of the system operating software.
5. Communication simultaneously on all Communication ports and using multiple concurrent protocols, including but not limited to the DNP3, IEC 61850 and MODBUS protocols.
6. Data transmission rates from 150 to 56,600 baud for serial ports for both DNP3 and MODBUS, 10/100base T (X) and 100baseFX for TCP/IP Ethernet ports.
7. RTU shall be compatible with various communication protocols including but not limited to DNP3, 61850 and Modbus to communicate with IEDs.
8. RTU shall be capable of simultaneously communicating with at least 50 DNP3 and 50 IEC 61850 devices. Contractor will need to demonstrate that RTU can actually communicate with the devices without degradation of performance.
9. RTU shall be capable of simultaneously communicating with at least 10 Modbus device types.
10. RTU shall have the capability of automatic start-up and initialization following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected master stations.
11.
12. RTU shall support time synchronization through messages received from master station using DNP3 protocol.
13. RTU shall support downloading of RTU database from the master station using the DNP3 protocol.
14. RTU shall support SOE (Sequence of events) feature
15. Acting as a data concentrator for acquiring data from IEDs and exercising supervisory control on end devices using DNP3, IEC 61850 and Modbus protocol.
16. RTU shall include at least 10 RS-485 and 4 RS232 connection ports available and integrated to the RTU.

17. Mandatory to guard the data/ equipment from intrusion/damage/breach of security & shall have SSL/VPN based security,
18. Shall have SNMP

C. COMPUTER FUNCTIONS

1. An industrial computer described in this specification shall be provided and installed in the RTU cabinet by the Contractor. The computer shall be used to run multiple applications including Digital Trace Recorder (DTR), the Human Machine Interface (HMI) and other applications.
2. The RTU manufacturer's SCOPE OF WORK shall only include provision and installation of the computer.
3. The system integrator or the manufacturer of the DTR and the HMI systems are responsible for the installation and integration of their systems software.

D. RTU SIZE AND EXPANDABILITY

1. RTU shall be equipped for the hardwire point counts defined in Table 1 (Basic+20% spare (wired & hardware). It shall be possible to expand the RTU capability for additional 100% of the basic point counts by way of addition of hardware such as modules, racks, panels; however, RTU software and database shall be sized to accommodate such growth without requiring software or database regeneration.
2. It should be noted that any expansion in point count, quantity of IEDs shall require no further licensing.

TABLE 1: RTU CONNECTION POINT REQUIREMENTS

RTU TYPE	**Control Points**		**Status Points**	**Analog Points**		**Accum Points**
	Momentary	**Latching**		**0-1mA**	**4-20mA**	
ALL RTUs	8	8	24	16	16	8

E. Auxiliary contacts, modules and data interfaces added to equipment specified in other sections are to be provided by the particular equipment manufacturer or coordinated with the particular equipment manufacturer so as not to void any warranties.

2.02 REMOTE TERMINAL UNIT

A. RTU System Design

1. The RTU shall be designed to work in a HV traction power substation and Electrical Stations by being of robust physical construction with immunity to electrical noise.
2. The RTU shall be assembled from modular units and shall be able to be arranged on the RTU rack in any order.
3. Modules shall be interconnected via a suitably robust plug and socket method. It shall not be necessary to unscrew individual wires/cables, internal RTU wiring and I/O wiring, to replace faulty modules. The failure of one module shall not affect the performance of any other module.
4. The RTU and the cubicles shall be designed to accommodate the actual number of input/outputs and IEDs at the specific substation, plus spare capacity.
5. Minimum RTU I/O quantities shall be developed in accordance with requirements specified in Table 1.
6. RTU shall be designed to interface directly and indirectly with electrical equipment and protection systems and other devices within the electrical and traction supply power distribution networks.
    a. Direct interface is via wiring directly from digital and analogue sensors located within the substation equipment to the RTU, and from relay outputs within the RTU to equipment panels in the substation.
    b. Indirect interface is via local network switches between the RTU and the IEDs in the substation.
7. RTU Architecture:
    1. TPSS and TBS RTU Architecture:
        a. Distributed RTU design is used where distributed I/O modules are housed in respective switchgear cubicles. All these distributed I/O modules are connected to a central processor in the RTU for further communication with master stations.
    2. Combined AC Rooms
        a. One centralized RTU is used where the data concentrator and all I/O modules are housed in the RTU cabinet and communicating with master stations through communication ports.
    3. In Separated AC Rooms:
        a. AC Room #1: One centralized RTU is used where the data concentrator and all I/O modules are housed in the RTU cabinet

and communicating with master station through communication port. This RTU also polls all information from the satellite RTU located in the AC room #2.

b. In AC Room #2: One satellite RTU is used where I/O modules are housed in a RTU panels and this RTU communicates with the main RTU located in AC room #1.

8. RTU shall be configured using WMATA point assignment chart templates to ensure compatibility with master stations.
9. RTU to master station communication protocols shall be DNP3 Level 2 which incorporates functionality and security.
10. The substation computer shall be provided and installed by the RTU manufacturer.
11. The computer shall be installed in the RTU cabinet on the equipment rack.
12. The contractors shall provide all software and hardware required for the configuration of the RTU's and the computer

B. RTU power supply

Each RTU supplied shall be provided with the following:

1. Power source 1 – 125VDC substation battery
   a. RTU shall derive its power requirements from the substation battery.
   b. Two pole thermal circuit breaker shall be provided in the facility 125VDC control power panel to isolate the station battery supply from the RTU system.
   c. The RTU power supply shall be designed to operate at full-specified performance for DC supplies.
   d. The RTU shall have adequate protection against reversed polarity, over current and under voltage conditions, to prevent the RTU internal logic from being damaged and becoming unstable or causing mal-operation.
2. Power source 2– 120V AC general purpose
   a. A general purpose 120VAC supply is used for the RTU cabinet interior illumination, GFI receptacle and other auxiliary.

C. Remote Terminal Unit Controller

1. The RTU shall be microprocessor based automation platform capable of providing highly secure select-before-operate controls, status monitoring with 1 millisecond Sequence of Events (SOE) time tagging, and user programmable automation functions. Once power is supplied to the unit, it shall be designed to operate without manual intervention; additionally, it shall auto restart and be able to communicate with the master station

without reporting spurious state changes on power resumption after a power failure. Suitable, reliable indicators such as LEDs shall be provided for personnel to readily ascertain the status of the RTU.2. The processor shall monitor the health of the RTU and shall have built in diagnostics. The RTU shall allow remote interrogation including but not limited to diagnostics for memory and bus errors, buffer overflows, local software routine health, communication ports status, input/output card health. Diagnostics shall also be supplied that shall permit complete testing of the RTU with a portable computer. Diagnostic checking of the communication ports shall be provided to permit checking by a portable computer.

2. Power supply and battery low volts or failure conditions shall be monitored.

1. The RTU shall possess memory to permit storage of a minimum of 2000 events (input changes) locally for subsequent transmission to the SCADA master station and these events shall not be lost on buffer overflow; an indication shall be provided of this latter condition. Events will be retained in the buffer until they are correctly read by the master station. As a minimum, separate buffers shall be provided for digital and analogue events.
2. A Separate event recording for the internal RTU events shall be provided and buffered. The internal events shall include but not limited to the events such as health, time synchronization and any internal errors. This shall permit storage of up to 2000 events.
3. When memory is provided for the purposes of local control or communications routines, spare memory capacity equal to the amount utilized shall be provided.
4. The RTU shall have a real time clock, with a resolution of 1msec or better. It shall have the capability of time stamping events. The RTU clock is normally synchronized by the master station using DNP3 protocol every 5 minutes. In the advent that this does not occur, the RTU internal clock shall drift no more than 1 second in 24 hours.
5. The RTU shall be capable of reporting, events in 1msec steps with accuracy of +/-1% of the stamped time.
6. The RTU shall be equipped with a “controls isolate” switch, which shall inhibit all control outputs from being executed. When this control inhibit switch is activated, the RTU shall maintain the last control output applied immediately before the switch activation for the duration the switch activation or until a local manual intervention is initiated. The status of this switch shall be monitored by the RTU.
7. The RTU shall be capable of programming in a high level language to implement local control and logic routines.
8. The RTU shall incorporate a unique digital address or identifier. The addressing

scheme shall allow operation of several RTUs on a common communications line as well as random access to individual RTU.

9. The RTU shall be an easily configurable unit capable of selectively concentrating data from multiple Intelligent Electronic Devices (IEDs) and local and distributed discreet I/O panels (status, accumulators, analog, controls) into communication channels with one or more SCADA Master Stations.
10. The RTU configuration software provided shall run on a standard Windows PC and shall provide drag & drop menus to configure the RTU's communication ports; status, alarm and control points; IED communication Clients; Master Station communication Servers; selective routing of data points between the IED Client databases and Master Station Server databases, and local calculations and stand-alone control algorithms. Gateway configuration shall require secure login with a user's ID and pass-word.
11. The RTU shall be scanned by the Operation Control Center (OCC) Advance Information Management System (AIM) master stations and the SCADA master stations. The protocol used is DNP3 over TCP/IP.
12. The message exchange between the Master Station computer and the RTU shall be controlled and supervised by the master station computer. Commands to which the RTU shall respond may include, but not necessarily be limited to, the following:
    a. Full scan request - Initiates transmission of all measurement and status.
    b. Selective scan request - Initiates transmission of selected measurement and/or status points.
    c. Report by exception - Initiates transmission of only those points which have changed since the last transmission. A range of values or dead band, which may be set by the operator, shall determine whether an analog variable shall be transmitted. If the variable has changed by less than the specified dead band since the last reported value, the value shall not be transmitted. If the variable has changed more than the specified amount since the last reported value, the value shall be retransmitted
    d. Control point select and verify - Command to select a digital control point select.
13. Transmit information only after receiving the proper address from the master station. Design RTU so that it will not respond to the reply messages of other RTUs. Replies of the RTU shall include, but not necessarily limited to, the following:
    a. Analog and pulse data value message.
    b. Digital data value message.
    c. Check back response - Acknowledgment of control point select.
    d. End message - End of block of data.

D. Communication Interfaces

The RTUs shall support simultaneous communications with multiple independent master stations (SCADA system), maintenance and configuration terminal (Laptop PC), Multi-function transducers and Local computer/Logger. The RTUs shall have communication ports as follows:

1. The RTU shall be capable of simultaneous communication over the following interfaces with both VPN and SSL security:
    a. Ethernet 10/100baseT(X) or 100baseFX (TCP/IP and OSI)
    b. RS232 ports: bit or byte oriented, synch or asynch, 150 - 57,600 bps
    c. RS485 ports: bit or byte oriented, synch or asynch, 150 - 57,600 bps
2. The RTU shall be capable to simultaneously communicate with:
    a. At least four independent Master Station Servers using DNP3 protocol, and communicating over of any combination of serial or Ethernet ports, or using two different IP addresses.
    b. In addition, at least two independent Masters using Modbus protocol (HMI computer), and communicating over of Ethernet ports and using two different IP addresses.
    c. The RTU shall also be capable to communicate simultaneously with 7 or more Modbus IEDs types.
    d. The RTU shall support remote configuration, remote down loading, remote uploading of stored data, and remote data base modifications.
    e. The RTU shall also be capable to communicate simultaneously with up to fifty IEDs using DNP3.
    f. The RTU shall also be capable to communicate simultaneously with up to fifty IEDs using IEC 61850 protocol.
3. The RTU shall respond to independent scans and commands from Master Stations, local computer and Configuration &Maintenance Terminal simultaneously. The RTU shall support the use of a different communication data exchange rate (bits per second) and scanning cycle on each port.

E. Communication Protocol between RTU and IEDs

1. The RTU shall use the DNP3, IEC 61850 and Modbus protocols for communication with IEDs over Substation LAN. The RTU shall act as a Client and collect data from the IEDs).
2. The RTU shall store the data acquired from the IEDs in its database and do processing like change detection/dead band processing on the data for optimizing its transmission to the Master Station (SCADA Control Centre). The processing shall include requirements of mapping of information from the protocol of IEDs to the protocol requirement for

communication with Master Stations.

F. Communication Protocol between RTU and Master Stations

1. DNP3 protocol shall be used as the standard protocol for communication between the RTU and Master Stations.
2. The RTU shall perform as a slave to SCADA master stations. All communication shall be initiated by the SCADA master stations. RTU must notify the master stations of unusual conditions at the RTU (such as a power fail/restoration, RTU malfunction and communication failure with an end IED), the transfer of changed data etc. All the notifications shall be accomplished within the framework of the periodic data acquisition exchanges.
3. As part of the general system design, alarm features shall be included which shall forward alarms to the SCADA Master Station(s) and/or substation Annunciator system if the SACDA system determines that any component is not operating properly (with such components including the station HMI, local HMI, IEDs, Communications Gateways.
4. The RTU shall process the various messages/commands for communication to the Master station using the following priority.
    a. Control command
    b. Status data by exception
    c. Analog data by exception
    d. Analog data periodic
    e. Status data integrity scan
5. The communication interface to the master station(s) shall allow scanning and control of defined points within the RTU independently for each master station using a separate logical database in the RTU. It shall be possible to pick points from the RTU database randomly and assign it for reporting to a Master station. Further, the RTU shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each master station.
6. SCAN GROUP
    a. Analog and digital input points (including points reported by exception) shall be assignable to scan groups. A scan group shall be a specified set of data points within the RTU central database which will be communicated to a master station when requested by a specific (addressed) scan request. A scan group size shall only be limited by the communication protocol message length. Any RTU input point shall be assignable to any scan group. The RTUs shall support at least sixteen scan groups and all scan groups per communication port (i.e. master

station/ LDMS interface). The Contractor shall provide a convenient and flexible scheme for assigning points in the RTU to scan groups.

b. The following scan groups are defined in the WMATA point assignment charts:
    1) OCC Scan group
    2) HMI scan group
    3) AEMS scan group

7. Reporting of Status Points:
    a. The RTU communication protocol shall be configured to report digital status changes by exception to master station. Digital status data shall have higher priority than the Analog data. All the digital status data shall also be assigned to scan groups for integrity check by Master stations at every 1 second.
8. Reporting of Analog Points:
    a. The analog data shall be reported periodically to update all the values at the master station within 10 to 15 seconds. Analog data shall also be reported by exception if the analog value exceeds its previous value by a configurable percentage.
9. Digital Control Commands:
    a. The RTU shall follow the select-and-execute sequence for operation of digital control commands from the master station. The RTU shall reset its control logic upon any error in the sequence.

G. Data Concentrator Communication Protocol

1. The RTU shall act as a DNP3, Modbus and IEC 61850 protocol master and collect data and also perform supervisory control from/on the slave RTUs and communicate it to the Control Center. The Master protocol implementation shall be such that the data polling requirements is at accomplished.
2. RTU as a Data concentrator shall have capability to report to four master stations.
3. Data concentrator shall support at least 1,500 (fifteen hundred) data points.
4. The RTU as a Data Concentrator shall use Network Time Protocol (NTP) for time stamping of Data concentrator which in turn shall synchronize the DNP 3, IEC and Modbus protocol connected RTU/device.
5. The RTU as a Data Concentrator shall come complete with built in monitoring mechanism such as “Sequence of Events, SOE” that receive all data changes without losing a single event.
6. The data concentrator shall have dual CPU or High Performance CPU and dual Power supply units. The overall data update requirement from any device to Control Centre

should not affect the functionality defined elsewhere in the specification.

7. The Data concentrator shall have the provision for remote login from SCADA servers.
8. The SCADA master station and the local computer system shall be able to configure and poll health of Data concentrator after due authentication of the users.
9. It shall include embedded Web Server for maintenance and remote diagnostics. Individual RTU configuration shall be possible from Data Concentrator including accommodating devices from different suppliers. The RTU as a Data Concentrator shall have following communication ports & support for protocols:
    a. DNP3 for Master Stations
    b. DNP3 for devices
    c. IEC 61850 for devices
    d. Modbus for devices
    e. TCP/IP
    f. Ethernet 100baseT to local Laptop
10. The other requirements given for RTU elsewhere in the specification shall be applicable to RTU as a Data concentrator also.

H. Switchgear Digital Input/ Output Modules (DIO):

1. Digital Output modules are installed in the AC and DC switchgears by the switchgear manufacturer for the control and status indication of circuit breakers.
2. The RTU shall provide the capability for a master station to select and change the state of digital output points of the DIO and receive status indications via the digital input points of the DIO.
3. The RTU shall use the DNP3 protocol for communication with switchgear DIOs over Substation LAN.
4. Refer to section 28 40 04 (16604) for remote digital input-output module requirements.
5. Switchgear DIO-Digital Outputs:
    a. A pair of outputs is supplied on the DIO for each two-state (open/close) control output point that drive control relays.
    b. One output is supplied for open, the other for close.
    c. Upon command from a master station using the check-before-execute sequence, the appropriate control output on the remote DIO operates for a preset (momentary) time period to control the circuit breaker through external interposing relays. The operation period shall be adjustable for each point from 0.1 to 2 seconds.
    d. Control Output Interposing Relays:

1) The operation the momentary relays on the remote DIO will activate external control output interposing relays supplied by the switchgear manufacturer for each control output as specified in section 16341.
2) The control output interposing relay 201T open the circuit breaker.
3) The control output interposing relay 201C close the circuit breaker.
4) The RTU manufacturer is not responsible for the control output interposing relays.

6. Switchgear DIO-Digital Inputs:
   a. Monitor circuit breaker's status and alarm points via remote digital input modules.
   b. Refer to section 28 40 04 (16604) for Remote Digital Input-Output modules connections.

I. RTU Instrumentation and Control Interfaces Input/output Modules (Inside **RTU Cabinet**):

1. Digital Input Modules (Status Inputs):
   a. Monitor status and alarm points via digital input modules. Digital input modules shall accept dry contact inputs.
   b. RTU shall be capable of accepting isolated dry (potential free) contact status inputs. The RTU shall provide necessary sensing voltage, current, optical isolation and de-bounce filtering independently for each status input. The sensing voltage shall not exceed 24Vdc.
   c. The sensing voltage source shall be isolated from that of the RTUs logic power so that any noise or a short circuit across the sensing supply of a digital status input terminals would not disrupt the RTU operation other than the shorted digital status input.
   d. The RTU shall be set to capture contact operations of 20 ms or more duration. Operations of less than 20 ms duration shall be considered no change (contact bounce condition). The RTU shall accept two types of status inputs i.e. Single point Status inputs and Double point status inputs.
   e. To take care of status contact chattering, a time period for each point and the allowable number of operations per time period shall be defined. If the allowable number of operations exceed within this time period, the status change shall not be accepted as valid
   f. Single point status input will be from a normally-open (NO) or normally-closed (NC) contact which is represented by 1-bit in the protocol message.
   g. The Double point status input will be from two complementary contacts (one NO and one NC) which is represented by 2-bits in the protocol message. A switching

device status is valid only when one contact is closed and the other contact is open. Invalid states shall be reported when both contacts are open or both contacts are closed.

h. All status inputs shall be scanned by the RTU from the field at 1 millisecond periodicity.

2. Digital Control Output Modules:
   a. Control Security and Safety Requirements:
      1. The RTU shall include the following security and safety features as a minimum for control outputs:
         a) Select- check-before-operate (SCBO) sequence for control output.
         b) No more than one control point shall be selected and executed at any given time.
         c) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "control execute" command is not received within the set time period.
         d) No control command shall be generated during power up or power down of RTU.
   b. The RTU shall provide the capability for a master station to select and change the state of digital output points. These control outputs shall be used to control power system devices such as Circuit breakers relay disable/enable and other two-state devices, which shall be supported by the RTU.
   c. A set of control outputs shall be provided for each controllable device. On receipt of command from a master station using the select check-before-execute operate (SCBO) sequence; the appropriate control output shall be operated for a preset time period which is adjustable for each point from 0.1 to 2 seconds. Outputs shall be latching continuous output contact closure. Receipt of a point selection address shall cause the RTU to return a verification message to the master station. Execute commands only after the dispatcher has verified that the selected point is the desired point and has issued an execute command for the function to be performed.
   d. Control relays shall be installed between the output modules and terminal strips. Each control output shall consist of one set of potential free NO contact. The output contacts shall be rated for at least 10Amperes at 120 Volts ac resistive load. These output contact shall be used to drive heavy duty relays. In case Control output module of RTU does not provide potential free control output contact of this rating, then separate control output relays shall be provided by the

contractor. These relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils & shall conform to the relevant requirements.

3. Analog Inputs:
    a. The RTU shall accommodate analog inputs which are unipolar or bipolar, 2-wire ungrounded differential signals. All analog inputs are of +4 to +20 mA. However, the RTU shall be capable of accepting other standard analog input ranges (0 to 5V, 0-10V, 0 to 10mA).
    b. The RTU shall make all appropriate signal level conversion and conditioning to allow full utilization of analog inputs and meaningful reasonability checking. The analog-to- digital converter shall have at least twelve (12) bits plus sign. Each type of analog input shall be converted with full resolution. The RTU shall monitor the drift in characteristics of its ADC and mark the analog points with a drift quality code if a drift is detected. This drift quality code shall be sent to the master station also.
    c. The overall accuracy of the analog input system shall be at least 0.2 %(i.e. 99.8%) at 25 ºC of full scale. Mean accuracy shall not drift more than 0.002% per degree C within the temperature range of –5 to +55 degree Linearity shall be better than 0.05%. Each input shall have suitable protection and filtering to provide protection against voltage spikes and residual current. Loading up to 150% of the input value shall not sustain any failures to the RTU input.
    d. The total burden imposed by the RTU/DC analog input circuit shall not exceed 0.5 volt-ampere for current and voltage inputs.
    e. All analog inputs shall be scanned by the RTU from the field at least at 1 second periodicity.
4. Pulse Input Modules:
    a. Pulse input modules shall receive pulses in the form of contact open/closure from 3-wire (Form C) pulse initiators. The accumulated count shall not be altered, nor shall counting be interrupted when a count is transferred to the master station. Each counter shall have enough capacity to accumulate the number of pulses expected at the metering point in a 4-hour period without overflow, assuming an average pulse rate of 1 pulse per second. Pulse counter inputs shall be capable of accepting pulse inputs at a rate of 5 pulses per second. The pulse forming voltage, if required, shall be furnished from the RTU circuit.
    b. The pulse count registers shall not be reset at the end of the interval and shall continue to accumulate and automatically roll over only when they reach maximum count.

J. Sequence of Events (SOE) feature

1. SOE is the time-stamped digital status data. SOEs will enable Employer's personnel to determine the sequential operation of digital status input devices for their state changes. The RTU shall time-stamp the digital status data with a time resolution of one millisecond.
2. Initially, all breakers & protection contacts digital status input points in the RTU shall be configured as SOE points. However it shall be possible to assign any digital status input data point in the RTU as SOE point. Each time a SOE status input point changes state, the RTU shall time-tag the change and send it to the Master station. The RTU shall maintain a SOE buffer within the RTU for communication delays and communication failure. SOE buffer shall be sized to store, as a minimum, of 600 events. The RTU shall transmit the SOE data stored in its buffer to master stations. An acknowledgement of receipt by the master station shall be made prior to the loss of any data in the RTU SOE buffer. Data not received at the master station shall be retransmitted. The RTU shall send a message to the master station to indicate the RTU SOE data buffer overflow condition.
3. Local/Remote selector switch
    a. A manual Local/Remote selector switch shall be provided for each RTU to disable all control outputs by breaking the power supply connection to the control output. When in the "Local" position, the Local/Remote switch shall allow testing of all the control outputs of RTU without activating the control outputs to field devices. A status input indication shall be provided for the Local/Remote switch to allow the SCADA system to monitor the position of the switch.
4. Dummy breaker latching relay
    a. The Contractor shall provide a latching relay to be used to simulate and test supervisory control from the Master station. The latching relay shall accept the control signals from the RTU to open and close, and shall provide the correct indication response through a single point status input.
5. RS485 Communications Ports:
    a. A minimum of 10 RS-485 and 4 RS232 connection ports shall be available and integrated to the RTU to interface to local computing device. Currently, these IEDs communicate using the Modbus and DNP3 protocols.
    b. A separate serial to Ethernet port server to increase the number of serial ports is not acceptable.
6. RTU Diagnostic and configuration utilities
    a. The contractor shall provide a laptop PC loaded with the diagnostic software, configuration and maintenance tools and the simulator & protocol analyzer software tool mentioned below. The laptop PC shall be provided with all hardware accessories including cables, connectors etc. required for interfacing

with Master station, RTU and end devices. A suitable Hub shall be provided to use the tool in monitor mode. A carrying case and a suitable power adaptor for laptop PC shall also be supplied.

b. Diagnostic Software:
    1) Diagnostic Software shall be provided to continuously monitor the operation of the RTU and report RTU hardware errors to the connected master stations. The software shall check for memory, processor, and input/output ports errors and failures of other functional areas defined in the specification of the RTU.

c. RTU Configuration and Maintenance Tool
    1) The RTU database configuration & Maintenance software tool shall be required to perform the database modification, configuration, compilation and documentation. The database compiler shall provide error detection services. It shall also perform the downloading of the compiled database into the RTU database.
    2) Monitoring of all inputs, control of all outputs and testing of calculation logic. Monitoring of all inputs and logic at card level, logic level and DNP3 level.
    3) Display of communications statistics and level of eavesdropping of communications channels, including Ethernet, IP, DNP3, Modbus and IEC61850.
    4) Download & upload of RTU software, database configuration and calculations, download the complete configuration from RTU to modify and then upload to RTU.
    5) On-line help.
    6) Display the installed version number of firmware, software and configuration running in the RTU
    7) Configuration and diagnostic software must run on Windows 7
    8) The diagnostic and configuration utility software shall be provided on a CD/DVD with Licenses. The current version number of such software shall be provided. Any costs in upgrading to subsequent version numbers shall be included in the pricing.

d. Master station-to-RTU simulator & protocol analyzer software tool:
    1) Master station to RTU simulator tools ASE2000-COM (SafeNet Sentinel Pro ™ USB security plug) and ASE 61850 shall be provided and used to test the communication interfaces of Master station, RTU and end devices. The RTU simulator shall be capable of emulating the servers

DNP3, IEC61850 and Modbus protocols. It shall also be possible to prepare illegal messages for transmission, such as messages having invalid checksum.

2) The protocol analyzer shall be used to monitor all communication traffic on a channel (between Master station & RTU and between RTU & end devices without interfering channels operation. Channel traffic captured in the active or passive modes of operation shall be displayed.

3) The Master station simulator and protocol analyzer tool shall also have the following features:

a) Each received message shall be checked for validity, including the check sum.

b) The tool shall maintain and display error counters so that the number of errors during a period of unattended testing can be determined.

c) All fields of a message shall be displayed. A pass/fail indication for the message shall be included.

7. Terminal Strips:

a. Terminal blocks shall be provided for disconnection (isolation), with full-depth insulating barriers made from molded self-extinguishing material.

b. Terminal blocks shall be appropriately sized and rated for the electrical capacity of the circuit and wire used.

c. No more than two wires shall be connected to any terminal. Each analog input signal, digital status input and digital output signals shall require two terminals per point plus a common shield termination for each cable.

d. All terminal blocks shall be suitably arranged for easy identification of its usages. Refer to contract drawing for connection arrangements

e. Direct connections of field wires to RTU input output modules shall not be allowed.

8. Spare:

a. Provide a minimum of 20% spare points and 2 spare serial ports.

2.03 SUBSTATION INDUSTRIAL COMPUTER

A. Contractor shall supply and install SEL 3355 industrial computer in each RTU cabinet for functions described in paragraph 2.01.C of this specification.

B. The computer shall operate with network access to provide a combination of functions including, but not limited to, visualization and control of equipment, data acquisition, simultaneous collection

of data from serial and Ethernet server devices, and simultaneous data access for multiple client devices.

C. The device shall conform to various industry standards, operate in harsh environments, and provide the operational and functional requirements as described below.

D. The computer shall use high performance x86-64 Architecture based on latest Intel core microprocessor architecture to deliver very high performance and broad operating system and software compatibility.

E. Multiple processor cores and Intel Hyper- Threading Technology to enable to run multiple time-critical applications simultaneously.

F. Operating System: The computer shall be provided with Microsoft Windows 7 Professional, 64-bit.

G. Power Supply. The device shall be available with 125VDC power supplies.

H. Temperature. The computer shall be capable of continuous operation over a temperature range of –40° to +75°C.

I. Communications Ports. The computer shall come standard with two front-panel USB ports, four rear-panel USB ports, two rear-panel serial ports, and two rear-panel Ethernet ports. Each standard serial port shall be EIA-232/EIA-422/EIA-485 RJ45 serial ports. Four additional Ethernet ports, SFP 100Base FX. All communications ports shall be ESD and RFI protected.

J. Hot-Swappable Industrial Solid-State Drives. The device shall have high quality, industrial-temperature rated, single-level cell (SLC) NAND Flash solid-state drives available. All drives shall support hot-swapping.

K. Solid State Drive sizes: Two 400GB Industrial Grade SLC SSD

L. RAM: 16GB

M. Display Interfaces. DVI, DisplayPort, VGA, or HDMI video connections enable to connect one or two simultaneous, independent, high-definition displays.

N. Expansion Slots. A legacy PCI, two PCI Express (PCIe) x4, and two PCIe x1 slots shall provide room for legacy and the latest PCIe expansion cards.

1. The computer shall be provided with the following ports:
    a. Two (2) RJ-45 10/100/1000
    b. Two (2) SFP 100Base-FX

O. Nonvolatile Storage. There shall be Flash memory used as nonvolatile storage of settings, configuration, and incoming and calculated data. Data stored in the nonvolatile memory shall be available for retrieval after sustained power outage, including failure of the internal battery.

P. Moving Parts and Vent Holes. The computer shall not include any rotating disk drives, fans, moving parts, or vent holes.

Q. Alarm Output. There shall be an alarm contact output to signal internal errors and malfunctions. The alarm contact shall be supervised by an internal watchdog system that independently monitors the operating system. The alarm contact shall be connected and monitored by the RTU.

R. Conformal Coating. The computer shall have conformal coating to protect the circuit boards from harsh environments.

S. Mounting. 3U Horizontal 19-inch rack

T. Reliability. The vendor shall supply the actual measured Mean Time between Failures (MTBF) for the computer.

U. Warranty. The computer shall include a TEN-YEAR, no-questions-asked warranty for all material and workmanship defects. In addition, the warranty shall cover accidental customer-induced damage.

2.04 PERFORMANCE REQUIREMENTS

A. Environmental conditions
The RTU shall be designed and supplied suitable for indoor equipment conditions as specified by ANSI/IEEE C37.1 for new RTU not currently installed in WMATA facilities, heat dissipation calculations shall be provided to demonstrate the RTU's ability to comply with the temperature ratings of the equipment in the range specified. These calculations shall be done on the assumption that maximum spare capacity as specified in section 2.02 is implemented.

B. Maintainability
RTUs shall not require routine or planned maintenance. Therefore, no fans or moving parts shall be used in the RTU to avoid any need for maintenance. RTU should be constructed to resist the entry of dust. A single technician shall be able to remove and replace RTU modules for repair

purposes, without the need for special tools, it should not be necessary to dismantle or remove multiple pieces of the RTU in order to replace a module.

C. Reliability

RTU should normally remain in continuous service to provide SCADA. Failure can result in the interruption of the operation of the railway and a high level of reliability is therefore required. The supplier shall provide the predicted mean time to failure and the mean time to repair of the equipment. Where insufficient historical data is available, the supplier shall state the methods used to determine the reliability performance.

Availabilities achievable by non-redundant commercial grade equipment should exceed the following:

D. Service life

The RTU supplied shall be capable of performing its intended purpose, for a minimum of 20 years from the date of installation.

2.05 RTU CONFIGURATION TOOLS

A. Contractor shall supply a Laptop with licensed software which shall provide followings capabilities:

1. RTU Data base configuration &Maintenance.
2. Local Operator Interface & RTU Diagnostics.
3. Master Station and RTU simulator protocol analyzer

B. RTU Data base configuration & Maintenance

1. The RTU database Configuration and Maintenance software shall be supplied with the RTU and shall have the following features:
    a. Perform the database modification, configuration, compilation and documentation. The database compiler shall provide error detection services. It shall also perform the downloading of the compiled database into the RTU database.
    b. Monitoring of all inputs, control of all outputs and testing of calculation logic. Monitoring of all inputs and logic at card level, logic level and DNP3 level.
    c. Display of communications statistics and level of eavesdropping of communications channels, including Ethernet, IP, DNP3, Modbus and IEC61850.
    d. Download & upload of RTU software, database configuration and calculations, download the complete configuration from RTU to modify and then upload to

RTU.

e. On-line help.
f. Display the installed version number of firmware, software and configuration running in the RTU
g. Configuration and diagnostic software must run on Windows 7
h. The diagnostic and configuration utility software shall be provided on a CD/DVD with Licenses. The current version number of such software shall be provided. Any costs in upgrading to subsequent version numbers shall be included in the pricing.
i. Provide standard template for database modelling required for I/O modules, switchgear DIO & IEDs, communication setting.
j. Provide mapping of the individual data points acquired from one protocol to another protocol for transmission.

2. The database configuration software shall use the same terminology for configuration of the various protocol parameters as specified in the communication protocol standard. It shall be possible for the user to define these parameters.

C. RTU diagnostic

1. The RTU shall have built-in features for monitoring the health of the RTU modules and detecting the type of errors.
2. The diagnostics software shall have diagnostics for the RTU's processor(s), memory, I/O ports, and any other functional areas of the RTU. It shall list the errors recorded by the RTU and provide troubleshooting tools for the RTU.
3. Diagnostic Software shall be provided to continuously monitor the operation of the RTU and report RTU hardware errors to the connected master stations. The software shall check for memory, processor, and input/output ports errors and failures of other functional areas defined in the specification of the RTU.

D. Master station-to-RTU simulator & protocol analyzer software tool:

1. The contractor shall provide a Master station and RTU simulator /Protocol Analyzer software ASE2000-COM (SafeNet Sentinel Pro ™ USB security plug) and ASE 61850 to be used to monitor and test the RTU's operation using the master station communication protocol. It shall have the following features:
   a. Capable of emulating both the master station and the RTU messages in the communication protocols DNP3, IEC61850 and Modbus. When the Master station and RTU simulator protocol analyzer software has received or transmitted

a message, it shall be possible to immediately "turn around" and transmit or receive a response message.

b. Capability of interfacing to digital side of the RTU for the above purpose.

c. Capable of receiving single and repeated messages using the supplied RTU communication protocol. Each received message shall be checked for validity, including the checksum code. The messages shall be displayed in HEX format or in the 'interpreted form' as desired by the user. It shall maintain and display error counters so that the number of errors during a period of unattended testing can be accurately determined.

d. Capable of formatting and transmitting, both as one-time and periodic transmissions, any master station-to-RTU command.

e. Capable of preparing illegal messages, such as messages having invalid check codes, for transmission.

2. The Master station and RTU simulator/ protocol analyzer software shall also be capable of passively monitoring all communication traffic on a channel without interfering with channel operation.

3. Channel traffic captured in the active or passive modes of operation shall be displayed. All fields of a message shall be displayed. A pass/fail indication for the security check code shall be included with each code displayed.

4. The contractor provided simulator /Protocol Analyzer software shall also to be capable of emulating both the RTU and the IEDs messages in the communication protocols DNP3, IEC61850 and Modbus.

2. 06 RTU CONFIGURATION

A. Contractor shall retain the services of the SCADA RTU manufacturer or their authorized representative to be the system integrator to develop RTU configuration files, compile database, program, supervise and perform check-out and start-up of all system components and conduct system integration tests.

B. The RTU point mapping shall comply in every respect with the RTU Point Assignment Charts (PAC) in section 28 40 00 (16051D) and of any supplements thereto that become effective before this Contract is awarded

C. The contractor shall develop RTU configuration template for each type of RTU supplied and for each type of facility in the contract.

1. Each RTU configuration file template shall include the maximum points and devices for

the type of facility as specified on the contract drawings.

2. Each RTU configuration template database shall include the database for WMATA Control Center Master Station (AIM), WMATA SCADA Master Station (AEMS) server and the Local HMI.

D. The proposed RTU and configuration files shall be tested at the WMATA SCADA Lab per section 28 40 06 (16606) paragraph 2.03 “System Compatibility Tests” before the first RTU is shipped for installation.

E. The contractor shall provide all labor, materials, software, configuration, equipment, engineering and incidentals required to perform the system compatibility tests.

F. As a minimum, the contractor shall provide the following equipment and devices. The material provided for Lab Test shall become property of WMATA and shall be used for the training included in this contract and future refresher courses. These equipment and devices shall not be counted as spare parts required by the contract.

1. Each type of RTU System with the following component mounted on an open rack
    a. One Data Concentrator
    b. One Digital Input Module
    c. One Analog Input Module
    d. One Digital Output Module.
    e. 125VAC to 24V DC power supply
    f. One Industrial Computer.
    g. One Display Monitor.
    h. Any other required components
2. Other devices as installed by the contractor.
    a. One DC Relay.
    b. One Power Quality Meter
    c. One Digital Power Meter
    d. One PLC
    e. One set of Rectifier Monitoring EIDs
    f. One Transformer Monitor IED.
    g. One DTR Digital and Analog input module or system.

G. The RTU configuration tools with Laptop specified in the contract shall be provided and used during the LAB and field tests.

H. The contractor shall develop site specific RTU configuration files after successful system

compatibility tests.

I. All AS BUILT configuration files shall be provided and become the property of the WMATA, such that the WMATA may make further changes without action from the Contractor. In other words, the system shall be complete and editable by others.

2. 07 SENSORS AND TRANSMITTERS:

A. General:
   1. All sensors and transmitter shall use a 24 VDC auxiliary power supply as provided with each RTU.
      a. Auxiliary power supply, 120-volt AC input, 24-volt DC output shall be provided with each RTU for all transmitters.
      b. DC power rating shall be capable of supplying the connected load plus 20-percent spare capacity.

B. Room Temperature Sensors and Transmitters:
   1. The contractor shall supply, install and connect Room air temperature transmitters with the following characteristics:

a. Sensor:	Air Temperature Sensor
b. Temperature Range:	Minus 20F to plus 120F
c. Accuracy of calibrated points:	Plus or Minus 0.5-degree F.
d. Sensing elements:	Platinum wire resistance type.
e. Transmitter output signal:	4 to 20 mA DC.

2. 08 RTU Cabinet

A. Each RTU shall be supplied fully assembled, together with all ancillary equipment, including wiring terminals, mounting rails, wiring ducts & wiring, to form a complete system, subject only to connection of substation equipment to field terminals.

1. Where AC switchgear #1 & 2 are located in the same room, one AC RTU type 1 shall be provided
2. Where AC switchgear #1 & 2 are located in separate rooms, two RTUs shall be provided:
   a. AC RTU type 1 shall be provided and installed in the AC switchgear Room #1
   b. AC RTU type 2 shall be provided and installed in the AC switchgear Room #2
3. One TPSS RTU type for each TPSS
4. One TBS RTU type for each TBS
5. One AC RTU type 1 for Bus and parking garages
6. Refer to Drawing “RTU Bill Of Material” for RTU types

7. Ancillary equipment to be supplied with the RTU includes the following:
   a. 1 x 24v power supplies, 125V DC to 24V DC 240W converters. This is used to power input/output circuits and RTU 24VDC circuits.
   b. 1 x 24v power supplies 120V AC to 24V DC 240W converters. This is used for all external transmitters.
   c. Cubicle switch/lighting and a 120V AC GFI receptacle. The GFI receptacle shall be mounted near the bottom of the RTU cubicle.
   d. RS485 Gas arresters (Quantity will be site specific and shall be specified at the time of order).
   e. pole 125V DC thermal circuit breakers
   f. 3x2 pole DC thermal circuit breakers minimum
   g. 1X2 pole AC thermal circuit breaker
   h. Fuse blocks and fuses as required.
   i. Factory install 4 x 24V DC interposing relays (type cube relay 24V DC or equivalent) These 4 x 24V DC relays are for the Battery Charger, Inverter and transfer switch alarms to be fed to both the RTU and the DTS systems from a single alarm source.

B. Cabinet Construction:
   1. Cabinet shall be free-standing, floor mounted and height shall not exceed 72 inch.
   2. Construction: NEMA 3R.
   3. Apply two finish coats, ANSI No. 61, Light Gray, to exterior surface and Paint interior per manufacturer's standard.
   4. Cutout for cable entry at the top and bottom with Non-ferrous cover plates are required for cable entry.
   5. Cabinet is with fixed side, rear and roof panels, front swing, full hinged door with three point latch, key, hasp and staple for padlock.
   6. Provide Protective pocket inside front cover with schematic diagram, connection diagram, operating instructions, and layout drawing of control wiring and components within enclosure.
   7. RTU cabinets shall have a cutout on the cabinet door with Non-ferrous cover plates for installation of a 19” LCD monitor as required.
   8. Door & cover plates shall be fitted with long life gaskets, to provide a dust proof environment and shall be suitably earthed with earth straps using flexible earth cable.
   9. Dimension: 72”H x 36”W x 24”D
   10. All major items of equipment shall be labelled.
   11. Din mounting rails shall be sized to provide a minimum of 30% spare space for future expansion.
   12. The cubicle shall be grounded to the station ground bus.

13. Provide a simplified means of connecting field cables and RTU cables such that spares can be utilized, additions and alterations can be readily made, and different voltage sources can be utilized.
14. Terminal Blocks:
    a. Terminal blocks located within the RTU cubicle shall define the point of separation between the electrical SCADA RTU and the substation electrical system.
    b. Power Terminals: Rated 30 Amp, 600 Volt with insulating barriers between poles and washer-head binding screws on each pole to accommodate up to 10 AWG wire.
    c. Signal and Control Terminals: Rated 10 Amps, 300 volts, modular construction type, screws to accommodate up to 14 AWG wire.
    d. Labels shall be placed to describe each cable from the field and from the RTU.
    e. Space shall be allocated between sections of terminals allocated to different cables to provide adequate space for labelling – a minimum label width of 9 mm shall be provided.
    f. To facilitate troubleshooting, field cable terminations have been standardized.
15. Fiber Patch Panel for RTU equipment:
    a. Install one Corning SPH-01P Fiber Patch panel with one Corning CCH-CP12LC for connection of multimode fibers.
    b. Install Duplex Multimode fiber patch cords, 50/125 um between the patch panel and the RTU units.
16. Equipment Rack:
    a. 19” rack fabricated from 11GA steel for mounting equipment modules shall be provided. No panel shall be mounted directed behind the equipment rack.
    b. Size: 30” High
17. Nameplate:
    a. Black laminated plastic composition with permanent white engraved lettering, and beveled edges.
    b. Fastened to panel using small round-head screws.
    c. Installed inside cubicle and cabinets with cement.
    d. Submitted for approval.

2. 09 Marking Tags:

A. Dekafix 6.5-FS or equal, consecutive vertical, No. 4682.2 or No. 5766.6 as approved.

B. Group marking carrier with paper marking strip and transparent cover.
   1. Type SCHT5, Catalog No. 2924.6.
   2. Type ES05, Catalog No. 2937.0.
   3. SST5, Catalog No. 2940.0.
   4. Cable shall be labeled at each end to indicate source and destination termination points.

2.10 Raceways, Boxes and Conduit

A. Provide conduit, raceways, boxes and fittings in accordance with Section 34 21 05 (16130)

2.11 WIRING:

A. Status, Control and Analog:

   1. Multicolor cable, UL-listed conductors of 98-percent copper with type XHHW insulation rated 600 volts. Nonmetallic jacket material complying with ICEA S-68-516, NEMA WC8, free of PVC or PVC-based compounds.
   2. Jacket: Chlorosulfanated polyethylene, crossed-linked polyolefin, or heavy duty neoprene.
   3. Use shielded twisted pair cable for analog inputs and outputs.
   4. All other IEDs shall be connected to the RTU through the substation network switch.

2.12 SPARE PARTS:

A. In accordance with special conditions or the following, whichever is the stringent:

   1. Provide a minimum of 1 (one) or 20% of the installed components (whichever is higher) per RTU as spare. RTU, Provide touch up paint in 1-quart container.

PART 3 - EXECUTION

3.01 SOURCE QUALITY CONTROL

A. Design and Production Tests: Perform and submit in accordance with the General Provisions and section 28 40 06 (16606), certified test results for the tests on each unit of Remote Terminal Unit supplied under the contract.

B. Factory Acceptance Test in accordance with section 28 40 06 (16606)

C. RTU compatibility tests Test in accordance with section 28 40 06 (16606)

D. CONTRACTOR shall retain a system integrator to supervise, perform check-out and start-up of all system components and conduct system integration tests.

3.02 INSTALLATION

A. RTUs shall be delivered and installed in accordance with approved shop drawings at the following facilities:

1. Passenger Station AC rooms
2. Traction Power Substations
3. Tie Breaker Stations

B. The Contractor shall terminate all wiring on terminal strips in accordance with approved shop drawings and interconnection diagrams.

C. Perform work in accordance with the NEC.

D. Raceways Boxes and Cabinets:

1. Install conduit, raceways, boxes, fittings in accordance with Section 16130 as necessary to facilitate connections in accordance with Table 2
2. Wiring in the AC switchgear room between the switchgear and the RTU may be made directly to the RTU without the requirement for an interface cabinet.
3. Connections to mechanical equipment in the AC switchgear room shall require an interface cabinet
4. Install wall mounted interface cabinets as necessary in the vicinity of equipment located outside of AC switchgear room.
   a. Label the interface cabinet as the AEMS INTERFACE CABINET.
   b. Install RTU interface cabinets at locations in accordance with approved shop drawings.
5. Install raceways, wiring and terminations between the interface boxes and the RTU unit in the AC switchgear room.
6. Arrange terminations in interface cabinets in a sequence to facilitate maintenance. Terminations shall comply with the following requirements:
   a. Terminal strips shall be identified with markings tags as TB-1, TB-2, TB-3, ext. as required from left to right.

b. Terminals shall be identified consecutively on the various terminal strips from top to bottom and from left to right.

c. Terminations for equipment shall be grouped by equipment identification with control functions located on top and indication functions located on the bottom within the grouping.

d. Terminations for various equipment of the same type/classification such as EF-1 and EF-2 shall be terminated on consecutive terminals from top to bottom in ascending equipment number sequence.

1. Spare terminals shall be concentrated in one area of the terminal strip to the extent possible.

E. Wiring:

1. Use shielded twisted pair cable for analog input and control output signals and multi-conductor cable for all other functions.
2. Install wiring for RTU interface circuits for all points identified for branch circuits to power supplies located in selected RTU interface cabinets and for circuits from power supplies to sensors and transmitters in accordance with the following requirements:
3. Terminate shield drain wire of two-conductor, shielded twisted-pair instrumentation cable on a terminal strip in the RTU interface cabinet located directly below the associated two conductors for the cable. Drain wire shall not be grounded at the interface cabinet. (Drain will be grounded at the RTU)
4. Terminate twisted pair instrumentation cables for analog circuits on terminal strips that are separate from terminal strips used to terminate non-analog circuits.
5. Install twisted pair instrumentation cables for analog circuits in conduits that are separate from conduits used for non-analog circuits.
6. All copper wires from DC switchgear and DC negative switchgear devices shall be terminated at the DC trace recorder terminal blocs.

F. Ground RTU and power supplies in accordance with Section 16060.

G. Install auxiliary contacts as required for remote monitoring implementation as shown on drawings.

H. Install thermostats and sensors at locations indicated on drawings with top of thermostat 5'-0" above finished floor.

3.03 POINT ASSIGNMENT CHART FORMAT

A. RTU Point Assignment Chart (PAC) is the listing of the input (status), output (control), and spare data points for each type of facility. The standard WMATA RTU PAC shall be used for all RTU provided to ensure compatibility with SCADA servers. All DNP3, IEC61850 and Modbus control, status and other point addresses must be the same as the existing system addresses for compatibility. Any modifications or change to the PAC must be evaluated and approved before implementation. The contractor PAC which has the same format as the WMATA PAC template, but which also contain additional columns showing RTU termination points must be submitted and used for all integration tests.

B. The RTU PAC shall include as a minimum all points included in the SCADA points listed in table 4.0 in 28 40 00 (16051D) Specifications and shall include any additions, corrections or revisions necessary to provide complete control and indication coverage of all support facilities within the respective RTU control areas, based on the latest information available.

3.04 FIELD TESTING:

A. The Contractor shall perform polarity and continuity test on all interconnection wiring.

B. The Contractor shall perform system start-up for each RTU in the presence of the system integrator. The system integrator shall verify correct operation of each input/output module using a simulated master control interface test unit. Additional checkout shall be made to verify wiring terminations, modem operation, power supply operation and CPU operation.

C. The Contractor shall label all wiring terminations to reflect the connection points.

D. The contractor is responsible for testing all RTU input signals to verify correct status and telemetry signal levels. A test data sheet shall be developed for each RTU/AEMS Interface Cabinet which list all I/O signal points. The data sheet shall be submitted as part of the Contractors test plan. The Contractor shall submit a list of discrepant I/O signal points to the Engineer. I/O equipment supplied under this contract that is not reporting properly shall be corrected and retested. The Contractor shall submit a discrepancy report for all I/O points indicating problems found and required action.

3.05 SYSTEM INTEGRATION TEST:

A. Refer to section 28 40 00 (16051D) SCADA system work.

B. Refer to section 28 40 06 (16606) “SCADA systems Site Acceptance Test Plan”.

END OF SECTION

SECTION 28 40 03

DIGITAL TRACE RECORDER (DTR) FOR TRACTION POWER SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. This section provides requirements for contractor who will design, supply, manufacture, install, and configure a data acquisition system, also called digital trace recorder (DTR), for traction power substations (TPSS) and tie breaker stations (TBS) to continuously monitor and store large number of analog and binary inputs. This specification also covers the software requirement for system configuration, recording, data playback, and data analysis.

B. The DTR system includes digital and analog input modules, data acquisition software, and an industrial-type computer to record and save DC currents, voltages, and system disturbances on a local hard drive to secure data in the event of a loss of communication. All data will periodically be pulled into a central server location for long-term archiving.

C. The DTR system also serves as a test equipment and shall be capable of recording at 10 kHz or more per channel on demand.

D. Licensed software shall be provided with each DTR to configure, view, analyze, and recorded data.

E. The DTR is connected to the industrial computer by fiber cable.

F. Related specification sections include the following:

1. Section 28 40 00 - SCADA Work for Traction Power Systems
2. Section 28 40 08 - Wire, Cable, Cable Tray and Termination Panel For SCADA System
3. Section 28 40 04 - Network Switch For SCADA and Automation Systems
4. Section 28 40 06 - SCADA system Integration Testing and Documentation for TPSS and TPS

G. Operating Requirements

1. Designed for continuous, unattended operation to perform:
    a. Analog data acquisition; and,
    b. Digital control.

H. Power Requirements:

1. 125 Volts DC from facility control power

1.02 REFERENCES

A. Code, Regulations, Reference Standards and Specifications

1. Code and Regulation of jurisdictional authorities
2. NEC
3. NEMA 250, ICS-6, WC8, 12
4. ANSI C37.90, Z55.1, C12
5. EIA: RS 232.C
6. ASTM: B138
7. ASHRAE/ANSI : 135P
8. ICEA: S-68-516

1.03 QUALITY ASSURANCE

A. Qualifications:

1. DTR equipment manufacturer: The following data acquisition system manufacturers are pre-qualified to manufacture and supply DTR to WMATA conditional upon the proposed equipment and software meeting all requirements in this specification.
    a. Dewesoft ™ (Krypton System)
    b. Astro Nova Test Measurement (Daxus System)

B. For Code, Regulations, Reference and Specifications, refer to Article 1.02 above.

C. Coordination:

1. The DTR system accessory parts or interfaces with the switchgear/switchboard shall be factory installed by the switchgear/switchboard manufacturers. Have the DC switchgear and switchboard equipment manufacturer review and design equipment to provide analog telemetering and operational status for items identified in the Interface Points List Requirements in PART 3 of this section.
2. The DTR data acquisition software shall run on a computer provided by the remote terminal unit (RTU) manufacturer. Have the RTU manufacturer review and design equipment monitor the DTR critical failure alarms.

D. The Contractor shall develop test procedures based on the section 28 40 06 (16606) “SCADA System Test Plan” and obtain Engineer approval prior to testing.

E. Contractor shall perform progressive tests in accordance with an approved test procedure to verify compliance with specified system performance requirements, including, as a minimum: proper component operation, module input and output signal operation, and telemetry between equipment sensors and each RTU.

1. All test discrepancies shall be corrected and test reports submitted to the Engineer prior to scheduling end-to-end testing.
2. Contractor shall notify the Engineer prior to commencing progressive testing and shall offer the Engineer the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.

F. End-to-End Test:

1. The Contractor shall provide acceptance test procedures for both hardware and software.
2. The Contractor shall demonstrate the proper functioning of the completed DTR system including all components and telemetry between each piece of equipment monitored by the DTR by using a laptop connected directly to the DTR or to the facility’s network switch. Simulation of sensors by shorting contacts is to be avoided unless specifically pre-approved as other activation method is not possible.
3. The Contractor shall demonstrate the recording performance of the DTR.
4. The Contractor shall demonstrate remote access to the DTR for data retrieval by server or remote computer.
5. The Contractor shall demonstrate that the stored data can be reviewed using Dewesoft or the provided software.

G. Submit certified test report within ten days after completion of field tests.

1.04 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements in accordance with Division 1 and with the additional requirements as specified for each:

1. Shop Drawings: Show the following as a minimum:
    a. Electrical wiring diagrams and schematics

b. Electrical and mechanical installation details
c. Site specific schedules, interconnection diagrams, and point assignment charts
d. DTR point count for various facilities in accordance with Tables in this section
e. DTR data point assignments are listed in Table1 thru Table 3
f. Composite status and telemetering sensing equipment schedule

2. Product Data: Submit annotated product data for each item of equipment and resubmittal for mechanical or electrical equipment that may have changed as a result of a required modification.
    a. Manufacturer's technical specification of the DTR product or its subassembly indicating all parameters, frequency responses, maximum sampling rate capability, A/D conversion speeds, etc. When requested, impulse responses of DTR component or its accessory shall be provided.
3. As-Built Documents: Prior Substantial Completion develop an as-built documents as follows:
    a. As-built drawings of the installation: 11-inch by 17-inch composite interconnection wiring diagram showing the entire DTR interface system;
    b. Provide laminated copy to be attached on each DTR interface cabinet door;
    c. Approved copies of each submittal; and,
    d. Provide as-built drawings in both AutoCAD and PDF formats on CD in sleeves.
4. Software and Documentations:
    a. For each programmable Intelligent Electronic Devise, provide configuration software, configuration file, manuals on disks licensed to WMATA six weeks prior to the start of any factory acceptance tests. Provide and submit proof that the software packages are licensed to WMATA when the software is delivered to WMATA. Provide and submit proof that a two-year software maintenance/upgrade package has been purchased for the Owner.
    b. All configuration files shall be in their native format, shall become property of WMATA, and shall not include any copyright license or any license terms that require permissions from the vendor for modifications to the files.
5. Operation and maintenance (O & M) manuals: Refer to Section 28 40 00 (16051D)
6. Preventive Maintenance Instructions: Refer to Section 28 40 00 (16051D)
7. Spare Parts Lists:
    a. Recommended spare parts shall be detailed for each DTR. The spare parts shall be sufficient to cover the complete range of DTRs supplied.
    b. Unit prices shall be supplied.
    c. The list shall include the following:

1) Item identification
2) Recommended spares quantities
3) Base price

8. Certificates from manufacturers verifying that equipment conforms to the requirements in this specification.

1.05 TRAINING: Refer to 16053D

A. Engineers and Operation and maintenance training may be required. This shall be required for any new type of DTR products, but may be required for familiarity training as part of a refresher course for both new and existing personnel.

B. The courses shall cover all aspects of the DTR design sufficient for the engineers to configure the DTR and maintainers to troubleshoot and maintain the DTR over its design life. Contents shall include:

1. DTR operation and data communications protocols
2. Diagnostic tools provided with the DTR and test equipment to fault find a DTR
3. Failure modes
4. Configuration of the DTR
5. Software

C. Instruction Period: One Day

D. Training course material: Training courses shall be conducted at WMATA. The Supplier shall provide all teaching aids for each attendee for the conduct of the courses, which shall be independent of any other material provided under this Agreement.

PART 2 – PRODUCTS

2.01 GENERAL:

A. DTR CONNECTION POINT REQUIREMENTS: The DTR is connected to the DC systems through current and voltage transducers for analog measurements and to the DC protective relays for disturbance trigger signal.

B. Typical WMATA Traction Power Systems DC current shunt ratios:

TYPICAL DC SWITCHGEAR CURRENT SHUNT RATIO	CURRENT TRANSDUCER INPUT/OUTPUT	VOLTAGE TRANSDUCER INPUT/OUTPUT
5000A :50mV	50Mv : 1mA	
7500A:50mV	50Mv : 1mA	
10000A:50mV	50Mv : 1mA	
15000A:50mV	50Mv : 1mA	
20000A:50mV	50Mv : 1mA	
		1000V : 1mA

TYPICAL DC SWITCHGEAR NUMBER OF INPUTS	TPSS POSITIVE DTR	TPSS NEGATIVE DTR	TBS POSITIVE DTR
ANALOG	16	8	8
DIGITAL	16	0	8
THE REQUIRED NUMBER OF ANALOG AND DIGITAL INPUTS SHALL BE PROVIDED ON DTR PROVIDED. REFER TO CONTRACT DRAWINGS FOR CONNECTIONS. ADDITIONAL ANALOG AND DIGITAL INPUTS SHALL BE PROVIDED AT LOCATIONS WHERE POINT COUNTS EXCEED THE TYPICAL NUMBER LISTED.			

2.02 DC TRACE RECORDER (DTR) SYSTEM

A. DTR INPUT MODULES

1. The DTR shall be a high-speed recorder used to capture individual samples of the currents, voltages, and harmonics measured by the device with a minimum 10Ks/s per channel sampling frequency to display DC power system faults and transients. Minimum 24 bit A/D (Preferably arranged as Dual A/D).
2. The hardware structure of the system shall be as follows:
    a. Flexible in configuration to accept variety of different modules available (analog, digital, counter and frequency) and to expand.
    b. Flexible as being a standalone data logger, an Ethernet based distributed measurement system or a full-featured independent data acquisition instrument.
    c. Flexible modular system design to allow signal conditioning & A/D's modules to be remotely located from CPU, and with single cable in between modules.
3. The DTR shall be designed for field applications in transit applications, with signal conditioning system for interfacing with transducers and relays, A/D cards for digitizing

the conditioned signals, and powerful data acquisition software that allows to set up the DTR and configure data recording parameters, initiate data acquisition, as well as to analyze data that has been stored.

4. The DTR shall be expandable up to 24 analog inputs and 16 digital inputs and designed with electrically isolated inputs to accept a wide range of sensors. For traction power system applications, the DTR will be connected to current and voltage transducers with the characteristics listed below. Normal operation output is between -2mA to 2mA.
    a. Voltage Transducers Characteristics :
        1) The DC switchgear/switchboard manufacturer shall install magnetic amplifier type transducers with the following characteristics to provide complete isolation of the DTR input signal.
            a) Normal Operation Input range: -1000V to +1000 V
            b) Normal Operation Output range: -1mA to +1mA
            c) Disturbance/Fault Input range: -2000V to +2000V
            d) Disturbance/Fault Output range: -2mA to +2mA
            e) Input Impedance: 5000 ohms/Volt
            f) Load Impedance: Any load between 0-10K
            g) Accuracy: + 0.5% Rated Output @ 25°C
            h) Temperature Range: -10°C to + 70°
    b. Current Transducer Characteristics:
        1) The DC switchgear/switchboard manufacturer shall install magnetic amplifier type current transducers with the following characteristics to provide complete isolation of the DTR input signal.
            a) Normal Operation Input range: -100mV to +100 mV
            b) Normal Operation Output range: -2mA to +2mA
            c) Disturbance/Fault Input range: -250mV to +250 mV
            d) Disturbance/Fault Output range: -5mA to +5mA
            e) Input Impedance: 5000 ohms/Volt
            f) Load Impedance: Any load between 0-10K
            g) Accuracy: + 0.5% Rated Output @ 25°C
            h) Temperature Range: -10°C to + 70°C
    c. Digital Input:
        1) Trigger contact from each breaker relay is connected to the DTR per Tables to trigger the DTR record in event mode.
5. Accuracy of measurement of analog signals shall be better than 1% within ±100% of normal operation values.

6. The data acquisition system's analog input modules shall be provided with their own external shunts if mA input modules are not available. These external shunts shall be mounted in the DTR cubicle.
    a. Current and voltage transducers can be shared between the DTR and other equipment, however, it shall be the responsibility of the DTR equipment supplier to insure the shunts have appropriate ratios and are suitable for the use as designed.
7. The DTR digital inputs shall connect to dry contacts from DC relays (triggers) to indicate that event related breaker tripping is initiated by the relay. These triggers shall cause the recorder to capture transient events at the maximum sampling rate of the DTR if possible for a minimum duration of 1 second before and 5 seconds after the event.
8. Self-diagnostics shall be provided in the system. Any fault in the system shall generate error message in the system panel and generate an alarm in the substation RTU.
9. The DTR shall be a continuous monitoring and recording data acquisition system that records instantaneous values (waveforms) of current and voltages with a raw data sampling rate of not less than 10KS/s per channel, 24 hours per day, and 7 days a week.
10. The DTR shall be capable to accept 20KS/s or higher sampling rate modules to capture signals up to 24th harmonics. Appropriate anti- aliasing filter features shall be integrated in the DTR equipment and software.
11. The DTR shall be suitable for working on DC electrified areas, where the DC switchgear enclosure is ungrounded with +25VDC floating ground voltage.
12. The system shall be capable of working in a traction power facilities' environment where an ambient temperature ranges of -10˚C to +70˚C and relative humidity up to 95% at ambient temperature of 40˚C. Special protection against ingress of dust, moisture, etc., shall be provided.
13. The DTR shall interface with the substation RTU for alarm monitoring.
14. Other Specifications:
    a. Communications ports: One Fiber Optics 100BaseFX, one 100BaseT Ethernet.
    b. Ethernet Interface for configuration and data output. Protocols: TCP/IP, Modbus TCP/IP or DNP-3, or IEC61850
    c. Configuration & Communication port: USB, EtherCAT
15. Refer to drawing for DTR connections

2.03 Cabinets

A. DTR Cabinet:

1. Construction: NEMA 3R.
2. Power Source: 125V DC control power is provided to the DTR cabinet. It shall be the responsibility of the DTR equipment supplier to provide a reliable power converter if the DTR input power requirement is different.
3. Apply two finish coats, ANSI No. 61, Light Gray, to exterior surface.
4. Paint interior per manufacturer's standard.
5. Fabrication
    a. Cabinet with fixed side, rear and roof panels, front swing, full hinged door with flush latch operable by screw driver, key, hasp and staple for padlock.
    b. Provide protective pocket inside front cover with schematic diagram, connection diagram, operating instructions, and layout drawing of control wiring and components within enclosure.
    c. Recommended Maximum Cabinet Size:24”h x 24”w x12”l
6. DTR input shunt:
    a. DTR manufacturer shall install 5000 ohm external shunt to convert the DC switchgear transducer 1mA outputs to 5V for nominal input to the DTR.
    b. The external shunts shall be factory installed by the DTR manufacturer as shown on drawings.
7. Terminal Blocks:
    a. Provide terminal blocks within the DTR cubicle for all external digital and analog inputs. The DTR manufacturer may pre-install the required shunts on the terminal blocks.
8. Field Wiring Terminals:
    a. Terminate field wiring on terminal block according the DTR layout drawings.
    b. All field wiring shall have source/destination labels.
9. Nameplate: “DTR”
    a. Black laminated plastic composition with permanent white engraved lettering, and beveled edges.
    b. Fastened to panel using small round-head screws.
    c. Installed inside cubicle and cabinets with cement.
    d. Submitted for approval.
10. The DTR shall be designed for wall mounting with top cable entry. Kindorf channel shall be used to reinforce switchgear panel where the DTR is mounted.
11. Caution: Data acquisition system shall be shipped separately to avoid damages to the electronics.

2.04 WIRING:

A. Use shielded twisted pair cable for analog and digital inputs. Shield shall be grounded on the substation ground bus.

B. Use multimode fiber jumper cable from DTR to the DC switch patch panel.

C. Use multimode fiber cable from DTR to substation computer.

2.05 SOFTWARE:

A. The DTR configuration and analysis software shall be an application software that combines the functionality of a power analyzer, a data logger, a transient recorder and a FFT harmonic analyzer. The software shall be designed to acquire different signals (analog, digital, etc.) simultaneously from multiple sources where not all of them are necessarily sampled at the same sampling rates and store them in one file allowing comprehensive analysis. All records—waveforms, disturbances or trends—shall be saved in their native file format. Software conversion from Excel or other file formats to the proposed software file format to view, and analyze is not acceptable.

B. DTR system shall be provided with all required software for data acquisition and analysis. Basic configuration shall be used during factory acceptance tests to verify proper wiring and recording. Final configuration of each unit shall be completed during field tests.

C. The DTR software shall be installed and configured by the DTR contractor on the substation computer provided by others.

D. DTR Configuration Application:

1. The DTR shall be configured with initial network parameters using a laptop computer. The software used for such initial configuration shall be provided together with its license.
2. Upon successful configuration and testing with laptop, the contractor shall program the industrial computer to communicate with the external input modules, to acquire and store data.
3. The DTR application shall include as a minimum the following to perform setup and configurations of the DTR's:
    a. A startup screen: This shall employ drop down menus to allow different operations such as creating, modifying current setup/configuration, downloading a new setup, or copying a recorded file.

b. Fields to assign/change site name, to be stored in the DTR.
c. Fields to assign/change channel name, type, unit, shunt ratio, and scale for channels individually.
d. Fields to create folder for data storage, duration of each recorded file.
e. Fields to change network communication parameters (IP address, subnet mask, gateway).
f. Fields to select and assign color to the desired channel for graph or channel color can be pre-assigned.
g. Fields to configure other communication parameters related to connection to network, NTP, remote viewing, streaming to network.
h. Field to configure each installed modules. Allow unused channels to be turned off. These channels shall not record.
i. Configure trigger points with external trigger.
j. Configure math/calculated channels.

4. DTR File Format
   a. The file format of the recorded DTR file (trace) shall be such that all the relevant information including the configuration information, record start time, record end time, total number of channels in the file, sampling rate for each channel at each instant, the DTR name, channel types, units used are all included in a single file. No other information other than this file shall be required to fully reconstruct and view the channels using the provided software.
   b. DTR shall be set to create new data files at 24:00 hours every day. Default file naming shall be in the form LLLLL_YYMMDD_HHMM, where LLLL is location code, YYMMDD is the year, month and date of data collection, and HHMM is recording start time, hours and minutes.
   c. The DTR data files shall be stored in equipment software native format capable to be exported into tab delimited text file formats that is acceptable in other software applications.

E. Viewing and Analysis Application:

1. Licensed Software shall be provided to view the recorded data, analyze and create reports.
2. The application shall display graphs and trends of the recorded analog data and digital collected from DTRs. At a minimum, the application shall include the following:
   a. Tracing/graphing of the trace file data into a two-dimensional plane (X-Y area) with the time on the X-axis and analog values on the Y-axis. The X-axis shall

default to viewing the entire timespan recorded in the file, and shall provide a dropdown list to select time segments from milliseconds to the entire 24 hours of recorded data.

b. By default, all channels shall graph in a single view window with option to hide and display individual channel.

c. The software shall be capable of creating multiple view windows with option to select individual channel to display.

d. Each window shall automatically get the label (channel name) used in the DTR channel setup. The Y-axis of each window shall automatically scale consistent with the recorded values and affix labels per the units entered in the DTR channel setup.

e. It shall also be possible to change the “scaling” of the axes of the individual windows manually irrespective of whether the graphed data is viewable or not. Scaling shall mean the numerical distance between any two consecutive units used to mark values on the axes. Selectable X-axis scales shall be Millisecond, Second, Minutes and Hours. Selectable Y-axis scales shall be (1/10th) Unit, (1/5th) Unit, (1/2nd)) Unit, Unity, 5 x unit, 10 x unit, 20 x unit, 100 x unit and 1000 x unit. The channel values in the record shall never be altered in the process of scaling. Scaling shall be a separate feature than zooming and shall be accessible via an appropriate drop-down menu.

f. Zooming shall mean fixing a view point within the view window and increasing/decreasing the field of view. Pointing the cursor inside anyone of the windows and left clicking to fix a view point and applying the scroll wheel of the computer mouse shall enable dynamic zooming within the particular window.

g. It shall be possible to rearrange the order of the vertical arranged windows based on their names and save the particular arrangement to default. This arrangement shall also save the selected scaling applied to the axes.

h. It shall be possible to apply filters before and after recording.

i. The default background of each window shall be black and the axes and the labels shall be in white. The application shall have a setup feature where users can select color preferences for the channels that are to be graphed inside the windows by their types.

j. Standard engineering calculation accompanying report generation for each channel shall include; minimum, maximum average and maximum rate of change along with the plotted graph. The same information shall also be available for view by right clicking the computer mouse inside any of the channel windows and

invoking the appropriate software tool.

k. If displayed data is anything other than all, the application shall add a horizontal scroll bar to scroll left-right.

l. Provide hot keys for panning and zooming through mouse interaction. Panning shall be left-click and drag.

m. The software shall enable composite graphing of selected number channels in one window. This feature shall be accessible through an appropriate drop-down menu where it shall cause a new, separate window to open from the default channel windows. To differentiate its composite nature, this window shall have its background white and its axes and labels in black. The X-axis shall be the time and manually scalable and the Y-axis shall be non-manually scalable real number with no labels so as to accommodate dissimilar units together such as voltages in Volts and currents in Amperes on the same axis. The Y-axis shall automatically scale such that the channel with largest value in the composite graph is viewable. A second Y-axis with a different range to accommodate for overlaying two different channel types (voltage and current).

n. The software shall be capable of generating virtual channels using any number of recorded channels for acquisition and also to generate new channel after recording. For example, it shall be possible to graph a composite graph of Traction power substation load by calculation using: ((Cathode 1 current) + (Cathode 2 current)) X Bus Voltage.

o. The software shall be capable of generating daily reports of the Maximum and Minimum values of each recorded channel.

F. Historian Server Data Storage Application:

1. DTR data shall be made available to all traction power engineers, SCADA engineers, managers and field maintenance supervisors to enable them to take actions in case of accidents or incidences.
2. Traction power engineers and SCADA engineers shall be able to access raw data of all the stations at any time. For security reasons no engineers or maintenance personnel will be granted access to remotely download files from the DTRs.
3. Servers play vital role in making the DTR data available for multiple groups simultaneously.
4. The SCADA historian server will connect to the DTRs computer at predetermined intervals, to download and archive the recorded files to long-term storage.
5. Server application software to access and download DTR files is provided by others. However, the DTR shall be capable of such feature and capable of communicating in the

file transfer protocol demanded by the server.

6. Default file naming shall be in the form LLLLL_YYMMDD_HHMM, where LLLL is location code, YYMMDD is the year, month and date of data collection, and HHMM is recording start time.
7. The DTR files shall be archived in the historian servers in their native file format.
8. The provided software or Dewesoft shall be used for data retrieval for view, analysis and create reports.

G. Use Ethercat cable for connection between Positive DTR and Negative DTR.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The DTR supplier shall deliver fully functional DTRs with test reports for factory installation on the DC switchgear and DC switchboards. TBS DTRs shall be factory installed in accordance with approved shop drawings.

B. TPSS DTR system that combines the DC switchgear input and the DC switchboard inputs in a single cabinet can be either factory installed on the DC switchgear or field mounted on the substation wall.

C. The Contractor shall terminate all wiring on terminal strips in accordance with approved shop drawings and interconnection diagrams.

D. Perform work in accordance with NEC.

E. Wiring:

1. Use shielded twisted pair cable for analog input and control output signals and multi-conductor cable for all other functions.
2. Install wiring for DTR interface circuits for all points identified.

F. The DTR cabinet mounted on the DC switchgear shall not be grounded.

G. The Contractor shall provide and install fiber optical cable between the DTR system and the substation computer. This fiber shall not be connected through the substation network switch.

3.02 FIELD TESTING:

A. The Contractor shall perform polarity and continuity test on all interconnection wiring.

B. The Contractor shall perform system start-up for each DTR.

C. The DTR Contractor is responsible for testing all DTR input signals to verify correct status and telemetry signal levels mapped to the right channels as specified in the tables in this section and as shown in the contract drawings. A test data sheet shall be developed for each DTR which list all I/O signal points. The data sheet shall be submitted as part of the Contractors test plan. The Contractor shall submit a list of discrepant I/O signal points to the Engineer. I/O equipment supplied under this contract that is not reporting properly shall be corrected and retested. The Contractor shall submit a discrepancy report for all I/O points indicating problems found and required action.

D. DC Positive & Negative DTR Test

1. Connect a laptop to the DTR and run the DTR software.
2. Verify DTR firmware.
3. Current Transducers Calibration
    a. Connect test equipment leads to the terminals of the fuse connected to the transducer (Observe correct polarities).
    b. Ensure test leads are not connected to the terminal of the fuse connected to the shunt.
        1) Inject 50mv observe breaker meter is reading full DC shunt ratio scale.
        2) Observe on DTR software that the signal is on the correct DTR channel.
        3) Observe correct reading on laptop.
        4) Calibrate as necessary using transducer Zero and Gain.
        5) Inject 100mv and 200mv observe breaker meter is reading 2X and 4X full DC shunt ratio scale.
        6) Observe laptop reading is correct.
        7) Calibrate current transducers for all feeder and cathode breakers.
4. Voltage Transducer Calibration
    a. Identify the correct Voltage Transducer for the DTR.
    b. Connect a variable 1000V DC power supply test leads to the fuse terminals (Observe correct polarities).
    c. Inject 1000v, observe breaker meter is reading 1000V.
    d. Observe on DTR software that the signal is on the correct DTR channel.
    e. Calibrate as necessary using Zero and Gain

f. Inject 0V, 750V and 1000V DC observe breaker meter reading is correct.

g. Observe laptop reading is correct.

5. Trigger Configuration

a. Set DTR trigger as external trigger for each analog current channel.

b. Set DTR trigger as internal trigger for Voltage channel set at 1000 VDC.

c. Trigger instantaneous function of each DC protective relay.

d. Observe current waveform is captured by the DTR.

e. Inject 1100 VDC to DTR

f. Observe current waveform is captured by the DTR.

3.03 DTR SETUP AND CONFIGURATIONS:

A. The Contractor is responsible for the development of the initial site specific DTR configuration files.

B. The Contractor is responsible for the programming and testing of the DTR.

TABLE 1: TPSS POSITIVE SWITCHGEAR DTR POINTS			
POINT TYPE	DESCRIPTION	SIGNAL RANGE	ANALOG TB
Analog 1	DC Bus Voltage	±2mA from Breaker transducer	TB1-1-2
Analog 2	DC Breaker 21 Current	±5mA from Breaker transducer	TB1-3-4
Analog 3	DC Breaker 22 Current	±5mA from Breaker transducer	TB1-5-6
Analog 4	DC Breaker 23 Current	±5mA from Breaker transducer	TB1-7-8
Analog 5	DC Breaker 31 Current	±5mA from Breaker transducer	TB1-9-10
Analog 6	DC Breaker 32 Current	±5mA from Breaker transducer	TB1-11-12
Analog 7	DC Breaker 33 Current	±5mA from Breaker transducer	TB1-13-14
Analog 8	DC Breaker 34 Current	±5mA from Breaker transducer	TB1-15-16
Analog 9	DC Breaker 35 Current	±5mA from Breaker transducer	TB1-17-18
Analog 10	DC Breaker 36 Current	±5mA from Breaker transducer	TB1-19-20
Analog 11	DC Breaker 37 Current	±5mA from Breaker transducer	TB1-21-22

TABLE 1: TPSS POSITIVE SWITCHGEAR DTR POINTS			
POINT TYPE	DESCRIPTION	SIGNAL RANGE	ANALOG TB
Trigger 1	DC Bus Voltage	Logical Trigger	
Trigger 2	MPR Relay Trigger Contact Breaker 21	Dry contact from relay	TB2-3-4
Trigger 3	MPR Relay Trigger Contact Breaker 22	Dry contact from relay	TB2-5-6
Trigger 4	MPR Relay Trigger Contact Breaker 23	Dry contact from relay	TB2-7-8
Trigger 5	MPR Relay Trigger Contact Breaker 31	Dry contact from relay	TB2-9-10
Trigger 6	MPR Relay Trigger Contact Breaker 32	Dry contact from relay	TB2-11-12
Trigger 7	MPR Relay Trigger Contact Breaker 33	Dry contact from relay	TB2-13-14
Trigger 8	MPR Relay Trigger Contact Breaker 34	Dry contact from relay	TB2-15-16
Trigger 9	MPR Relay Trigger Contact Breaker 35	Dry contact from relay	TB2-17-18
Trigger 10	MPR Relay Trigger Contact Breaker 36	Dry contact from relay	TB2-19-20
Trigger 11	MPR Relay Trigger Contact Breaker 37	Dry contact from relay	TB2-21-22

TABLE 2: TPSS NEGATIVE SWITCHBOARD DTR POINTS			
POINT TYPE	DESCRIPTION	FIELD DEVICE I/O SIGNAL	DTR INPUT PANEL TB
Analog 1	Mainline Track 1 Return Current Transducer #1	±1mA from transducer	TB3-1-2
Analog 2	Mainline Track 1 Return Current Transducer #2	±1mA from transducer	TB3-3-4
Analog 3	Mainline Track 2 Return Current Transducer #1	±1mA from transducer	TB3-5-6
Analog 4	Mainline Track 2 Return Current Transducer #2	±1mA from transducer	TB3-7-8
Analog 5	Mainline Rail to Ground Voltage Track #1	±1mA from Switchboard Voltage Transducer #1	TB3-9-10
Analog 6	Mainline Rail to Ground Voltage Track #2	±1mA from Switchboard Voltage Transducer #2	TB3-11-12
Analog 7			TB3-13-14
Analog 8			TB3-15-16
FOR DC SWITCHBOARD PROVIDED WITH TWO CURRENT SHUNTS PER RETURN TRACK, THE DTR SOFTWARE SHALL TOTALIZE CURRENTS OF EACH TRACK. THE HMI AND RECORD FILE SHALL ONLY SHOW THE TOTAL CURRENT.			

TABLE 3: TBS POSITIVE SWITCHGEAR DTR POINTS

POINT TYPE	DESCRIPTION	FIELD DEVICE I/O SIGNAL	DTR INPUT PANEL TB
Analog 1	DC Bus Voltage	±2mA from Breaker transducer	TB1-1-2
Analog 2	DC Breaker 41 Current	±5mA from Breaker transducer	TB1-3-4
Analog 3	DC Breaker 42 Current	±5mA from Breaker transducer	TB1-5-6
Analog 4	DC Breaker 43 Current	±5mA from Breaker transducer	TB1-7-8
Analog 5	DC Breaker 44 Current	±5mA from Breaker transducer	TB1-9-10
Analog 6	DC Breaker 45 Current	±5mA from Breaker transducer	TB1-11-12
Analog 7	DC Breaker 46 Current	±5mA from Breaker transducer	TB1-13-14
Analog 8	DC Breaker 47 Current	±5mA from Breaker transducer	TB1-15-16
Analog 9	DC Breaker 48 Current	±5mA from Breaker transducer	TB1-17-18
Analog 10	DC Breaker 49 Current	±5mA from Breaker transducer	TB1-19-20
Analog 11	SPARE	±5mA from Breaker transducer	TB1-21-22
Trigger 1	DC Bus Voltage	Logical Trigger	
Trigger 2	MPR Relay Trigger Contact Breaker 41	Dry contact from relay	TB2-3-4
Trigger 3	MPR Relay Trigger Contact Breaker 42	Dry contact from relay	TB2-5-6
Trigger 4	MPR Relay Trigger Contact Breaker 43	Dry contact from relay	TB2-7-8
Trigger 5	MPR Relay Trigger Contact Breaker 41	Dry contact from relay	TB2-9-10
Trigger 6	MPR Relay Trigger Contact Breaker 45	Dry contact from relay	TB2-11-12
Trigger 7	MPR Relay Trigger Contact Breaker 46	Dry contact from relay	TB2-13-14
Trigger 8	MPR Relay Trigger Contact Breaker 47	Dry contact from relay	TB2-15-16
Trigger 9	MPR Relay Trigger Contact Breaker 48	Dry contact from relay	TB2-17-18
Trigger 10	MPR Relay Trigger Contact Breaker 49	Dry contact from relay	TB2-19-20
Trigger 11	SPARE		TB2-21-22

END OF SECTION

SECTION 28 40 04
NETWORK SWITCH FOR SCADA AND AUTOMATION SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. This section specifies Network Switch required at Substations

B. Related Sections:

1. Section 28 40 00 – SCADA Work for Traction Power Systems.
2. Section 28 40 00.1 – SCADA Work for Passenger Stations AC Rooms.
3. Section 28 40 08 – Wire, Cable, Cable Tray and Termination Panel for SCADA Systems.
4. Section 28 40 02 - RTU for SCADA systems.

C. Power Requirements

1. 125 VDC nominal input voltage

D. Cisco's CGS-2520-16S-8PC network switches are provided, configured, and installed by WMATA in an enclosure provided and installed by the contractor.

E. General Features

1. Network Switches:
   a. Cisco's CGS-2520-16S-8PC Network Switch is designed to support a wide array of Industrial Ethernet protocols for automation. This Switch features a programmable logic controller (PLC) form-factor design with extended environmental ratings, convection cooling, rack-mounting, alarm relays, and surge/noise immunity. The Switch software and configuration tools allows for easy setup, optimized for Industrial Ethernet applications (for example, Ethernet/IP).
   b. The Network Switch supports advanced quality of service (QoS) capabilities to support mission-critical substation applications such as SCADA.

c. The Network Switch is a rugged industrial type and in compliance with IEC-61850-3 and IEEE 1613 for utility substation environments.

d. The Network Switch supports extensive instrumentation, remote diagnostics, comprehensive network security features and should be easy for deployment, management and replacement.

e. Network switches are provided, configured and installed by WMATA

2. The contractor shall provide and install a network switch enclosure with fiber patch panels and circuit breakers at each AC room, TPSS and TBS.

1.02 REFERENCES

A. Codes, Regulations, Standard, Contract drawings and Specifications

1. Authorities Having Jurisdiction (AHJ)
2. NEC
3. SCADA design Drawings for Traction Power Substation, Tie Breaker Substation and AC Switchgear room Tables (See Section 4 of this spec)

B. Standards Support: The Network Switch provided shall at minimum meet the following industrial requirements:

1. Standard safety certifications
   a. UL 60950-1
   b. CSA60950-1
   c. EN 60950-1
   d. IEC 60950-1
2. Mechanical stability
   e. A minimum operating shock- 30 g at 11 ms
3. Standard Electromagnetic emissions Compatibility (EMC) certifications
   a. IEC61000-4-2 [Criteria A-Class 2]
   b. IEC61000-4-3/ENV50204 [Criteria A]
   c. IEC61000-4-4 [Criteria A / Criteria B]
   d. IEC61000-4-5 [Criteria B]
   e. IEC61000-4-6 [Criteria A]
4. Standard electromagnetic emissions certifications
   a. FCC Part 15 Class A
   b. EN 55022: 1998 (CISPR22 Class A)

c. CE Marking

5. Industrial electromagnetic emissions certifications
   a. EN 50081-2
   b. EN 50082-2
   c. CISPR11
6. Industry specifications
   a. IEC 61850-3 (Substations)
   b. IEEE1613 (Substations)
   c. ODVA Common Industrial Protocol
   d. IEEE 1588v2
   e. IEEE 137, IEEE Recommended Practice for Data Communications between Intelligent Electronic Devices and Remote Terminal Units in a Substation.
7. Hazardous locations
   a. The Network Switch selected should be rated to operate safely in the Hazardous areas of TPSS/TBS or AC Switchgear Rooms.

C. Standard SCADA Drawings

1.02 QUALITY ASSURANCE

A. Qualifications:

1. Network Switch equipment manufacturer: Network Switch and router are specified and provided by WMATA Information Technology/ Network & Communications Services (IT/NCS).
2. Network Switch Enclosure installer: Have piping and wiring installed by a qualified installer.

B. Coordination:

1. Network switches shall be fully assembled and tested inside a cabinet as depicted in standard drawings or specified in this or related sections.
2. The WMATA IT/NCS shall provide all software required for testing and configuration of the Network Switches.

3. Network Switch cabinet installer coordinates with electrical installers and other contractors as to the exact locations where the Network Switch cabinet will be mounted inside each Electrical, Traction power substation, and Tie breaker station.
4. Final location of the Network Switch cabinet shall be coordinated with WMATA SCADA engineers prior to installation.

C. For Code, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.

D. WMATA IT/NCS is responsible for all tests required to verify that the network switch provided and installed is in compliance with specified system performance requirements.

1.04 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements in accordance with Division 1 and with the additional requirements as specified for each:

1. Shop Drawings: Show the following as a minimum:
   a. Proposed changes and revised equipment layouts
   b. Network Switch cabinet installation detail drawings
   c. Network Switch port assignment charts
2. Product Data: Submit annotated product data for each item of equipment and resubmittal for mechanical or electrical equipment which changes as a result of required modification.
3. As-Built Documents: Prior Substantial Completion develop an as-built documents as follows:
   a. As-built drawings of the installation: 11-inch by 17-inch composite interconnection wiring diagram showing the entire Network Switch interface system. Provide sufficient copies to be stored in each switchgear cabinet door pocket.
   b. Approved copies of each submittal.
   c. Provide As-built drawing in both AutoCAD and PDF formats on CD in sleeves.

PART 2 – PRODUCTS

2.01 GENERAL

A. NETWORK SWITCHES :

1. Secured network switches are specified and installed by WMATA IT/NCS in Traction Power Substation and Tie Breaker Station to reliably connect and safeguard SCADA equipment from attacks. They are ruggedized and use highly secure firewall to monitor application traffic and stop unauthorized and potentially damaging activity. The switches are Layer 3 switches with packet filtering configured by WMATA IT/NCS to segregate certain traffic from the data network, permitting WMATA SCADA master stations at JGB and CTF, engineer test laptop, specified desktop computers to communicate with the RTU, Relays and other intelligent electronic devices while denying access from the rest of the data network.
2. The Network Switches are designed to support a wide array of Industrial Ethernet protocols for automation. These Switches features programmable logic controller (PLC) form-factor design with extended environmental ratings, convection cooling, rack-mounting, alarm relays, and surge/noise immunity. The Switch software and configuration tools allows for easy setup, optimized for Industrial Ethernet applications (for example, Ethernet/IP).
3. The Network Switches support advanced quality of service (QoS) capabilities to support mission-critical substation applications such as SCADA.
4. The Network Switches are rugged industrial type and in compliance with IEC-61850-3 and IEEE 1613 for utility substation environments. .
5. The Network Switches support extensive instrumentation, remote diagnostics, comprehensive network security features and easy for deployment, management and replacement.
6. The provided Network Switches for the SCADA and Automation systems support both fiber optics and copper type inputs. They offer SFP module slots, 10/100 Fast Ethernet P0E2 ports and AC and DC power supply module slots so that the switch is able to support monitors, laptop and different other types of devices through corresponding cables.
7. These switches are ideal product for Industrial Ethernet applications for SCADA and substation automations in harsh environments.
8. WMATA IT/NCS is currently using Cisco’s CGS-2520-16PS-8PC switches for SCADA.

9. The switches are provided fully-loaded with appropriate SFP modules for each of the fiber ports and with redundant power supply module (Model No. PWR-RGD-AC-DC).
10. The provided Network Switches for each TPSS and TBS are rack-mounted inside a cabinet along with fiber patch panel and control power circuit breakers.
11. For each TBS, a minimum of two CGS-2520-16PS-8PC Network Switches are provided and mounted inside the cabinet.
12. For each TPSS, unless noted otherwise, a minimum of four CGS-2520-16PS-8PC Network Switches are provided and mounted inside the cabinet.
13. The use of any other managed/unmanaged network switch for connection to the Wide Area Network (WAN) is prohibited.
14. The minimum number of SFP modules and other accessories provided per each Network Switch is defined in Section 4.0 'Tables' of this specification.
15. Contractor shall provide and install a wall mount, lockable network switch cabinet. The Network Switches for SCADA communications shall be powered by station batteries via redundant power supplies.

2.02 ENVIRONMENTAL

A. Operating temperature: -40°C to +60°C (-40°F to 140°F)

B. Storage temperature: -40°C to 85°C

C. Operating altitude: Up to 10,000 ft (3049m)

D. Storage altitude: Up to 15,000 ft (4573m)

E. Relative Humi Humidity: 10% to 95% non-condensing

2.03 CABINET:

A. Hoffman's Comline Series enclosure, catalog No. ECL1207060P or approved equal shall be provided and installed by the contractor for the installation of network switches, wireless router and fiber patch panels and accessories.

B. The enclosure shall be properly grounded to the station ground bus as specified in Section 16060 Substation Equipment Grounding.

C. The contractor shall specify the location of the Network Switch cabinet inside the AC room, TPSS and TBS prior to installation for approval by WMATA.

D. The Network Switch cabinet shall be pre-wired and fully tested for the proper installation and functioning of each component as shown in the standard drawings provided and as recommended by the manufacturer prior to field installation.

E. The contractor shall also install the single mode and multimode fiber patch panels and adapters in the network switch cabinet as specified in WMATA SCADA Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Network Switches are provided and installed by as shown in accordance with approved contract drawings.

B. The Contractor shall terminate all the incoming single mode fibers from the communication room and outgoing multi -mode fibers from network switch to the equipment within the station on the patch panels inside the network switch cabinet. Pre-fabricated fibers jumper cables shall be connected from the patch panels to the network switch ports in accordance with the approved wiring termination diagram.

C. Perform work in accordance with the NEC.

D. Wiring:

1. UL 508A Compliant
2. In accordance with WMATA specification 28 40 08 (16149)

3.02 FIELD TESTING:

A. The Contractor shall perform polarity and continuity test on all interconnection wiring.

B. WMATA shall perform system start-up for each Network Switch in the presence of contractor. The WMATA IT/NCS representative shall configure and verify correct operation of each Network Switch unit.

C. The Contractor shall perform a complete, end to end functional test for each termination and ensure the installation is done as specified and shown in the approved design drawings.

D. The Contractor shall label all wiring terminations to reflect the connection points.

APPENDIX

AC ROOM AND TBS NETWORK SWITCH CONFIGURATION

Product #	Description	Quantity
CGS-2520-16S-8PC	Cisco CGS2520 front/rear cabling w/2GE, 16-SFP, 8-10/100 PoE	2
PWR-RGD-AC-DC	High AC/DC (88-300VDC/85-264VAC) Pwr Sup for CGR2010/CGS2520 for each Switch	2
S252ILK9-12253EX	Cisco CGS 2520 IP SERVICES WITH EXPRESS SETUP	2
GLC-SX-MM-RGD	1000Mbps Multi-Mode Rugged SFP	4
GLC-FE-100FX-RGD	100Base-FX Multi-Mode Rugged SFP for each Network Switch	16
GLC-LX-SM-RGD	1000Mbps Single Mode Rugged SFP	2
CON-SNT-C2520PC	SMARTNET 8X5XNBD for Cisco CGS2520 support	2

TPSS NETWORK SWITCH CONFIGURATION

Product #	Description	Quantity
CGS-2520-16S-8PC	Cisco CGS2520 front/rear cabling w/2GE, 16-SFP, 8-10/100 PoE	4
PWR-RGD-AC-DC	High AC/DC (88-300VDC/85-264VAC) Pwr Sup for CGR2010/CGS2520 for each Switch	2
S252ILK9-12253EX	Cisco CGS 2520 IP SERVICES WITH EXPRESS SETUP	4
GLC-SX-MM-RGD	1000Mbps Multi-Mode Rugged SFP	4
GLC-FE-100FX-RGD	100Base-FX Multi-Mode Rugged SFP for each Network Switch	16
GLC-LX-SM-RGD	1000Mbps Single Mode Rugged SFP	2
CON-SNT-C2520PC	SMARTNET 8X5XNBD for Cisco CGS2520 support	4

END OF SECTION

SECTION 28 40 05

DISTRIBUTED I/O (DIO) FOR NEW TRACTION POWER SWITCHGEARS

PART 1 – GENERAL

1.01 SUMMARY

A. This section specifies Distributed Input Output (DIO) modules factory installed in new AC & DC switchgears for Traction power substations (TPSS) and Tie Breaker Stations (TBS).

1. Control I/O Modules are DIOs to be provided for each Traction Power System AC & DC breaker. The modules receive digital control signals from the RTU and provide relay contact control outputs to the breakers. The modules also receive contact signals from the breakers and send the corresponding digital signals to the RTU.
2. The DIO communicates with the station RTU via Network switch using DNP3 protocol over fiber cable.
3. These DIOs provide supervisory control of breakers through interposing relays.

B. Related Sections:

1. Section 28 40 00 – SCADA Work for Traction Power Systems
2. Section 20 40 01 - SCADA Training
3. Section 28 40 07 – Human Machine Interface (HMI)
4. Section 28 40 02 –- RTU for Traction Power systems
5. Section 28 40 04 – Network Switch for SCADA and Automation Systems
6. Section 28 40 06 – SCADA Systems Integration Testing and Documentation for TPSS and TBS

C. Operating Requirements

1. Designed for continuous, unattended operation to perform:
   a. Analog and digital data acquisition.
   b. Digital control.

D. Input Power Requirements

1. 125 Volts DC from switchgear control power.

E. Wetting Voltages

1. 125VDC external voltage from the switchgear.

1.02 REFERENCES

A. Code, Regulations, Reference Standards and Specifications

1. Code and Regulation of jurisdictional authorities
2. NEC
3. NEMA 250, ICS-6, WC8, 12
4. ANSI C37.90, Z55.1, C12
5. EIA: RS 232.C
6. ASTM: B138
7. ASHRAE/ANSI: 135P
8. ICEA: S-68-516

1.04 QUALITY ASSURANCE

A. Qualifications:

1. DIOs and manufacturers or approved equal:
   a. SEL -2440 by Schweitzer Engineering Laboratories, Inc.
   b. DDIO by Novatech
2. DIO installers: AC and DC switchgear manufacturers.

B. For Code, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.

C. The Contractor shall coordinate with the switchgear manufacturer to develop factory acceptance and field test procedures for the installed DIOs.

D. The contractor shall submit certified factory test report on individual DIO.

E. The contractor shall perform progressive tests in accordance with an approved test procedure to verify compliance with specified system performance requirements, including as a minimum, proper component operation, module input and output signal and telemetry between equipment sensors and each DIO.

1. Contractor shall notify the WMATA prior to commencing progressive testing and shall offer the Engineer the opportunity to witness the testing. Witnessing of any portion of the progressive testing by the Engineer shall not relieve the contractor from responsibility for any portion of follow-on testing.

F. End-to-End Test:

1. The Contractor shall demonstrate the proper functioning of each installed DIO including all components and telemetry between each piece of equipment monitored or controlled by the DIO by using the station HMI connected to the RTU/Network Switch in the presence of WMATA representative.
2. Simulation of sensors by shorting contacts is to be avoided unless other activation is not possible.
3. Each status and control point connected to the DIO shall be tested for proper operation.

G. Submit certified test report within ten days after completion of field tests.

1.04 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements in accordance with Division 1 and with the additional requirements as specified for each:

1. Shop Drawings: Show the following as a minimum:
   a. Electrical wiring diagrams and detail control schematics.
   b. Electrical and mechanical details
   c. Wire and cable schedules, interconnection diagrams, point assignment charts, and connection diagrams
2. Composite control/status and telemetering sensing equipment schedule.
3. Product Data: Submit DIO data sheet annotated product data for each item of equipment and resubmittal
4. Software and Configuration file: Submit the DIO configuration software and configuration files.
5. As-Built Documents: Prior Substantial Completion develop an as-built documents as follows:
   a. As-built drawings of the installation: 11-inch by 17-inch composite interconnection wiring diagram showing the entire DIO interface system. Provide sufficient copies to be stored in each switchgear cabinet door pocket.

b. Approved copies of each submittal.

c. Provide As-built drawing in both AutoCAD and PDF formats on CD in sleeves.

6. Operation and maintenance (O & M) manuals: Refer to section 16053B Training for SCADA

7. Spare Parts Lists: Provide 20% complete control I/O modules.

8. Certification:

a. Certified test results for the specified tests on the DIO Unit or provide certified test reports on identical unit.

b. Certificates from manufacturers verifying that equipment conforms to the specified

B. Software: Provide a configuration and testing software with licenses.

1.05 TRAINING: Refer to section 28 40 01 for training requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. Remote control and monitoring of the Traction Power System breakers by the Operations Control Center (OCC) and Human Machine Interface (HMI) are provided by DIOs installed in individual breaker cubicle or in a separate DIO control cabinet. OCC control commands are received by the SCADA RTU through the Wide Area Network (WAN)/Local Area Network (LAN), the RTU executes the control through the DIOs using DNP3 protocol. The RTU receives breaker status from the DIOs and transmit the data back to OCC through the WAN/LAN.

B. DIO shall be provided for each AC & DC breaker. The modules shall receive digital control signals from the RTU or switchgear PLC and provide relay contact control outputs to the breakers. The module shall also receive dry contact signals from the breakers and send the corresponding digital signals to the RTU. The Control I/O Modules shall be power using 125VDC supply at the switchgear.

2.02 DISTRIBUTED I/O (DIO)

A. The I/O modules shall provide status monitoring with 1 millisecond Sequence of Events

(SOE) time tagging, and a highly secure select-before-operate controls. The I/O modules installed in AC/DC switchgears shall be in self-contained enclosures with shock mount provisions and suitable for surface mounting, 19" Rack mounting, or DIN rail mounting. The I/O modules shall provide front panel LED indicators for all status inputs, all controls, and all communication port transmit/receive.

2.03 WINDOWS CONFIGURIBILITY

A. The DIO configuration software provided shall run on a PC with standard Windows 7 or higher and shall provide drag & drop menus to configure communication ports; status, alarm and control points; RTU communication Servers; and local calculations and stand alone control algorithms. The module configuration shall require secure login with a user's ID and pass-word login and shall maintain all attempted log-ins (dated, time-stamped) and all operational and configurable changes to the module database in a log file.

2.04 COMMUNICATIONS

A. I/O modules shall be equipped and easily configured to communicate with a single RTU over 100baseFX Ethernet multimode fiber optic using DNP3 protocol.

2.05 TIME SYNCRONIZATION

A. The I/O modules shall be equipped to receive NTP time synchronization over the multimode fiber port.

2.06 CONTROLS

A. DIO shall control AC and DC breakers through 125VDC interposing relays. Trip/close relay pairs shall execute controls with secure, multi-step handshaking with a DIO consisting of receiving a point selection message, responding with a "checkback" message, receiving a control execution message, and responding with an execution acknowledgment message. Failsafe control circuits in the I/O module shall ensure that only one relay can be energized at a time, and execute duration shall be configurable per point from 50 milliseconds to 10 seconds. Control relay outputs shall consist of one one form-A contact rated 10-amp "make" at 130 VDC. Termination shall be made to removable terminal blocks secured with screws to the I/O modules.

2.07 STATUS INPUTS

A. Each switchgear Control DIO shall monitor a minimum of sixteen (16) status inputs with Sequence of Events (SOE) recording accurate to 1 millisecond. The modules shall respond to rapid polls for changes only, and shall retain all changes until the RTU acknowledges receipt of those changes. Each I/O module shall buffer and report a minimum of 7 changes of state occurring between polls for each status point. In addition, the I/O modules shall store up to 25 time-stamped events per-point in files that can be retrieved by a Laptop Test Set. Status inputs shall be optically isolated to meet IEEE Surge Withstand Capability test C37.90.1-2000. Each status inputs shall be configurable for 5 milliseconds to 1 second de-bounce, and for 24 or 125VDC keying voltage. Switchgear 125VDC control power shall be used for 125VDC keying voltage source. Termination shall be made to removable terminal blocks secured with screws to the I/O module.

2.08 ENVIRONMENTAL

A. -40 to +85 degrees centigrade, 5 to 95% humidity (non-condensing)

B. IEEE Surge Withstand Capability test C37.90.1-2000

C. IEEE Susceptibility C37.90.1, .2, and .3

2.09 WIRING

A. Status: Status indication wire to DIO with 24VDC keying voltage shall be colored blue to identify the 24VDC voltage level. Wire size shall be 16AWG for status and the type as specified in the switchgear sections. Wiring identified at each termination, with same number shown on wiring diagram, using suitable plastic sleeve attached within six inches of terminal connections.

B. DIO wiring shall be in compliance with requirement in Section 34 24 05 (16052) - Basic Materials and Methods for Traction Power.

C. Fiber from DIO to Network switch shall be via patch panel.

PART 3 - EXECUTION

3.01 SOURCE QUALITY CONTROL

A. Design and Production Tests: Perform and submit in accordance with the General Provisions, certified test results for the tests on each unit of DIO supplied under this contract.

3.02 INSTALLATION

A. DIO shall be installed with the LEDs visible to a technician standing in front of the cubicle.

B. DIOs shall be delivered and installed by the manufacturer of the switchgear as shown in accordance with approved shop drawings.

C. For DIO with 24V DC wetting voltage, the Contractor shall color code blue all 24V DC status wire and terminate all wiring on terminal strips in accordance with approved shop drawings and interconnection diagrams.

D. Perform work in accordance with the NEC.

E. Raceways Boxes and Cabinets:
   1. Install conduit, raceways, boxes, fittings in accordance with Section 16130.

F. Wiring:
   1. Install wiring per terminal block assignments tables.

G. Install auxiliary contacts as required for remote monitoring implementation as shown on drawings.

3.03 FIELD TESTING:

A. The Contractor shall perform polarity and continuity test on all interconnection wiring.

B. The manufacturing representative shall verify correct operation of each input/output data card using a simulated DIO interface test unit.

C. The Contractor shall label all wiring terminations to reflect the connection points.

D. The Contractor is responsible for the programming of the DIOs. Refer to appendix A

tables for point assignments.

E. The Contractor is responsible for testing all DIO input signals to verify correct status and telemetry signal levels. A test data sheet shall be developed for each DIO which list all I/O signal points. The data sheet shall be submitted as part of the Contractors test plan. The Contractor shall submit a list of discrepant I/O signal points to the Engineer. I/O equipment supplied under this contract that is not reporting properly shall be corrected and retested. The Contractor shall submit a discrepancy report for all I/O points indicating problems found and required action.

APPENDIX A: TERMINAL BLOCK ASSIGNMENTS TABLES

DIO Terminal Block Assignments For AC Switchgear

CONTROL	FUNCTION	DESCRIPTION		
OUT-1	CONTROL TRIP	To energize relay 94 Trip coil		
OUT-2	CONTROL CLOSE	To energize relay 94 Close coil		
STATUS	**FUNCTION**	**DESCRIPTION**	**OPEN CONTACT WHEN**	**CLOSED CONTACT WHEN**
IN-1	CLOSED	Breaker status	Brk Open or Racked out	Bkr Closed
IN-2	TRIP	Breaker status	Brk closed or Racked out	Bkr Open
IN-3	86 LOCKOUT	Lockout relay status	Lockout	Normal
IN-4	27/59 PICKUP	27/59 from AC Relay	Picked up	Normal
IN-5	SPARE			
IN-6	BREAKER RACK IN	Breaker position	Racked out	Racked in
IN-7	LOCAL POSITION	Local/Remote Switch Position	Remote Position	Local Position
IN-8	RELAY 94C PICKUP	From 94C relay contact	Normal	Picked Up
IN-9	RELAY 94T PICKUP	From 94T relay contact	Normal	Picked Up
IN-10	LOST OF CONTROL POWER (27)	Contact from relay 27	Loss Power	Normal
IN-11	51BX PICKUP		Normal	Picked Up
IN-12	AC MPR Critical Failure	Contact from AC relay	Failure	Normal
IN-13	**SPARE**			
IN-14	**SPARE**			
IN-15	**SPARE**			
IN-16	**SPARE**			
	COMMOM WIRE (-) COMMON IS CONNECTED TO EVEN NUMBERS			

NOTES:

1. DIO output contacts shall be connected to interposing relays for breaker controls.
2. Use 125VDC external control power source for the interposing relays close and trip coils.
3. To provide racked out indication to Control Center:
   a. For “breaker open” status indication, the breaker MOC “b” contact is wired in parallel with the breaker TOC “a” Contact.
   b. For “breaker closed” status indication the breaker MOC “a” contact is wired in series with the breaker TOC “a” Contact.

DIO TERMINAL BLOCK ASSIGNMENTS FOR TPSS DC CATHODE BREAKER

CONTROL	FUNCTION	DESCRIPTION		
OUT-1	CONTROL TRIP	To energize relay 201 Trip coil		
OUT-2	CONTROL CLOSE	To energize relay 201 Close coil		
STATUS	**FUNCTION**	**DESCRIPTION**	**OPEN CONTACT WHEN**	**CLOSED CONTACT WHEN**
IN-1	CLOSED	Breaker status	Brk Open or Racked out	Bkr Closed
IN-2	TRIP	Breaker status	Brk closed or Racked out	Bkr Open
IN-3	SPARE			
IN-4	TEST POSITION	Breaker Position	Racked In or Racked Out	Test Pos.
IN-5	MANUAL POSITION	Auto/Manual Switch Position	Auto Position	Manual Position
IN-6	RELAY 201C PICKUP	From 201C relay contact	Normal	Picked Up
IN-7	RELAY 201T PICKUP	From 201T relay contact	Normal	Picked Up
IN-8	DC SWG 86 LOCKOUT	Lockout relay status	Lockout	Normal
IN-9	LOST OF CONTROL POWER (27)	Contact from relay 27	Loss Power	Normal
IN-10	RACKED-IN	Breaker position	Racked out	Racked in
IN-11	DC SWGR ENERGIZED STRUCTURE (64DX)	Contact from 64 relay	Alarm	Normal
IN-12	DC MPR Critical Failure	Contact from DC relay	Failure	Normal
IN-13	BRK CBCM TRIP CKT SUPERVISION FAILURE [1]	CBCM TCS healthy contact	Failure	Normal
IN-14	BRK CBCM CONTROLLER FAILURE [1]	CBCM Control Healthy contact	Normal	Failure
IN-15	DC SWGR GROUNDED STRUCTURE (64DY)	Contact from 64 relay	Alarm	Normal
IN-16	DC BKR REVERSE CURRENT (32) DEVICE PICKUP	Breaker Trip on reverse current	Normal	Picked Up
	COMMOM WIRE (-) COMMON IS CONNECTED TO EVEN NUMBERS			

NOTES:

1. DIO output contacts shall be connected to interposing relays for breaker controls.
2. Use 125VDC external control power source for the interposing relays close and trip coils.
3. To provide racked out indication to Control Center:
   a. For “breaker open” status indication, the breaker MOC “b” contact is wired in series with the breaker TOC “a” Contact.
   b. For “breaker closed” status indication the breaker MOC “a” contact is wired in series with the breaker TOC “a” Contact.

DIO TERMINAL BLOCK ASSIGNMENTS FOR TPSS DC FEEDER BREAKER

CONTROL	FUNCTION	DESCRIPTION		
OUT-1	CONTROL TRIP	To energize relay 201 Trip coil		
OUT-2	CONTROL CLOSE	To energize relay 201 Close coil		
STATUS	**FUNCTION**	**DESCRIPTION**	**OPEN CONTACT WHEN**	**CLOSED CONTACT WHEN**
IN-1	CLOSED	Breaker status	Brk Open or Racked out	Bkr Closed
IN-2	TRIP	Breaker status	Brk closed or Racked out	Bkr Open
IN-3	SPARE			
IN-4	TEST POSITION	Breaker Position	Racked In or Racked Out	Test Pos.
IN-5	LOCAL POSITION	Local/Remote Switch Position	Remote Position	Local Position
IN-6	RELAY 201C PICKUP	From 201C relay contact	Normal	Picked Up
IN-7	RELAY 201T PICKUP	From 201T relay contact	Normal	Picked Up
IN-8	DC SWG 86 LOCKOUT	Lockout relay status	Lockout	Normal
IN-9	LOST OF CONTROL POWER (27)	Contact from relay 27	Loss Power	Normal
IN-10	RACKED-IN	Breaker position	Racked out	Racked in
IN-11	SPARE			
IN-12	DC MPR Critical Failure	Contact from DC relay	Failure	Normal
IN-13	BRK CBCM TRIP CKT SUPERVISION FAILURE [1]	CBCM TCS healthy contact	Failure	Normal
IN-14	BRK CBCM CONTROLLER FAILURE [1]	CBCM Control Healthy contact	Normal	Failure
IN-15	BRK CBCM OVERLOAD OPERATION[1]	CBCM Overload Operation contact	Normal	Failure
IN-16	SPARE			
	COMMOM WIRE (-) COMMON IS CONNECTED TO EVEN NUMBERS			

NOTES:

1. DIO output contacts shall be connected to interposing relays for breaker controls.
2. Use 125VDC external control power source for the interposing relays close and trip coils.
3. To provide racked out indication to Control Center:
   a. For “breaker open” status indication, the breaker MOC “b” contact is wired in series with the breaker TOC “a” Contact.
   b. For “breaker closed” status indication the breaker MOC “a” contact is wired in series with the breaker TOC “a” Contact.

DIO TERMINAL BLOCK ASSIGNMENTS FOR TBS DC FEEDER BREAKER

CONTROL	FUNCTION	DESCRIPTION		
TB2A-1-2	CONTROL TRIP	To energize relay 201 Trip coil		
TB2A-4-5	CONTROL CLOSE	To energize relay 201 Close coil		
STATUS	**FUNCTION**	**DESCRIPTION**	**OPEN CONTACT WHEN**	**CLOSED CONTACT WHEN**
IN-1	CLOSED	Breaker status	Brk Open or Racked out	Bkr Closed
IN-2	TRIP	Breaker status	Brk closed or Racked out	Bkr Open
IN-3	SPARE			
IN-4	TEST POSITION	Breaker Position	Racked In or Racked Out	Test Pos.
IN-5	LOCAL POSITION	Local/Remote Switch Position	Remote Position	Local Position
IN-6	RELAY 201C PICKUP	From 201C relay contact	Normal	Picked Up
IN-7	RELAY 201T PICKUP	From 201T relay contact	Normal	Picked Up
IN-8	DC SWG 86 LOCKOUT	Lockout relay status	Lockout	Normal
IN-9	LOST OF CONTROL POWER (27)	Contact from relay 27	Loss Power	Normal
IN-10	RACKED-IN	Breaker position	Racked out	Racked in
IN-11	DC SWGR ENERGIZED STRUCTURE (64DX)	Contact from 64 relay	Alarm	Normal
IN-12	DC MPR Critical Failure	Contact from DC relay	Failure	Normal
IN-13	BRK CBCM TRIP CKT SUPERVISION FAILURE [1]	CBCM TCS healthy contact	Failure	Normal
IN-14	BRK CBCM CONTROLLER FAILURE [1]	CBCM Control Healthy contact	Normal	Failure
IN-15	BRK CBCM OVERLOAD OPERATION[1]	CBCM Overload Operation contact	Normal	Failure
IN-16	DC SWGR GROUNDED STRUCTURE (64DY)	Contact from 64 relay	Alarm	Normal
	COMMOM WIRE (-) COMMON IS CONNECTED TO EVEN NUMBERS			

NOTES:
1. DIO output contacts shall be connected to interposing relays for breaker controls.
2. Use 125VDC external control power source for the interposing relays close and trip coils.
3. To provide racked out indication to Control Center:
   a. For “breaker open” status indication, the breaker MOC “b” contact is wired in series with the breaker TOC “a” Contact.
   b. For “breaker closed” status indication the breaker MOC “a” contact is wired in series with the breaker TOC “a” Contact.

END OF SECTION

SECTION 28 40 05.01

DISTRIBUTED I/O (DIO) FOR RETROFITT TRACTION POWER SWITCHGEAR

PART 1 - GENERAL

1.01 SUMMARY

1. This section specifies Distributed Input Output (DIO) modules to be retrofitted into existing AC & DC switchgears.
2. Control I/O Modules are DIOs to be provided to retrofit existing Traction Power System AC & DC switchgears only. The modules receive digital control signals from the RTU and provide relay contact control outputs to the breakers. The modules also receive contact signals from the breakers and send the corresponding digital signals to the RTU.
3. The DIOs are provided pre-wired and mounted in DIO cabinets
4. The DIO communicates with the station RTU via Network switch using DNP3 protocol over fiber cable.
5. These DIOs provide supervisory control of breakers without 201T and 201C interposing relays.

A. Related Sections:

1. Section 28 40 00 – SCADA Work for Traction Power Systems
2. Section 28 40 01 – SCADA Systems Training
3. Section 28 40 07 – Human Machine Interface (HMI)
4. Section 28 40 02 –- RTU for Traction Power systems
5. Section 28 40 04 – Network Switch for SCADA and Automation Systems
6. Section 28 40 06 – SCADA Systems Integration Testing and Documentation for TPSS and TBS

B. Operating Requirements

1. Designed for continuous, unattended operation to perform:
    a. Analog and digital data acquisition
    b. Digital control.

.

C. Input Power Requirements

1. 125 Volts DC from switchgear control power.

D. Wetting Voltages

1. 125VDC external voltage from the switchgear.

1.02 REFERENCES

A. Code, Regulations, Reference Standards and Specifications

1. Code and Regulation of jurisdictional authorities
2. NEC
3. NEMA 250, ICS-6, WC8, 12
4. ANSI C37.90, Z55.1, C12
5. EIA: RS 232.C
6. ASTM: B138
7. ASHRAE/ANSI: 135P
8. ICEA: S-68-516

1.03 QUALITY ASSURANCE

A. Qualifications:

1. DIO and manufacturers or approved equal:
   a. SEL -2240 AXION by Schweitzer Engineering Laboratories, Inc.
   b. BITRONICS 878 DIOD by Novatech
2. DIO installers: AC and DC switchgear manufacturers.

B. For Code, Regulations, Reference Standards and Specifications, refer to Article 1.02 above.

C. The Contractor shall develop field test procedures for the installed DIOs.

D. The contractor shall submit certified factory test report on individual DIO.

E. End-to-End Test:

1. The Contractor shall demonstrate the proper functioning of each installed DIO including all components and telemetry between each piece of equipment monitored or controlled by the DIO by using the station HMI connected to the RTU/Network Switch in the presence of WMATA representatives.
2. Simulation of sensors by shorting contacts is to be avoided unless other activation is not possible.
3. Each status and control point connected to the DIO shall be tested for proper operation.

F. Submit certified test report within ten days after completion of field tests.

1.04 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements in accordance with Division 1 and with the additional requirements as specified for each:

1. Shop Drawings: Show the following as a minimum:
   a. Electrical wiring diagrams and detail control schematics.
   b. Electrical and mechanical details
   c. Wire and cable schedules, interconnection diagrams, point assignment charts, and connection diagrams.
   d. DIO cabinet drawings
2. Composite control/status and telemetering sensing equipment schedule.
3. Product Data: Submit data sheet annotated product data for each item of equipment and resubmittal.
4. Software and Configuration file: Submit the DIO configuration software and configuration files.
5. As-Built Documents: Prior Substantial Completion develop an as-built documents as follows:
   a. As-built drawings of the installation: 11-inch by 17-inch composite interconnection wiring diagram showing the entire DIO interface system. Provide sufficient copies to be stored in each switchgear cabinet door pocket.
   b. Approved copies of each submittal.
   c. Provide As-built drawings in both AutoCAD and PDF formats on CD in sleeves.
6. Operation and maintenance (O & M) manuals: Refer to section 16053B Training for SCADA

7. Spare Parts Lists: Provide 20% complete control I/O modules.
8. Certification:
   a. Certified test results for the specified tests on the DIO Unit or provide certified test reports on identical unit.
   b. Certificates from manufacturers verifying that equipment conforms to the specified

B. Software: Provide a configuration and testing software with licenses.

1.05 TRAINING: Refer to section 28 40 01 (16053D) for training requirements.

PART 2 – PRODUCTS

2.01 GENERAL

A. Remote control and monitoring of the existing AC & DC switchgear to remain. Traction Power System breakers by the Operations Control Center (OCC) and Human Machine Interface (HMI) are provided by DIOs and installed in a free stand cabinet. OCC control commands are received by the SCADA RTU through the Wide Area Network (WAN)/Local Area Network (LAN), the RTU executes the control through the DIOs using DNP3 protocol. The RTU receives breaker status from the DIOs and transmit the data back to OCC through the WAN/LAN.

B. DIOs shall be provided for each existing AC & DC switchgear to remain. The modules shall receive digital control signals from the RTU or switchgear PLC and provide relay contact control outputs to the breakers. DIO Digital output contacts shall be rated high current for direct control of breakers without the use of interposing relays. The Digital input contacts shall also receive dry contact signals from the breakers and send the corresponding digital signals to the RTU.

C. The Control I/O Modules shall be 125VDC supply at the switchgear.

D. The DIO wetting voltage shall be 125V DC.

2.02 DISTRIBUTED I/O (DIO)

A. The I/O modules shall provide status monitoring with 1 millisecond Sequence of Events (SOE) time tagging, and a highly secure select-before-operate controls. The I/O modules

installed in AC/DC switchgears DIO cabinet shall be in self-contained enclosures with shock mount provisions and suitable for surface mounting, 19” Rack mounting, or DIN rail mounting. The I/O modules shall provide front panel LED indicators for all status inputs, all controls, and all communication port transmit/receive.

2.03 WINDOWS CONFIGURIBILITY

A. The DIO configuration software provided shall run on a PC with standard Windows 7 or higher and shall provide drag & drop menus to configure communication ports; status, alarm and control points; RTU communication Servers; and local calculations and stand-alone control algorithms. The module configuration shall require secure login with a user’s ID and password, and shall maintain all attempted log-ins (dated, time-stamped) and all operational and configurable changes to the module database in a log file.

2.04 COMMUNICATIONS

A. I/O modules shall be equipped and easily configured to communicate with a single RTU over 100baseFX Ethernet multimode fiber optic using DNP3 protocol.

2.05 TIME SYNCRONIZATION

A. The I/O modules shall be equipped to receive NTP time synchronization over the multimode fiber port.

2.06 CONTROLS

A. DIO digital output contacts shall be rated high current for direct control of breakers without the use of interposing relays.

a. Mechanical Durability: 10 M no load operations

b. Rated Operational Voltage: 250 VDC

c. Rated Voltage Range: 19.2–275 Vdc

d. DC output current rating: 30 A @ 250 Vdc per IEEE C37.90

e. DC Output Continuous current: 6 A @ 70°C; 4 A @ 85°C

f. DC Output Thermal Rating: 50 A for 1 s

g. Contact Protection: 330 Vdc, 145 J MOV protection across open contacts

h. Operating Time (coil energization to contact closure, resistive load):

i. Pickup time: ≤ 16 µs at 125 Vdc, (results with 100 k□ resistive load)

ii. Dropout time: ≤ 8 ms typical

B. Trip/close relay pairs shall execute controls with secure, multi-step handshaking with a DIO consisting of receiving a point selection message, responding with a “checkback” message, receiving a control execution message, and responding with an execution acknowledgment message.

C. Failsafe control circuits in the I/O module shall ensure that only one relay can be energized at a time, and execute duration shall be configurable per point from 50 milliseconds to 10 seconds.

D. Control relay outputs shall consist of one form-A contact rated 30-amp “make” at 130 VDC. Termination shall be made to removable terminal blocks secured with screws to the I/O modules.

E. Minimum quantity of high current digital output contacts shall be 40 for each of AC or DC switchgear. The minimum quantity includes the required spare contacts.

2.07 STATUS INPUTS

A. Each switchgear DIO system shall monitor a minimum of two hundred forty (240) status inputs with Sequence of Events (SOE) recording accurate to 1 millisecond. The modules shall respond to rapid polls for changes only, and shall retain all changes until the RTU acknowledges receipt of those changes.

B. Each I/O module shall buffer and report a minimum of 7 changes of state occurring between polls for each status point.

C. In addition, the I/O modules shall store up to 25 time-stamped events per-point in files that can be retrieved by a Laptop Test Set.

D. Status inputs shall be optically isolated to meet IEEE Surge Withstand Capability test C37.90.1-2000.

E. Each status inputs shall be configurable for 5 milliseconds to 1 second de-bounce, and for 125VDC keying voltage.

a. 125 VDC Control Signals: ON for 100–135.5 Vdc OFF below 75 Vdc
b. Current Draw at Nominal DC Voltage: 2–4 mA (Except for 24 V, 8 mA)
c. Rated Insulation Voltage: 300 Vac

d. Rated Impulse Withstand Voltage (Uimp): 4000 V

F. Switchgear 125VDC control power shall be used for 125VDC keying voltage source. Termination shall be made to removable terminal blocks secured with screws to the I/O module.

2.08 ENVIRONMENTAL

A. -40 to +85 degrees centigrade, 5 to 95% humidity (non-condensing)

B. IEEE Surge Withstand Capability test C37.90.1-2000

C. IEEE Susceptibility C37.90.1, .2, and .3

2.09 WIRING

A. Status: Status indication wire size shall be 12AWG and the type as specified in the switchgear sections.

B. Wiring identified at each termination, with same number shown on wiring diagram, using suitable plastic sleeve attached within six inches of terminal connections.

C. DIO wiring shall be in compliance with requirement in Section 34 24 05 (16052) - Basic Materials and Methods for Traction Power

D. Fiber from DIO to Network switch shall be via patch panel.

PART 3 - EXECUTION

3.01 SOURCE QUALITY CONTROL

A. Design and Production Tests: Perform and submit in accordance with the General Provisions, certified test results for the tests on each unit of DIO supplied under this contract.

3.02 INSTALLATION

A. DIO shall be installed in a free standing DIO cabinet with the LEDs visible to a technician standing in front of the cubicle.

B. DIO cabinet shall be delivered with DIO pre-installed and wired for field installation as

shown in accordance with approved shop drawings.

C. DIO Cabinet shall be installed on the side of the AC or DC switchgear where space is available.

D. Perform work in accordance with the NEC.

E. Raceways Boxes and Cabinets:

1. Install conduit, raceways, boxes, fittings in accordance with Section 16130.

F. Wiring:

1. Install wiring per terminal block assignments tables.

G. Install auxiliary contacts as required for remote monitoring implementation as shown on drawings.

3.03 FIELD TESTING:

A. The Contractor shall perform polarity and continuity test on all interconnection wiring.

B. The contractor shall verify correct operation of each input/output contact. Simulated DIO interface test unit shall be used to verify spare contacts operations.

C. The Contractor shall label all wiring terminations to reflect the connection points.

D. The Contractor is responsible for the programming of the DIOs. Refer to appendix A tables for point assignments.

E. The Contractor is responsible for testing all DIO input signals to verify correct status and telemetry signal levels. A test data sheet shall be developed for each DIO which list all I/O signal points. The data sheet shall be submitted as part of the Contractors test plan. The Contractor shall submit a list of discrepant I/O signal points to the Engineer. I/O equipment supplied under this contract that is not reporting properly shall be corrected and retested. The Contractor shall submit a discrepancy report for all I/O points indicating problems found and required action.

APPENDIX A: TERMINAL BLOCK ASSIGNMENTS TABLES

DIO control point Assignments

DIO CABINET TERMINAL BLOCK	AC SWITCHGEAR		DC SWITCHGEAR	
	FUNCTION	DESCRIPTION	FUNCTION	DESCRIPTION
TB2/1-2	01 TRIP	01 Breaker trip control	21 TRIP	21 Breaker trip control
TB2/4-5	01 CLOSE	01 Breaker close control	21 CLOSE	21 Breaker close control
TB2/7-8	02 TRIP	02 Breaker trip control	22 TRIP	22 Breaker trip control
TB2/10-11	02 CLOSE	02 Breaker close control	22 CLOSE	22 Breaker close control
TB2/13-14	11 TRIP	11 Breaker trip control	23 TRIP	23 Breaker trip control
TB2/16-17	11 CLOSE	11 Breaker close control	23 CLOSE	23 Breaker close control
TB2/19-20	12 TRIP	12 Breaker trip control	24 TRIP	24 Breaker trip control
TB2/22-23	12 CLOSE	12 Breaker close control	24 CLOSE	24 Breaker close control
TB2/25-26	13 TRIP	13 Breaker trip control	31 TRIP	31 Breaker trip control
TB2/28-29	13 CLOSE	13 Breaker close control	31 CLOSE	31 Breaker close control
TB3/1-2	14 TRIP	14 Breaker trip control	32 TRIP	32 Breaker trip control
TB3/4-5	14 CLOSE	14 Breaker close control	32 CLOSE	32 Breaker close control
TB3/7-8	AUX1 TRIP	AUX1 Breaker trip control	33 TRIP	33 Breaker trip control
TB3/10-11	AUX1 CLOSE	AUX1 Breaker close control	33 CLOSE	33 Breaker close control
TB3/13-14	AUX2 TRIP	AUX2 Breaker trip control	34 TRIP	34 Breaker trip control
TB3/16-17	AUX2 CLOSE	AUX2 Breaker close control	34 CLOSE	34 Breaker close control
TB3/19-20	SPARE	SPARE	35 TRIP	35 Breaker trip control
TB3/22-23	SPARE	SPARE	35 CLOSE	35 Breaker close control
TB3/25-26	SPARE	SPARE	36 TRIP	36 Breaker trip control
TB3/28-29	SPARE	SPARE	36 CLOSE	36 Breaker close control
TB4/1-2	SPARE	SPARE	37 TRIP	37 Breaker trip control
TB4/4-5	SPARE	SPARE	37 CLOSE	37 Breaker close control
TB4/7-8	SPARE	SPARE	38 TRIP	38 Breaker trip control
TB4/10-11	SPARE	SPARE	38 CLOSE	38 Breaker close control
TB4/13-14			39 TRIP	39 Breaker trip control
TB4/16-17			39 CLOSE	39 Breaker close control
TB4/19-20			SPARE	
TB4/22-23			SPARE	
TB4/25-26			SPARE	
TB4/28-29			SPARE	

NOTES: For standardization, control points are spares if breaker is not provided in substation.

DC SWITCHGEAR BREAKER DIO STATUS POINT ASSIGNMENTS

STATUS TB BREAKER X	FUNCTION	DESCRIPTION	OPEN CONTACT WHEN	CLOSED CONTACT WHEN
TBX-1/2	CLOSED	Breaker status	Brk Open or Racked out	Bkr Closed
TBX-3/4	TRIP	Breaker status	Brk closed or Racked out	Bkr Open
TBX-5/6	MPR SETTING VIOLATION	Alarm when MPR setting is changed	Failure	Normal
TBX-7/8	TEST POSITION	Breaker Position	Racked In or Racked Out	Test Pos.
TBX-9/10	LOCAL POSITION	Local/Remote Switch Position	Remote Position	Local Position
TBX-11/12	RELAY 201C PICKUP	From 201C relay contact	Normal	Picked Up
TBX-13/14	RELAY 201T PICKUP	From 201T relay contact	Normal	Picked Up
TBX-15/16	DC SWG 86 LOCKOUT	Lockout relay status	Lockout	Normal
TBX-17/18	LOST OF CONTROL POWER (27)	Contact from relay 27	Loss Power	Normal
TBX-19/20	RACKED-IN	Breaker position	Racked out	Racked in
TBX-21/22	ENERGIZED STRUCTURE	DC SWG Energized Structure	Alarm	Normal
TBX-22/23	DC MPR Critical Failure	Contact from DC relay	Failure	Normal
TBX-25/26	BRK CBCM TRIP CKT SUPERVISION FAILURE [2]	CBCM TCS healthy contact	Failure	Normal
TBX-27/28	BRK CBCM CONTROLLER FAILURE [2]	CBCM Control Healthy contact	Normal	Failure
TBX-29/30	BRK OVERLOAD OPERATION	Overload Operation contact	Normal	Failure
TBX-31/32	GROUNDED STRUCTURE	DC SWG Grounded Structure	Alarm	Normal
	COMMOM WIRE (-) COMMON IS CONNECTED TO EVEN NUMBERS			

NOTES:

1. To provide racked out indication to Control Center:
   a. For “breaker open” status indication, the breaker MOC “b” contact is wired in series with the breaker TOC “a” Contact.
   b. For “breaker closed” status indication the breaker MOC “a” contact is wired in series with the breaker TOC “a” Contact.
2. For breakers with control module

X = CATHODE AND FEEDER BREALERS

AC SWITCHGEAR DIO STATUS POINT ASSIGNMENTS

STATUS TB BREAKER X	FUNCTION	DESCRIPTION	OPEN CONTACT WHEN	CLOSED CONTACT WHEN
TBX-1/2	CLOSED	Breaker status	Brk Open or Racked out	Bkr Closed
TBX-3/4	TRIP	Breaker status	Brk closed or Racked out	Bkr Open
TBX-5/6	DC SWG 86 LOCKOUT	Lockout relay status	Lockout	Normal
TBX-7/8	27/59 PICKUP	Under/Over Voltage	Picked up	Normal
TBX-9/10	SPARE			
TBX-11/12	RACKED-IN	Breaker position	Racked out	Racked in
TBX-13/14	LOCAL POSITION	Local/Remote Switch Position	Remote Position	Local Position
TBX-15/16	RELAY 201C PICKUP	From 201C relay contact	Normal	Picked Up
TBX-17/18	RELAY 201T PICKUP	From 201T relay contact	Normal	Picked Up
TBX-19/20	LOST OF CONTROL POWER (27)	Contact from relay 27	Loss Power	Normal
TBX-21/22	51 BX PICKUP	51B ACTIVATION	Alarm	Normal
TBX-22/23	DC MPR Critical Failure	Contact from DC relay	Failure	Normal
TBX-25/26	MPR SETTING VIOLATION	Alarm when MPR setting is changed	Failure	Normal
TBX-27/28	SPARE			
TBX-29/30	SPARE			
TBX-31/32	SPARE			

NOTES:

1. To provide racked out indication to Control Center:
   a. For “breaker open” status indication, the breaker MOC “b” contact is wired in series with the breaker TOC “a” Contact.
   b. For “breaker closed” status indication the breaker MOC “a” contact is wired in series with the breaker TOC “a” Contact.

X = ALL AC BREAKERS

END OF SECTION

SECTION 28 40 06

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATION

PART 1 – GENERAL

1.01 SUMMARY

A. This section describes the specific requirements for testing and documenting the SCADA system installed.

B. Equipment wherever mentioned in this specification for type testing shall conform to the type tests listed in the relevant specifications. In case, the submitted reports are not as per specification, the type tests shall be conducted without any cost implication to WMATA.

C. Tests listed in this specification cover design test, Factory Acceptance test, system compatibility tests and site acceptance tests required before new SCADA system and components are put into production for the support of WMATA revenue services.

D. Site Acceptance Tests shall be conducted by contractor system integrator and witnessed by WMATA SCADA engineering.

E. Related Sections:

1. Section 28 40 00 – SCADA Work for Traction Power Systems
2. Section 28 40 00.1 – SCADA Work for Passenger Station AC Rooms
3. Section 28 40 08 – Wire, Cable, Cable Tray and Termination Panel for SCADA System
4. Section 28 40 07 – Human Machine Interface (HMI) Panel for Traction Power
5. Section 28 40 02 – RTU for Traction Systems.
6. Section 28 40 03 – DC Digital Trace Recorder for Traction Power.
7. Section 28 40 04 – Network Switch for SCADA and Automation Systems
8. Section 28 40 05 – Distributed input output (DIO) module for Traction Power
9. Section 28 40 05.1 – DIO for Retrofitted Traction Power Switchgears

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements in accordance with Division 1 and with the additional requirements as specified for each:

1. Design Tests reports performed for each type of RTU as assembled in its complete RTU unit, furnished under this contract.
2. Production Tests reports performed for each SCADA equipment or Device as assembled in its complete unit, furnished under this contract.
3. Test Procedures: The contractor shall develop and submit Design, production and installation test procedures based on requirements in this specification.
4. As Built documents: All sign-off sheets to be included in the as-built documents.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. CONTRACTOR shall retain the services of the SCADA RTU manufacturer or their authorized representative to be the system integrator, supervise and/or perform check-out, start-up of all system components, check the equipment installation and place the equipment in operation. The manufacturers' representative shall be thoroughly knowledgeable about the installation, operation and maintenance of the equipment.

B. System Configuration:

1. RTU provided under this contract shall be configured and setup using WMATA Point Assignment List template in the same order to ensure compatibility with existing master stations.
2. Database shall be able to be created automatically from the RTU file using an intermediate conversion program for Master Stations.
3. The contractor is responsible for all SCADA field equipment configuration and setup to properly communicate with Master station using DNP3 Protocol.

C. Factory Testing: Factory testing of each RTU shall be conducted at the manufacturer’s facility in the USA.

D. System Compatibility Test: System compatibility test shall be conducted at the WMATA

SCADA LAB where the RTU shall be connected to WMATA DNP3 Master Stations. The RTU shall be simulated for the complete ultimate size point counts. The requirements for exchanging data with AIM servers, SCADA server, and IT system shall also be simulated.

E. Site Acceptance Tests: Field installation and end to end tests shall be conducted.

PART 2 – EXECUTION

2.01 RTU Factory Acceptance Test (FAT):

A. Factory testing of each RTU shall be conducted at the manufacturer's premises. Provision shall be made for witness testing of all equipment. Three weeks advanced notice shall be provided to WMATA prior to testing.

B. Each RTU shall be fully assembled and configured for factory testing.

C. Tests shall include, but not be limited to:

1. Point to point wiring check.
2. Serial numbers of all cards and modules shall be listed in an Excel spreadsheet
3. Confirmation of all digital inputs & outputs, from the field terminal through to the diagnostic laptop.
4. Verification of analogue values received (at least zero, half full scale, full scale values and negative full scale values for bipolar analogues) using a DC current or voltage signal generator measured from the field terminals to the diagnostic laptop.
5. Confirmation of control functions from the diagnostic laptop to the field terminals, including exercising the dummy circuit breaker, and the controls isolate switch.
6. Confirmation of effective communications between the RTU and other devices using the specified protocols.
7. All powered tests shall be carried out at the specified power supply rating of the RTU.

D. Test results for each RTU showing tests undertaken, results and any corrective action taken shall be provided in an approved format and shipped with the RTU. Color photographs shall be included in the test results to record the equipment layout.

2.03 System Compatibility Test:

A. After completion of the SCADA system design tests, the proposed RTU shall be tested for and compatibility with WMATA system servers.

B. The compatibility tests shall be conducted at the WMATA SCADA engineering LAB where the provided RTU shall be connected to WMATA AIM and SCADA servers.

C. CONTRACTOR shall provide all labor, materials, software, configuration, equipment, engineering and incidentals required to perform system compatibility tests.

D. The RTU shall be simulated for the complete ultimate size point counts. All requirements for exchanging data with AIM servers and SCADA servers shall be simulated. The compatibility tests shall include but not limited to the following functional performance tests:

1. Simulation of field inputs from DNP3/Modbus simulator that allow sample inputs to be varied over the entire input range.
2. Simulation of field input error and failure conditions.
3. Simulation of all type of sample control outputs.
4. Verification of RTU communication Protocol DNP3 with master stations.
5. Verification of Security & Encryption for all connectivity.
6. Verification of Data Integration from SCADA system to AIM and SCADA server over DNP3.
7. Verification of RTU communication interfaces.
8. Verification of LAN and WAN interfaces with other computer systems.
9. Testing of all user interface functions, including random tests to verify correct database linkages.
10. Simulation of hardware failures and input power failures to verify the reaction of the system to processor and device failure.
11. Verification of all features of the database, display, and report generation on both the OCC primary and backup servers.
12. Demonstration of the software utilities, libraries, and development tools.
13. Verification that the RTU meets or exceeds performance requirements for peak & normal loading.

E. Continuous operation Test (48 hours)

1. This test shall verify the stability of the RTU and software after the functional performance test has been successfully completed. During the test, all SCADA functions shall run concurrently and the RTU shall operate for a continuous 48 (forty-eight) hour period with simulated exchange with other interconnected system AIM and SCADA servers. The test procedure shall include periodic repetitions of the normal and peak loading scenarios defined. These activities to be tested may include, but shall not be limited to, database, display, and report modifications, configuration changes (including user-commanded processor and device failover), switching off of a primary server and the execution of any function described in this Specification. During the tests, un-commanded functional restarts or device failovers are not allowed; in case the problems are observed, the Contractor shall rectify the problem and repeat the test.

2.04 Site Acceptance Tests:

A. The SCADA system shall be tested at the site. All hardware and software associated with the SCADA system along with all RTUs/HMI/DIOs/DTR/RELAYs/IEDs with all field devices connected shall be tested under the field tests.

B. The SCADA system shall be scheduled, coordinated and performed by the contractor system integrator and witnessed by WMATA.

C. The system integrator shall develop site specific RTU, HMI configuration files before the SCADA system site acceptance test is scheduled. The configuration of the RTU, HMI shall be scheduled by the contractor as part of the SCADA system site acceptance tests.

D. All AIM and SCADA server points shall be verified using a master station simulator.

E. All SCADA server points shall be verified using an actual SCADA server if connectivity is available.

F. TEST EQUIPMENTS

The following test equipment shall be used in the performance of the field tests. Record of test equipment calibration is noted on the last page of the test forms.

1. AC Microprocessor Relay Test Set
2. Variable DC power supply from 0 to 1000 volt D.C.
3. Digital and Analog Multi-meters
4. Voltage/current precision calibrator

5. RTD/Heat gun

G. FIELD INSTALLATION TESTS

1. The equipment which has undergone the factory testing shall be installed at site and integrated with other systems though the communication medium.
2. The field installation test shall include the following:
   a. Proper installation of all delivered hardware as per approved layout.
   b. Interconnection of all hardware.
   c. Communication cables (Fiber and Cat 6).
   d. Interconnection with communication network switches.
   e. Interconnection with power supply.
   f. Diagnostic tests to verify the operation of all hardware.
   g. Random checking of SCADA software basic functions.
   h. Set and Verify Network Time Synchronization for each IP device.
3. The Contractor shall be responsible for performing all field installation tests witnessed by WMATA contract officer representative.
   a. Communication Network
      1) Install network switches as per approved layout and drawings.
      2) Install and test fiber cables (Single-Mode and Multi-Mode).
      3) Install and test CAT 6 cables.
      4) Install Fiber patch cords as per approved layout.
      5) Verify connectivity to WMATA Metronet.
   b. RTU Configuration
      1) Complete RTU Configuration and Setup.
      2) Verify communication between RTU and all field equipment IEDs.
      3) Verify Communication between RTU and Network servers
   c. HMI Configuration
      1) Complete HMI Configuration and Setup.
      2) Verify communication between RTU and HMI.
      3) Verify HMI properly displays all equipment status and analog values.
      4) For all individual IED test, observe all status report by HMI are correct.
      5) Observe all Annunciator points are on HMI.

6) Control all breakers from HMI.
7) Observe “HMI commanded” on Alarm History.
8) Observe active alarm log is correct.
9) Observe Alarm History is correct.
10) Verify all critical alarms activate the buzzer.
11) Verify buzzer is silenced by the touch screen button.

d. Miscellaneous field verifications

1) Verify all IP addresses assigned for each device.
2) Verify version for each DIO Module.
3) Verify the DIP switch address for each DIO Module.
4) Verify hard Wire terminations inside RTU.
5) Verify all fiber terminations and connectivity to the Network switch.

e. AC Microprocessor Relays Test

Objective: Verification of relay communication and DNP3 mapping as per the approved point assignment charts.

1) Set relay IP address.
2) Using a suitable three phase current source verify that the relay protection settings operate the appropriate output relays at the proper current and time settings.
3) Verify proper target operation on relay for each point.
4) Verify HMI for proper display of point tested.
5) Verify AIM points are received.
6) Verify SCADA server points are received.

f. AC Switchgear Power Quality Meters

Objective: Verification that AC Switchgear meters are set correctly and communicate with SCADA using DNP3 protocol.

1) Set meter IP address.
2) Verify the Digital Power Meters have been programmed to communicate with the SCADA system.
3) Using a suitable three phase current and voltage source verify the scale of the instrumentation.
4) Verify meter display proper values at 25%, 50%, 75% and 100% of full scale.
5) Verify proper polarity.

6) Verify proper communication with the SCADA system using the substation HMI.

7) Verify server for correct data.

g. Distributed Input Output Module (DIO)

Objective: Verification of breaker controls and status, verification of DIO communication with SCADA.

1) Set IP address.

2) Verify DIO communication with RTU

3) Verify breaker status display on HMI

4) Perform functional checks of all control and indication circuitry. Specific functions include tripping, closing, remote operation, rack-out, 86 lockout, local remote switch position, 201C pickup, 201T pickup, AC MPR critical failure, Loss of Dc control Power and DIO failure.

5) For each control or indication point, verify proper communication with the SCADA system using the substation HMI.

6) Verify controls by OCC and HMI

7) Verify all indication points on AIM and SCADA server.

h. Transformer testing

Objective: Verification that rectifier transformer monitoring system communication module is properly wired to RTU and alarms are properly received by the SCADA RTU.

1) Set Transformer Monitor IP address

2) Verify transformer monitor communication with RTU

3) Verify transformer data is properly displayed on HMI

4) Use a laptop computer with the appropriate software to simulate faults, alarms and contact closure as appropriate for remote indications.

5) Verify status and analog points are properly received by the RTU.

6) Verify status and analog points are properly displayed on the HMI.

7) Verify AIM points.

8) Verify all SCADA server points.

i. Rectifier Testing

Rectifier tests shall be scheduled after functional tests of all control circuitry including temperature, Diode and other protective devices have been verified for proper operation.

1) Set IP address.
2) Verify Rectifier monitor communication with RTU.
3) Verify Rectifier data is properly displayed on HMI.
4) Simulate faults, alarms and contact closures as per the rectifier point assignment charts for remote indications.
5) Verify status and analog points are properly received by the RTU.
6) Verify status and analog points are properly displayed on the HMI.
7) Verify all AIM points.
8) Verify all SCADA server points.

j. DC Protective Relays Testing

1) Set IP Addresses.
2) Program relays to communicate with SCADA per the approved DNP3 protocol communication mapping.
3) Set relays per the approved coordination study.
4) Enable appropriate alarms.
5) Verify proper target operation for each mapping point tested.
6) Verify proper communication with the SCADA system using the substation HMI.
7) Verify all AIM points.
8) Verify All SCADA server points.

k. Digital Trace Recorder (DTR) Test

1) Create a DTR setup configuration offline and program the DTR.
2) Laptop with DTR software shall serve as HMI for the tests.
3) Set all communication parameter and IP addresses.
4) Verify interconnection of all hardware.
5) Disconnect wire to each DTR input module and calibrate each module individually without connection to the shunts.
6) Verify and calibrate each current transducer (Pos. SWG & Neg. SWBD)
   a) Connect DTR input modules to the appropriate

transducers.

b) Connect test equipment leads to the terminals of the fuse connected to the transducer (Observe correct polarities). Ensure test leads are not connected to the terminal of the fuse connected to the shunt.

c) Inject 50mv, observe breaker meter is reading full DC shunt ratio scale.

d) Observe on laptop that the signal is on the correct DTR channel and the analog value is correct.

e) Calibrate as necessary using transducer Zero and Gain

f) Inject 100mv, observe on laptop DTR software that the reading is correct.

g) Calibrate as necessary using transducer Zero and Gain

h) Inject 300mv and 450mv, observe on laptop that the analog value is correct.

i) Calibrate current transducers for all feeder and cathode breakers.

7) Verify and calibrate each voltage transducer (Pos. SWG & Neg. SWBD)

a) Identify the correct Voltage Transducer for the DTR.

b) Connect a variable 1000V DC power supply test leads to the fuse terminals (Observe correct polarities).

c) Inject 1000v, observe breaker meter is reading 1000V.

d) Observe on laptop that the signal is on the correct DTR channel and the analog value is correct.

e) Calibrate as necessary using Zero and Gain.

f) Inject 0V, 750V and 1000V DC observe breaker meter reading is correct

g) Observe on laptop that the analog value is correct.

8) DC Relay Fault Trigger Verification.

a) Simulate a DC switchgear fault that will initiate the tripping of the DC breaker by the MPR.

b) Verify and record fault type on DC switchgear.

c) Verify that the DTR trigger function worked and recorded the fault wave form with proper before and after fault

time.

d) Discrepancies must be addressed by the System Integrator.

l. Room Temperature sensor test

1) Verify connections
2) Check and verify temperature sensor reading is correct
3) Verify temperature display on HMI is correct.

m. Battery Charger Test

1) Verify connection between battery charger and RTU
2) Verify connection between the battery charger and DTS (as applicable)
3) Test by opening AC power input breaker to charger and observe alarm on HMI annunciator panel.
4) Verify AIM and SCADA server points.

n. Inverter Test

New inverter is provided with both Ethernet and hard wire connections. The inverter may have only one set of form C contact for Inverter failure alarm and one set of form C contact for Inverter Transfer switch alarm. These contacts need to be connected to both the DTS and the RTU. Interposing relays provided in the RTU shall be used by the contractor to provide output to the RTU and DTS.

1) Hardwire connection Test
   a) Refer to inverter board form “C” drawing
   b) Verify interposing relays have been installed
   c) Verify contacts are wired to RTU terminals
   d) Verify contacts are wired to DTS terminals
   e) Simulate inverter failure; observe alarm on HMI and DTS
   f) Simulate Inverter transfer switch alarm; observe alarm on HMI and DTS
2) Ethernet connection Test
   a) Change IP address to 10.18.xxx.xxx (Follow manual instructions)
   b) Establish communication
   c) Check webpage (Follow manual instructions)

o. UPS

UPS is provided with Ethernet RJ45 and Modbus over RS485 for analog and digital points and form C contacts for alarms. UPS may have only one set of form C contact for each Battery charger failure, Inverter failure and Inverter Transfer switch Abnormal that need to be connected to both the DTS and the RTU. Interposing relays provided in the RTU shall be used by the contractor to provide output to the RTU and DTS.

1) Ethernet connection Test
   a) Change IP address to 10.18.xxx.xxx (Follow manual instructions)
   b) Establish communication
   c) Check webpage (Follow manual instructions)
2) RS485 connection Test
   a) Verify RS485 connection to RTU terminals.
   b) Verify RTU is polling data from UPS.
   c) Verify HMI is properly displaying UPS information/data points
   d) Refer to point assignment charts for UPS points to validate.
3) Hardwire connection Test

   Refer to UPS communication board drawings.
   a) Verify interposing relays have been installed (as applicable)
   b) Verify contacts are wired to RTU terminals
   c) Verify contacts are wired to DTS terminals (as applicable)
   d) Simulate battery charger, inverter and transfer switch failures.
   e) Observe alarm on HMI and DTS for each of the failure type.
   f) Observe alarms on AIM server.
   g) Observe alarms on SCADA server.

p. Battery Monitor (BM)

Verification of BM communication and Modbus mapping per SCADA point assignment chart

1) Verify BM IP address is correct and the BM is communicating with the substation RTU
2) Connect a laptop to configure the BM per WMATA Settings
3) Use a variable DC Voltage source to simulate low voltage and High Voltage conditions.
4) Observe on BM webpage that alarms are generated.
5) Verify RTU received alarms
6) Verify HMI for proper display of point tested and correct analog values
7) Verify AIM for correct point and voltages
8) Verify SCADA Server for correct point and voltages
9) Correct all scaling issues

q. Fire Alarm
1) Simulate fire alarm activation
2) Verify RTU received alarm
3) Verify AIM point.
4) Verify SACAD Server point.

r. Unauthorized Entry Alarm
1) Simulate fire alarm activation
2) Verify RTU received alarm
3) Verify AIM point.
4) Verify SACAD Server point.

2.05 End-to-End Test

This test is coordinated through the WMATA Operation Control Center (OCC) and shall be witnessed by the OCC IT group, the WMATA SCADA engineering group and the system integrator.

A. OCC IT shall update and configure the OCC Production Engineering Test (PET) room servers for the End to End tests. (In case PET room server is not available, local simulator shall be used to conduct the tests).

B. An Operator support from OCC is required.

C. WMATA shall carry out end-to-end test to verify:

1. The communication of RTUs with SCADA OCC master stations (AIM & AEMS)
2. RTU communication channel monitoring in the SCADA system
3. All controls and Monitoring points on the approved OCC Point Assignment Chart.
4. All controls and Monitoring points on the approved SCADA server Point Assignment Chart.
5. The mapping of SCADA database with RTU database for all RTU points
6. The mapping of SCADA database with displays and reports

D. The Contractor shall provide the details of all the variances observed and corrections carried out during end to end test.

2.06 SCADA System Functional Performance Test

After the completion of the site acceptance tests, WMATA shall conduct the field performance test to verify the functional performance of the system which includes the following:

A. The communication of other system with SCADA system.

B. Verify that all the variances observed during the Factory test are fixed and implemented.

C. Verify the execution rates of all SCADA application.

D. Verify update rate & time for data update & control command execution as per specification requirements.

E. Verify the response time of all SCADA applications.

F. Verify the response time for User interface requirements.

G. System Availability Test (360 hours).

1. System availability tests shall be conducted after completion of the field tests. The system availability test shall apply to the SCADA system (hardware and software) integrated with IT SYSTEM and Servers.
2. The SCADA system (hardware and software systems) shall be available for 99.5% of the time during the 360hours (15 days) test period. However, there shall not be any outage /down time during last 85 Hours of the test duration. In

case the system availability falls short of 99.5%, the contractor shall be allowed to repeat the system availability test after fixing the problem. The contractor shall upgrade the system to meet the availability criteria without any additional cost implication to WMATA.

3. Availability tests of RTUs shall be conducted along with System availability test for 360 hours. Each RTU shall exhibit minimum availability of 98%. In case the RTU availability falls short of 98%, the contractor shall be allowed to repeat the RTU availability test (for failed RTU only) after fixing the problem. The contractor shall upgrade the RTU to meet the availability criteria without any additional cost implication to WMATA.
4. In the event of unsuccessful reruns of the availability test, WMATA may invoke the default provisions described in the General Conditions of Contract.
5. The system availability tests shall be performed by WMATA by using the SCADA system and RTUs for operation, control and monitoring of distribution system and using Contractor supplied documentation. WMATA shall also be required to generate daily, weekly and monthly reports. The supplied system shall be operated round the clock.
6. The SCADA system shall be considered as available if:
    a. One of the redundant hardware is available so that all the SCADA applications are functional to ensure the design & performance requirement as envisaged in the specification
    b. At least one of the operator console is available.
    c. All SCADA applications are available
    d. All SCADA functions described in the specification are executed at periodicities specified in the specification without degradation in the response times.
    e. Requests from available OCC operator Consoles are processed
    f. Information Storage and Retrieval applications are available.
    g. Data exchange with other system is available.
    h. Each device, including servers, shall individually exhibit a minimum availability of 98%.
7. During the availability test period, WMATA reserves the right to modify the databases, displays, reports, and application software. Such modifications shall be described to the Contractor at least 48 hours in advance of implementation to allow their impact on the availability test to be assessed, except where such

changes are necessary to maintain control of the power system.

8. The successful completion of system availability test at site shall be considered as “operational acceptance” of the system.

2.07 Documentation

A. The complete documentation of the systems shall be provided by the contractor and WMATA system integrator. Each revision of a document shall highlight all changes made since the previous revision. WMATA's intent is to ensure that the Contractor supplied documentation thoroughly and accurately describes the system hardware and software.

B. The contractor/ WMATA system integrator shall submit the electronic copy of all necessary standard and customized documents for SCADA for review/approval by the WMATA for necessary reference which includes the following:

1. System overview document
2. Functional design document
3. Standard design documents
4. System Administration documents- software utilities, diagnostic programs etc.
5. Software description documents
6. Bill of Quantity & List of software and hardware deliverable
7. Protocol implementation documents
8. Point Assignment Chart document
9. IP addressing plan document
10. Software Maintenance document
11. Training documents
12. Database settings, Displays and Reports to be implemented in the system
13. Test procedures
14. Test reports
15. Hardware description documents
16. Hardware User documents
17. Hardware Maintenance documents
18. Data Requirement Sheet of all Hardware
19. Site specific Layout, Installation, schematics and cabling details drawings/documents

20. SCADA & IT Integration Plan Document
21. RTU/HMI/and all IED configuration files.

C. After approval, two sets of paper copies of all the above documents as final documents shall be delivered to WMATA by the Contractor. One set shall remain on site and the other set shall remain at WMATA engineering office. In case some modifications/ corrections are carried out at site, the contractor shall again submit as built site specific drawings in two sets after incorporating all such corrections as noticed during commissioning. Any software modifications/updates made at site shall also be documented and submitted in one sets to site and one set to WMATA.

D. In addition to paper copies, two sets of final documentation shall be supplied on Electronic media to WMATA. The contractor shall also submit two sets of the standard documentation of Operating system and Databases in electronic media. Paper copies of these may be submitted, if the same are available from the OEM as a standard part of delivery.

E. For each programmable Intelligent Electronic equipment or Device, provide configuration software, configuration file, manuals on disks licensed to the WMATA. Provide and submit proof that the software packages are licensed to the WMATA when the software is delivered to the WMATA. Provide and submit proof that a two year software maintenance/upgrade package has been purchased for the Owner.

F. All configuration files shall be in their native format, shall become property of WMATA and shall not include any copyright license or any license terms that require permissions from the vendor for modifications to the files.

G. After successful completion of System availability test, the contractor shall save the software backup of complete SCADA system on electronic media and two copies of these backup software shall be submitted to the WMATA.

TEST CHECK LISTS

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATIONS
Sign-Off Sheet

Test Location: **Date:**
Test Engineer:

DESCRIPTION OF THE TESTS	Type Test	Routine Test	Site Test	Date completed (mm/dd/yy)
COMMUNICATION NETWORK				
1. Single Mode Fiber Test Report			√	
Multimode Fiber Network			√	
Fiber Cable Installation			√	
Fiber Cables Test Report Approved			√	
Network Switch Systems				
Network Switches Installed			√	
Fiber Patch Cord /Cat 6 Cable Installed			√	
Connectivity to WMATA Network checked			√	
FUNCTIONAL TESTS FOR RTU				
1. Check for Technical details, Construction & Wiring as per RTU drawings	√	√	√	
2. Check for database & configuration settings	√	√	√	
3. Check the operation of all Analog inputs, Status input & Control output points of RTU	√	√	√	
4. Check operation of all communication ports of RTU	√	√	√	
5. Check for communication with master stations including remote database downloading from master station	√		√	
6. Check for auto restoration of RTU on DC power recovery after its failure	√		√	
7. Test for self-diagnostic feature	√		√	
8. Test for time synchronization from Master	√		√	
9. Test for SOE feature	√		√	
10. End to end test (between RTU & Master station) for all I/O points			√	
11. Test for DNP3 protocol implemented for communication with Master station and check communication latency.	√		√	
12. Test for DNP3 protocol implemented for acquiring data from end devices and check communication time.	√		√	
13. Test for MODBUS protocol implemented for acquiring data from end devices and check updating time demonstration in daisy chain configuration	√		√	

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATIONS
Sign-Off Sheet

Test Location: **Date:**
Test Engineer:

DESCRIPTION OF THE TESTS	Type Test	Routine Test	Site Test	Date completed (mm/dd/yy)
14. Test for IEC 61850 protocol implemented for acquiring data from end devices and check updating communication time.	√		√	
15. Test for Noise level measurement	√			
16. Test for Control Security and Safety for Control outputs	√		√	
17. Test for functionality/parameters verification	√	√	√	
18. Test for data concentrator	√		√	
19. Test for IED pass through	√		√	
20. Test for SOE buffer & time data back up	√		√	
FUNCTIONAL TESTS FOR HMI				
1. Check for Technical details, Construction & Wiring as per HMI drawings	√	√	√	
2. Check for database & configuration settings			√	
3. Check for communication with RTU			√	
4. Check all screen graphics and tables for correctness			√	
5. Test for time synchronization from Master			√	
6. Check the operation of all Analog inputs, Status input & Control output points of HMI			√	
7. Check for auto restoration of HMI on DC power recovery after its failure			√	
8. Test for self-diagnostic feature			√	
9. Test for Data backup			√	
10. End to end test (between HMI & End Devices) for all I/O points			√	
11. Check for remote access of Webpages			√	
AC SWITCHGEAR MICROPROCESSOR OVER CURRENT, UNDER/OVER VOLTAGE RELAY TESTS				
1. Check for configuration settings			√	
2. Check for communication with RTU			√	
3. Check Relay HMI screen graphics and LED for correctness			√	
4. Test for time synchronization from Master			√	

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATIONS
Sign-Off Sheet

Test Location: **Date:**
Test Engineer:

DESCRIPTION OF THE TESTS	Type Test	Routine Test	Site Test	Date completed (mm/dd/yy)
5. Check the operation of all Analog inputs, Status input & Control output points of the relay as per the PAC.			√	
6. Check for remote access of Webpages			√	
7. Enable, Check and Verify log file setting			√	
AC SWITCHGEAR POWER QUALITY METER TESTS				
1. Check for configuration settings			√	
2. Check for communication between Incoming meters and Rectifier/Aux breaker meters			√	
3. Check for communication between Incoming meters and the station RTU			√	
4. Check HMI screen graphics and LED for correctness			√	
5. Test for time synchronization from Master			√	
6. Check the operation and accuracy of all Analog inputs & Status input points as per the PAC.			√	
7. Check for remote access of Webpages			√	
8. Check for communication with master stations including remote database downloading from master station			√	
9. Enable, Check and Verify log file setting			√	
DISTRIBUTED INPUT OUTPUT MODULE (DIO) TESTS				
1. Check for Technical details, Construction & Wiring as per drawings	√	√	√	
2. Check for database & configuration settings			√	
3. Check for communication with RTU			√	
4. Check for communication with HMI			√	
5. Test for time synchronization from Master			√	
6. Check the operation of all Status input & Control output points as per PAC			√	

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATIONS
Sign-Off Sheet

Test Location: **Date:**
Test Engineer:

DESCRIPTION OF THE TESTS	Type Test	Routine Test	Site Test	Date completed (mm/dd/yy)
7. Check for auto restoration on DC power recovery after its failure			√	
8. Test for self-diagnostic features			√	
9. Check for remote access of Webpages			√	
10. Enable, Check and Verify log file setting			√	
TRANSFORMER MONITOR TESTS				
1. Check for Technical details, Construction & Wiring as per drawings	√	√	√	
2. Check for configuration settings			√	
3. Check for communication with RTU			√	
4. Check for communication with HMI			√	
5. Test for time synchronization from Master			√	
6. Check the operation of all Status input & Control output points as per PAC			√	
7. Check for auto restoration on DC power recovery after its failure			√	
8. Test for self-diagnostic features			√	
9. Check for remote access of Webpages			√	
10. Enable, Check and Verify log file setting			√	
RECTIFIER MONITOR TESTS				
1. Check for Technical details, Construction & Wiring as per drawings	√	√	√	
2. Check for Database & configuration settings	√	√	√	
3. Check for correct Name tags and Alarms on Monitor HMI.	√	√	√	
4. Check for communication with RTU	√	√	√	
5. Check for communication with HMI	√	√	√	
6. Test for time synchronization from Master	√	√	√	
7. Check the operation of all Status input & Control output points as per PAC	√	√	√	
8. Check for auto restoration on DC power recovery after its failure	√	√	√	
9. Test for self-diagnostic features	√	√	√	

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATIONS
Sign-Off Sheet

Test Location: **Date:**
Test Engineer:

DESCRIPTION OF THE TESTS	Type Test	Routine Test	Site Test	Date completed (mm/dd/yy)
10. Check for remote access of Webpages	√	√	√	
11. Enable, Check and Verify log file setting			√	
DC SWITCHGEAR MICROPROCESSOR RELAY TESTS				
1. Check for configuration settings	√	√	√	
2. Check for communication with RTU	√	√	√	
3. Check for all analog values and scaling on station HMI One-line Diagram.	√	√		
4. Check Relay HMI screen graphics and LED for correctness	√	√	√	
5. Check for Relay Alarm Log Settings	√	√	√	
6. Check for Trigger alarm contact connection to the DTR	√	√	√	
7. Test for Configuration Security-All change to settings are reported to SCADA	√	√	√	
8. Test for time synchronization from Master	√	√	√	
9. Check the operation of all Analog inputs, Status input & Control output points of the relay as per the PAC.	√	√	√	
10. Check for remote access of Webpages	√	√	√	
11. Enable, Check and Verify log file setting			√	
DIGITAL TRACE RECORDER (DTR) TESTS	√		√	
1. Check for Database and configuration settings	√		√	
2. Check for communication with SCADA Servers	√		√	
3. Check for Trigger alarm contact connection to the DTR	√		√	
4. Test for time synchronization from Master Station	√		√	
5. Test for Current Transducers Calibration	√		√	
6. Test for Voltage Transducers Calibration	√		√	
7. Check the operation of all Analog inputs & Status input points of the relay as per the PAC.	√		√	
8. Check for communication with master stations including remote stored files downloading from master station	√		√	
9. Check for communication with RTU	√		√	
ROOM TEMPERATURE SENSOR TEST				
a. Check for Technical details, Construction & Wiring as per			√	

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATIONS
Sign-Off Sheet

Test Location: **Date:**
Test Engineer:

DESCRIPTION OF THE TESTS	Type Test	Routine Test	Site Test	Date completed (mm/dd/yy)
drawings				
Check for communication with RTU			√	
Check for temperature sensor reading and scaling			√	
Check for correct temperature display on HMI			√	
INVERTER TEST				
a. Check for Technical details, Construction & Wiring as per drawings			√	
Check for configuration settings				
Check for communication with RTU			√	
Check the operation of all Analog inputs & Status input points of the inverter as per the PAC.			√	
Check for correct display on HMI			√	
Check for remote access of Webpages			√	
UPS				
a. Check for Technical details, Construction & Wiring as per drawings			√	
Check for configuration settings			√	
Check hardwire connections to RTU			√	
Check for communication with RTU			√	
Check the operation of all Analog inputs & Status input points of the UPS as per the PAC.			√	
Check for correct display on HMI			√	
Check for remote access of Webpages			√	
Battery Cycle Monitor Test				
a. Check for Technical details, Construction & Wiring as per drawings			√	
Check for configuration settings			√	
Check for communication with RTU			√	
Check the operation of all Analog inputs & Status input points as per the PAC.			√	

SCADA SYSTEMS INTEGRATION TESTING AND DOCUMENTATIONS
Sign-Off Sheet

Test Location: **Date:**
Test Engineer:

DESCRIPTION OF THE TESTS	Type Test	Routine Test	Site Test	Date completed (mm/dd/yy)
Check for correct display on HMI			√	
Check for remote access of Webpages			√	
Fire Alarm				
a. Check for Technical details, Construction & Wiring as per drawings			√	
Check hardwire connections to RTU			√	
Check the operation of all Status input points as per the PAC.			√	
Check for correct display on HMI			√	
Unauthorized Entry Alarm				
a. Check for Technical details, Construction & Wiring as per drawings			√	
Check hardwire connections to RTU			√	
Check the operation of all Status input points as per the PAC.			√	
Check for correct display on HMI			√	

SIGNATURES

NAMES	SIGNATURE	DEPT	PHONE #	DATE

END OF SECTION

SECTION 28 40 07

HUMAN MACHINE INTERFACE FOR TRACTION POWER SYSTEMS SCADA

PART 1 - GENERAL

1.01 SUMMARY

A. This section provides requirements for vendors who will design, supply, manufacture, install and configure Human Machine Interface (HMI) required at Tie Breaker Station (TBS) and Traction Power Substations (TPSS) for Supervisory Control and Data Acquisition (SCADA).

1. The document covers software, programming, equipment and testing activities to be provided by the contractor.
2. The substation HMI provides a centralized graphical user interface for viewing system status, analog values, issuing control commands to station IEDs and provides remote monitoring.
3. The HMI System shall be provided as a complete and functional system including computer-based HMI software and configuration, HMI touch screen monitor, cables, connections necessary for operation.
4. The contractor is responsible for the programming and testing of the HMI.
5. WMATA HMI template that shall be used as a basis for the creation of all HMI screens. This HMI template is included as appendix A.

B. Related sections

1. Section 28 40 00 – SCADA Work for Traction Power Systems
2. Section 28 40 02 - RTU for Traction Power Systems
3. Section 28 40 04 - Network Switch for SCADA and Automation Systems
4. Section 28 40 06 - SCADA System Integration Testing and Documentation for TPSS and TBS

C. Power Requirement

1. 125 Volts DC from the station DC Panel.

1.02 REFERENCES

A. Codes, Regulations, Reference Standards and Specifications:

1. Codes and regulations of jurisdictional authorities (AHJ)
2. NEC
3. NEMA: 250, ICS-6, 12
4. IEEE: C37.90.1
5. ANSI Z55.1
6. UL: 94, 508A
7. EIA: RS 232.C
8. ASHRAE/ANSI: 135-2001
9. ICEA: S-68-516

B. Drawings:

1. HMI Cabinet Layout
2. HMI Cabinet Wiring Diagram
3. HMI Buzzer circuit wiring diagram

1.03 SUBMITTALS:

A. General: Refer to Division 1 for Shop Drawings, Product Data, and Samples submittal requirements and procedures.

B. Submit the following drawings, data, and procedures for approval prior to furnishing and installing the equipment:

1. Complete system data flow and software architecture diagrams for all modules of the system and all interfaces to the system.
2. Complete circuit drawings and systems diagrams, in a manner as hereinafter specified, for all system and subsystem interfaces, including interconnections of all hardware to the system.
3. Complete comprehensive Installation and Inspection Procedures.
4. Field Test Procedures in accordance with the testing section of these specifications to verify that the installed system meets all safety and operational requirements of these Specifications, section 28 40 06 (16606) and that it has been installed in accordance with the final approved plans.
5. End to End Test Procedures in accordance with the testing section of these Specifications to verify that the installed system meets all safety and operational requirements of these Specifications, section 28 40 06 (16606) and that it has been installed in accordance with the final approved plans.

6. The Contractor shall provide on electronic media six weeks prior to the start of factory acceptance testing a complete sets of application, service, and development system manuals, including manuals covering all software and hardware provided as part of the application software development system as part of this Contract.
7. Submit as-built drawings of all the works done under this specification for approval.

1.04 CLOSEOUT SUBMITTALS:

A. Software and Firmware Operational Documentation:

1. The contractor shall provide the following:
   a. HMI application software.
   b. HMI development software
   c. HMI Configuration file
   d. Licensing agreement which states that the HMI software package is licensed to WMATA.
   e. Program Software Backup: On electronic media or compact complete with data files.
   f. All configuration files shall be in their native format and will become the property of WMATA.
   g. This shall not include any copyright or license terms that require permissions from the vendor for modifications to the files.
   h. Device address list.
   i. Tags list and description
   j. Developed software's operator maual
   k. Printout of software application and graphic screens.

1.05 QUALITY ASSURANCE

A. HMI software shall be of proven design and suited for SCADA applications in Power automation system.

B. The HMI point mapping shall comply in every respect with the HMI Point Assignment Charts (PAC) in section 28 40 00 (16051D) and of any supplements thereto that become effective before this Contract is awarded.

C. The Contractor shall certify that the HMI monitor being furnished under this contract is rugged and has been tested to successfully operate in high electric background noise environment. The system shall comply with the requirements of with IEEE C37.90.1.

D. The HMI monitor shall be capable of continuous operation at temperatures of –40 degrees F to 160 degrees F and humidity levels of 5% to 95%, noncondensing, without

the need of any external environment controls.

E. No failure of the HMI software shall cause the system to falsely or erroneously maintain for any reason a trip state of a piece of equipment.

F. The HMI shall be designed and configured to communicate with the station RTU using DNP3 protocol.

G. HMI monitor cabinet installer coordinates with electrical installers and other contractors as to the exact locations for the installation of HMI cabinet inside the station and sizes of new conduits and their proposed routes to be used by HMI wiring systems.

H. The contractor shall provide all software and licenses required for installation, testing and configuration of the HMI.

I. Contractor is responsible for verifying the location of the HMI monitor shown in the drawings. Where the location shown in the drawings needs to be changed due to a field conditions, the contractor shall communicate with the Engineer, and submit an alternate installation location for approval prior to installation.

End-to-End Test:

J. The end-to-end test is scheduled and supported by the contractor.

1. The Contractor shall demonstrate the proper functioning of the completed HMI system including all components and telemetry between each piece of equipment monitored or controlled by the HMI in the presence of the WMATA Engineer.
2. Verification that the HMI is communicating with the RTU at the station.
3. Verification that each device monitored by a remote sensor is monitored from the RTU and operation of the device is observed in the field thru the HMI.
4. Verification that each device controlled by the RTU system is to be operated with the control command initiated at the HMI.
5. Simulation of sensors by shorting contacts is to be avoided unless other activation is not possible.
6. Demonstrate that the HMI is accessible for remote viewing.
7. Demonstrate that HMI event log and critical historical data are stored in a non-volatile memory.

K. Submit certified test report within ten days after completion of field tests.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Equipment for each facility shall be delivered in accordance with the access dates in Special Conditions, and shall be coordinated with WMATA.

B. Each shipped unit shall be securely packaged, braced, and labeled for safe handling in shipment, and to avoid damage or distortion.

C. Temporary Bracing: Where necessary, brace each unit for hoisting, lowering, and skidding into position. Temporary internal bracing of the equipment labeled as follows:

TEMPORARY-REMOVE BEFORE OPERATION.

D. Store equipment in secure and dry storage facility.

PART 2 – PRODUCTS

2.01 HMI system Features

A. The HMI enables WMATA authorized personnel to have dynamic overview over operating status of all major areas and equipment of the electrical power systems.

B. HMI touch screen monitor shall be located in a wall mounted cabinet, which would allow for remote user interface with the equipment lineup outside the OSHA limited approach boundary.

C. The HMI software provided under the scope of this work shall be latest version of the approved software application. The application software shall run on the Industrial computer with Windows 7 provided by others.

D. The HMI Computer shall connect to the SCADA RTU directly as a DNP3 Slave through event and static data types either polled or unsolicited. The DNP interface shall also include control points that cause control actions in station IEDs.

E. Human machine interface status and measurement data shall be forwarded to the personal computer serial port using unsolicited data transfer. Control messages shall be sent using Fast Operate commands that include information redundancy and shifting to provide data security and prevent false operations.

F. The HMI system shall be capable of scripting to allow the calculation of substation quantities including total MW power load.

2.02 HMI SYSTEM DESIGN

A. The security management tools of the HMI software shall be configured to allow for multiple access levels with different privileges. Administration tools for Authentication/authorization to perform HMI control/ status functions shall be based on specific users using user IDs.

B. System User shall only be able to monitor and shall NOT be able to acknowledge alarm/ perform any control operation without login to the system.

C. User shall be locked after three wrong password entrees

D. Only administrator user will have user administration rights

E. All HMI displays shall include a Screen Header or button that allows selection of other displays.

F. The HMI design shall be made in unification with the PLC program development. The design shall follow the naming conventions adopted in conjunction with PLC programing.

G. All alarms shall be assigned priority to handle alarms intelligently and avoid avalanche of alarms being presented to the operator. The alarms shall be presented starting from the highest to the lowest priority.

H. AC and DC breaker analog values on the One line diagrams shall be mapped to the respective AC and DC Microprocessor protective relays (MPR)

I. AC incoming bus voltages on the Oneline diagrams shall be mapped to the Power Quality Meters.

J. DC incoming bus voltage on the Oneline diagrams shall be mapped to Cathode breaker#1 MPR load side bus voltage.

K. Any failure in database engine will not affect the real-time data to HMI and other applications.

L. The HMI shall provide controlling, alarming, trending, logging, reporting and maintenance information. Information shall be capable of being generated automatically or on demand. HMI features shall include:

1. Main Display
2. Dynamic online color displays.
3. Alarms window.
4. Events window
5. Annunciator Panel display.
6. ETS system display.
7. Device communications network display

M. The system shall include access protection on a structured level of privilege. Facilities shall be provided against loss of system data. The access protection is to be developed in three levels of privilege. The levels configured will be capable of being modified in the future.

1. Operator access allows the user to view all screens, change the state of equipment locally.
2. Engineer access includes operator access and, in addition, the right to change controller variables, control parameters, and system alarm settings.
3. The monitor access level is used on a network level to allow the user to view all screens without being able to make any changes. When logging on as a monitor access user, the user can access only webpages.

N. The remote user (Engineer and Monitor access) name shall be indicated with color and text with an indicator in the alarm and indicator window at the bottom of the screen.

O. Operator access level shall be default on the local touch screen. The local operator must not log in order to gain access to the system.

P. The system shall automatically return to default access level, 10 minutes after the last operator action.

Q. WMATA STANDARD HMI SCREEN WINDOWS

1. The HMI display shall have a main menu that covers the station equipment that

the HMI controls. From the main menu and the relevant equipment control, there shall be sub-menus for all visible equipment. The hierarchy of the HMI system shall be the same whenever it is possible and use the same hierarchy and appearance as the SCADA system to all possible extents.

2. There shall be a main menu window, with sub-menu windows visible on top, a online diagram, annunciator, alarm, history, Schematic, ETS and communication button windows at the bottom of the screen.
3. The main purpose of this set-up is to have on each screen, access to all major parts of the substation, by selecting one button and within each display, be able to select every available display within that group using easy accessible display drop down menus or buttons. Buttons can be of the nature of active icons, displaying the individual parts on the single-line diagram of substation and operate as buttons on the display to jump to the relevant sub- displays. Refer to Appendix 1 for sample of WMATA HMI screen windows.
4. The Main Menu window makes it possible to select individual equipment/Device group. The buttons for alarms and individual group may be equipped with drop-down menus if the selection options exceed five options. Their name shall appear in letters using Arial bold and black-colored font size 12.
5. One-Line Diagram Window Selection of One-Line on the screen shall display a system one-line that shows all substation equipment and indicates whether any equipment in not in the normal operating state or status. This window is divided into multiple parts:
    a. Substation Calculated Power Usage
    b. Annunciator common alarm
    c. Room Temperature
    d. Equipment being controlled
    e. Analog Values
    f. Time and date
    g. Negative Switchboard Analog Values
6. Annunciator Window provides up to 54-windows annunciator for displaying alarm conditions and notifying personnel of abnormal conditions in each individual window panel. If an alarm occurs, the alarm indicator will change color according to the severity of the alarm, and flash until the alarm is acknowledged. After the acknowledgement, the alarm indicator will show its color steadily until the alarm condition returns to normal state. The color of the alarm indicator signals the highest severity of the alarm in the system at each time and

when alarm signal disappears, the color shall change to a color other than red/yellow. Alarm colors are two: red indicates severe alarm or dangerous condition, and yellow which indicates abnormal condition.

7. Active Alarms Window: Selection of Alarms pushbutton on the screen header or button shall display the alarm summary screen. The alarm summary screen shall list all active alarms.
8. Alarm History Window: Selection of Historical Alarms pushbutton shall display the alarm history screen showing a scrolling record of system alarms. The screen shall include the ability to display alarm history or active alarms, to filter and sort alarms, and to display alarms based on dates.
9. Schematic Window: Selection of schematic pushbutton shall display contract rail schematics for the substation power zone. This window also contains the ETS push buttons.
10. ETS System Window: Selection of ETS pushbutton shall display a single line window that identifies the ETS system control wires, the Blue and amber lights, and the Distributed Input-Output modules for the ETS zone controlled by the RTU.
11. Device Communication Window: Selection of Communication pushbutton from the screen header or button shall display a system communications screen showing the status of all communications links in the system. The link color shall change dynamically with the status of communications in the system.
12. Trend Graph Window: Selection of the trend graph pushbutton from the screen header or button shall allow allows you to connect to the DTR and view binary and analog data in a graphical format.
13. Device Group Screen Window: Selection of device pushbutton from the main screen shall display a screen that shows all active targets on all station relays, transformer monitor, rectifier, UPS etc.

R. HMI SCREEN DISPLAY DESIGN

1. Display background color shall be black. The display name shall be positioned in the middle of the top window, in White Arial bold font letters.
2. Symbol colors shall be consistent from one display to another.
3. One-line Diagram Window:
   a. Selection of One-Line on the screen header or button shall display a system one-line that shows all substation equipment and indicates whether any equipment in not in the normal operating state or status.

b. Green shall be used to indicate breaker open.

c. Red shall be used to indicate breaker closed.

d. Yellow shall be used to indicate breaker rack out.

e. Magenta shall be used to indicate breaker status error.

f. White outline shall be used to indicate a device

g. White border with black background shall be used to indicate device failure.

h. Letter (T) on the left top side of a breaker shall indicate breaker in test position.

i. Letter (L) on the left top side of a breaker shall indicate breaker in local control.

j. Letter (M) on the left top side of a breaker shall indicate breaker in manual control.

k. Green numbers shall be used to indicate analog values.

1) AC breaker's analog Values shall be mapped to AC MPR

2) DC breaker's analog Values shall be mapped to DC MPR

l. Yellow shall be used to indicate Bus bars or cables are active. Color will be white if the Bus bar or cable is not active.

m. Grey shall be used for all future equipment.

4. Breaker Control:

a. Selection of a circuit breaker on the system one-line shall display a screen that allows control of the breaker.

b. The HMI shall provide highly secure select-before-operate controls, status monitoring with 1 millisecond Sequence of Events (SOE) time tagging.

c. Control initiated by local HMI shall be recorded on the Event history as "HMI-Commanded Trip or Close"

d. Control initiated by Operation Control Center (OCC) shall be recorded on the Event history as "OCC-Commanded Trip or Close".

e. All other tripping or closing shall be recoded as "Un-commanded"

5. Annunciator Window:

a. Black outline with white background color shall be used to indicate a device.

b. If an alarm occurs, the alarm indicator will change color according to the severity of the alarm, and flash until the alarm is acknowledged.

c. After the acknowledgement, the alarm indicator will show its color steadily until the alarm condition returns to normal state.

d. The color of the alarm indicator signals the highest severity of the alarm in the system at each time and when alarm signal disappears, the color shall change to white.

e. Alarm color red shall indicate severe alarm or dangerous condition.

f. Alarm yellow color shall indicate abnormal condition.

6. ETS System Window:

a. Green shall be used to indicate Normal Operation.

b. Red shall be used to indicate alarm condition.

c. White outline with black background shall be used to indicate a device communication failure.

7. Device Communication Window:

a. Black outline with white background color shall be used to indicate normal operation.

b. Cyan shall be used to indicate device communication failure.

8. All Sub-Menus Windows:

a. Black outline with white background color shall be used to indicate functions.

b. Black letter shall be used to describe normal operation.

c. Red letter shall be used to describe abnormal operation.

d. Green numbers shall be used to indicate analog values.

e. White letter shall be used to describe Functions.

f. Black outline with green background color shall be used to indicate device off.

g. Black outline with red background color shall be used to indicate device on

9. Measured and Pre-set Values

a. Measured value and its unit shall be displayed without box for devices represented on the online diagram.

b. The value shall be indicated with a green font on a black background for a normal state, yellow font on a black background for warning state, and red font on a black background for Alarm State.

c. Pre-set values are not to be display on the online diagram.

d. Stage 1 and stage 2 pre-set values are to be displayed on the transformers and rectifiers screen displays.

e. The Transformer and Rectifier preset values and units shall be displayed in a box. The box frame shall be a Gray colored button type. The value shall be indicated with a green font on a black background.

2.03 HMI software

A. HMI software provided by the following manufacturers shall run on the provided industrial computer.

1. GE IFIX or Approved Equal

B. The proposed HMI solution shall use web technologies to build interactive screens accessible from standard web browsers.

C. A browser shall connect to the HMI and view data from connected IEDs and RTUs. Displays as described above.

D. The HMI software shall be capable of creating multiple password protected drill-down screens for viewing IED data or establishing a pass-through connection with the IED.

E. WEB server shall have configured pages for Data Archiving/Sequence of Events Recording, Alarm Annunciation, one-line diagrams, control screens, alarms, trending, communications diagnostics and capable of including IED faceplates,

F. The HMI shall enable WMATA authorized personnel to have dynamic overview over operating status of all major areas and equipment of the electrical power systems.

G. The HMI software shall be capable of serving webpages to multiple remote clients using secure protocol between the webserver and the remote PC.

H. Control through HMI shall be enabled only on the Local HMI.

2.04 HMI Touch Screen Monitor

A. Touch screen LCD TFT monitors designed for use in Industrial harsh applications shall be provided in enclosure.

B. Display/Screen:

1. Screen Size: 19” touch screen
2. Resolution/Type: TFT active matrix
3. Entry Mode: Analog touch pad, resolution 1,280 X 1,024.

4. Operational Temperature Range, -20°C to +50°C (-4°F to +122°F)

C. Input Power: 125V DC. (DC-DC converter for monitors not available with 125VDC input)

D. Input Interface:

1. DVI.
2. USB
3. VGA

E. Approved Manufacturers and Models:

1. Transduction, Model: TR-LCD1900-PM-TOUCH125V DC
2. Approved equal

2.05 HMI and Keyboard Cabinets:

A. The HMI monitor shall be installed in a stand-alone cabinet with bottom drawer for keyboard and mouse.

1. Cabinet Dimensions: 24X20X12 or as required
2. Construction: NEMA 3R.
3. Apply two finish coats, ANSI No. 61, Light Gray, to exterior surface.
4. Paint interior per manufacturer's standard.

B. Fabrication

1. Cabinet with fixed side, rear and roof panels, front swing, full hinged door with flush latch operable by both Screwdriver and hand.
2. Provide Cut-out for flush mounting of the HMI.

C. Cabinet layout as referenced in Section 1.02. B.1

D. Mounting: Cabinet shall be wall mounted type using metallic mounting ears, welded to the enclosure. No holes at the back of the enclosure are allowed for mounting.

E. Field Wiring Terminals:

1. Provide terminal blocks in the HMI cabinet to accommodate all field wires including spares.

F. Nameplate:

1. Black laminated plastic composition with permanent white engraved lettering, and beveled edges.
2. Nameplate 2-1/2 inches by 6-1/2 inches, inscribed in letters ½ inch high: “SCADA HMI”
3. Fastened to panel using small round-head screws.
4. Installed inside cubicle and cabinets with cement.
5. Submitted for approval.

G. Audible Signal (Buzzer Circuit):

1. Provide a Horn/buzzer mounted on the HMI cabinet capable of reproducing sustained tones through the use of HMI control. The recommended horn is supplied by Federal Signal, Model Streamline part #LP4-09-028 or equal.
2. The audible signal shall be triggered by the HMI under WMATA’s defined alarms.
3. The buzzer circuit as referenced in SCADA drawings

2.06 Wiring/Cabling: Wiring for the HMI system shall be done as shown on the contract drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

A. HMIs shall be delivered and installed as shown in accordance with approved shop drawings at the following facilities:

1. Traction Power Substations
2. Tie Breaker Stations

B. Perform work in accordance with the NEC.

C. Terminate interface points in the HMI touch screen enclosure cabinet.

D. Ground HMI cabinet and power supplies as shown on the drawings, in accordance with Section 16060 and as specified here.

E. HMI is connected to the industrial computer via Ethernet cable and approved video cable in conduit/Cable tray. Contractor shall specify and provide the appropriate video cable in

accordance with the location of the HMI monitor.

F. The contractor is responsible for testing all HMI input signals to verify correct status and telemetry signal levels, control and annunciation. I/O equipment supplied under this contract that is not reporting properly shall be corrected and retested at no extra cost to WMATA. The System Integrator shall submit a discrepancy report for all I/O points indicating problems found and required action.

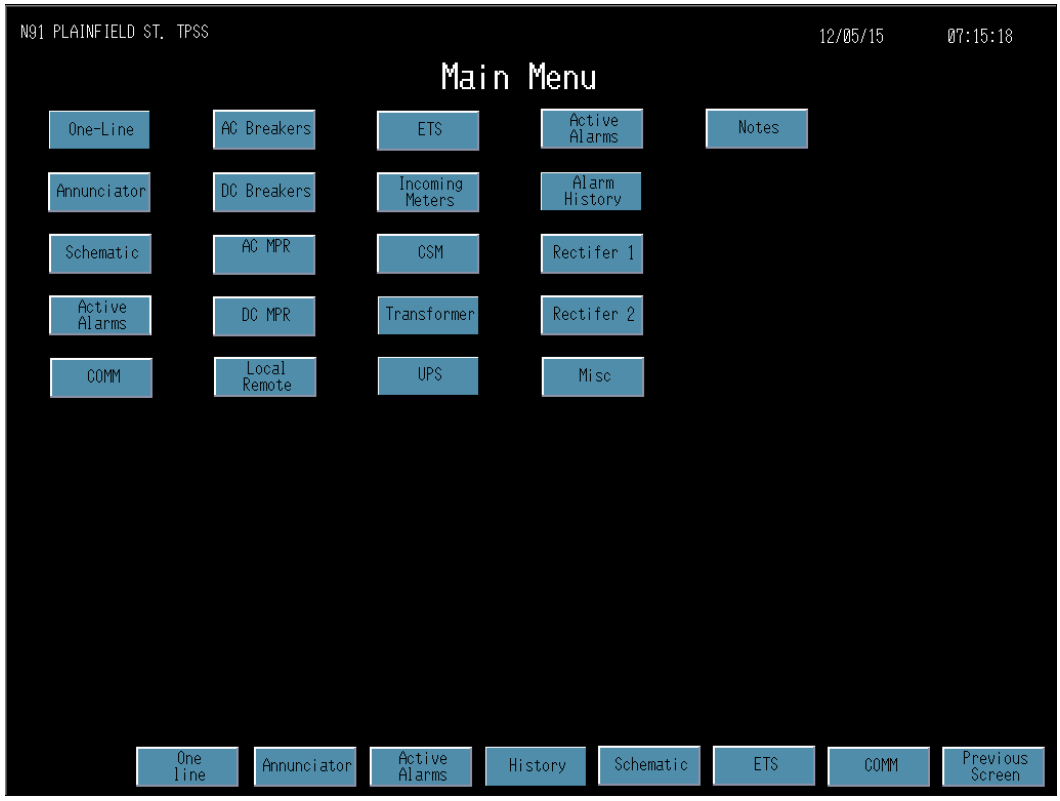
3.02 FIELD QUALITY CONTROL

A. The Contractor shall perform polarity and continuity test on all interconnection wiring.

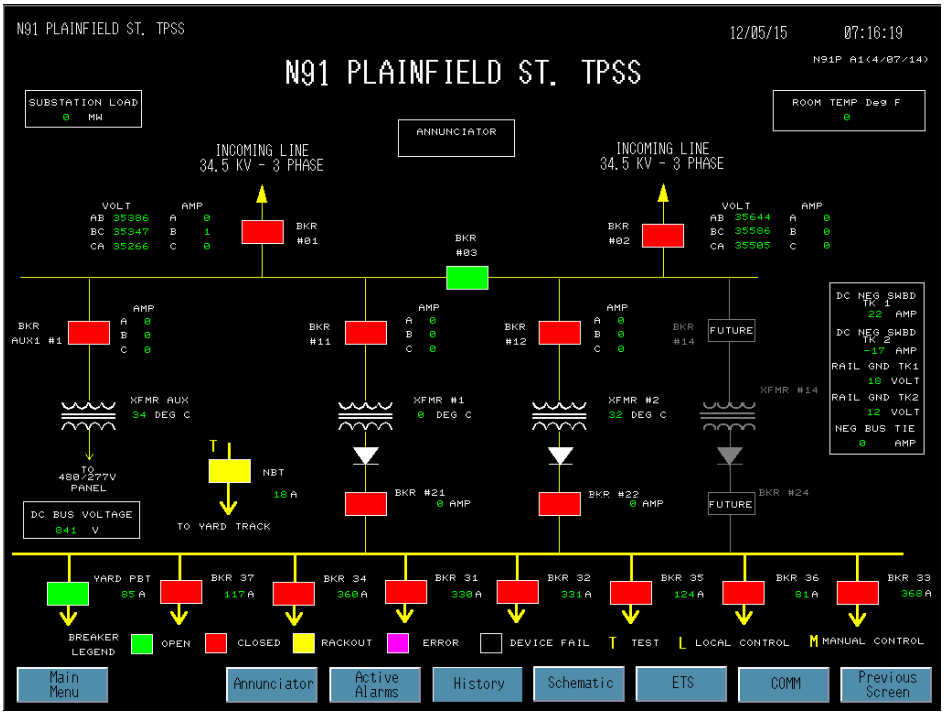
B. HMI field test shall be integrated with the SCADA field acceptance tests. Refer to section 28 40 06 (16606) SCADA System Integration Site Acceptance Test Plan.

APPENDIX –C: HMI SCREENS

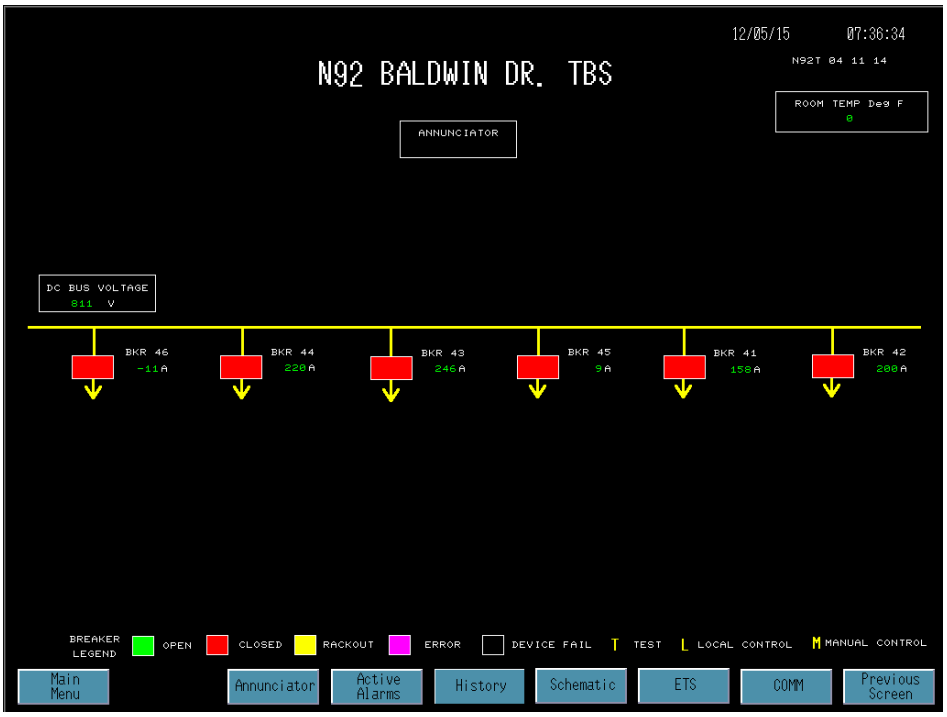
The following HMI screens are WMATA working HMI template that should to be used as a basis for the creation of all HMI screens.



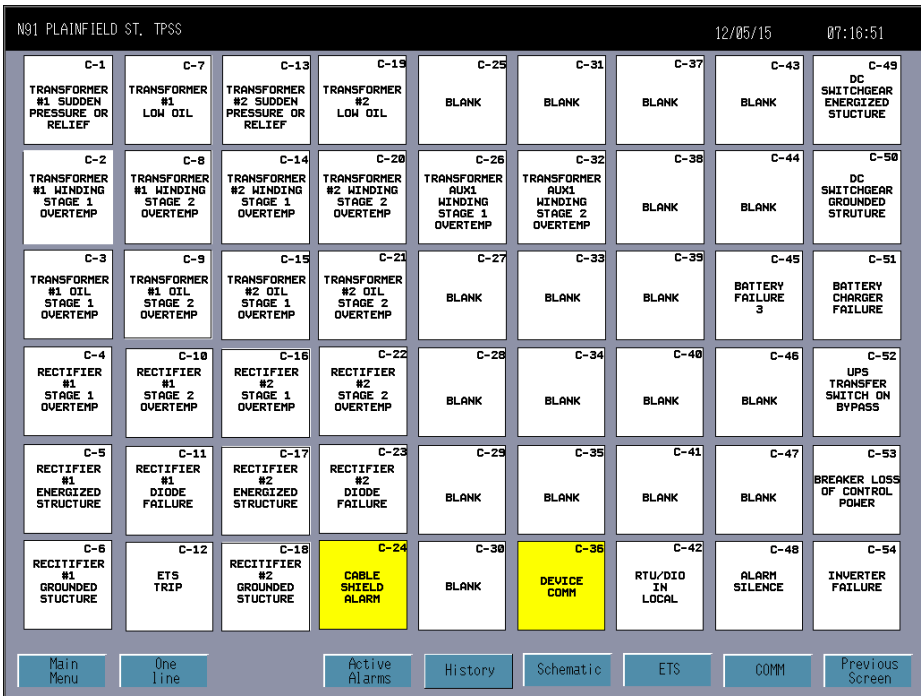
TPSS MAIN MENU SCREEN



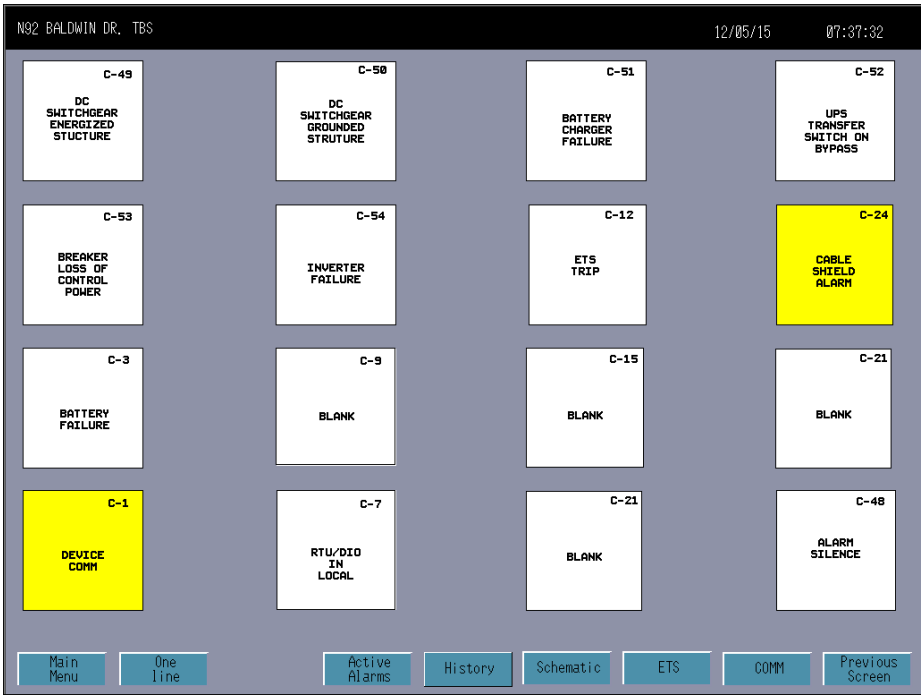
TPSS ONELINE DIAGRAM SCREEN



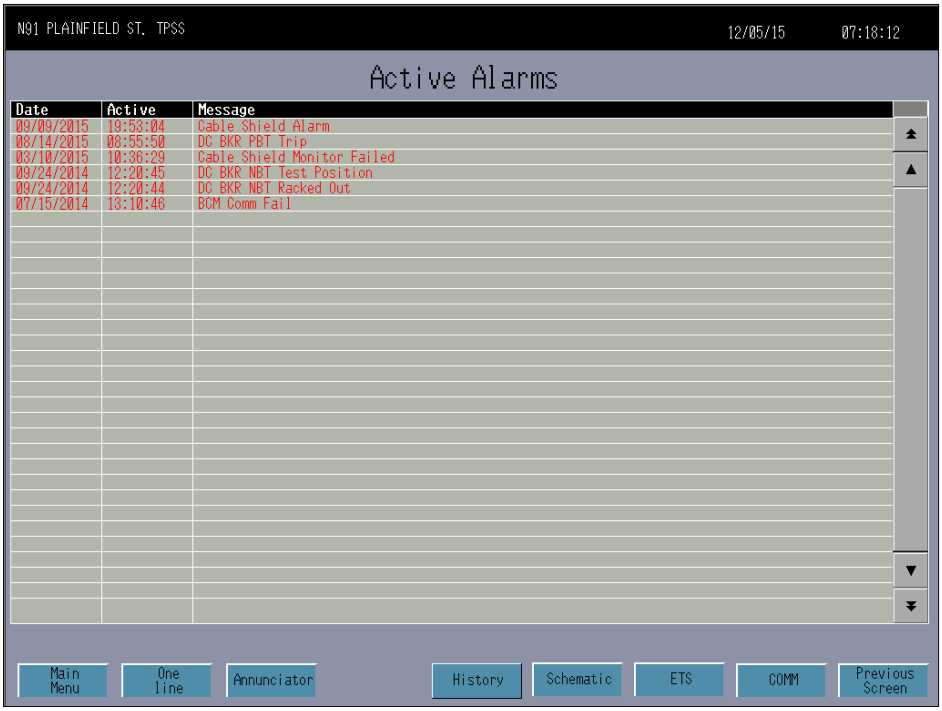
TBS ONELINE DIAGRAM SCREEN



TPSS ANNUNCIATOR PANEL SCREEN

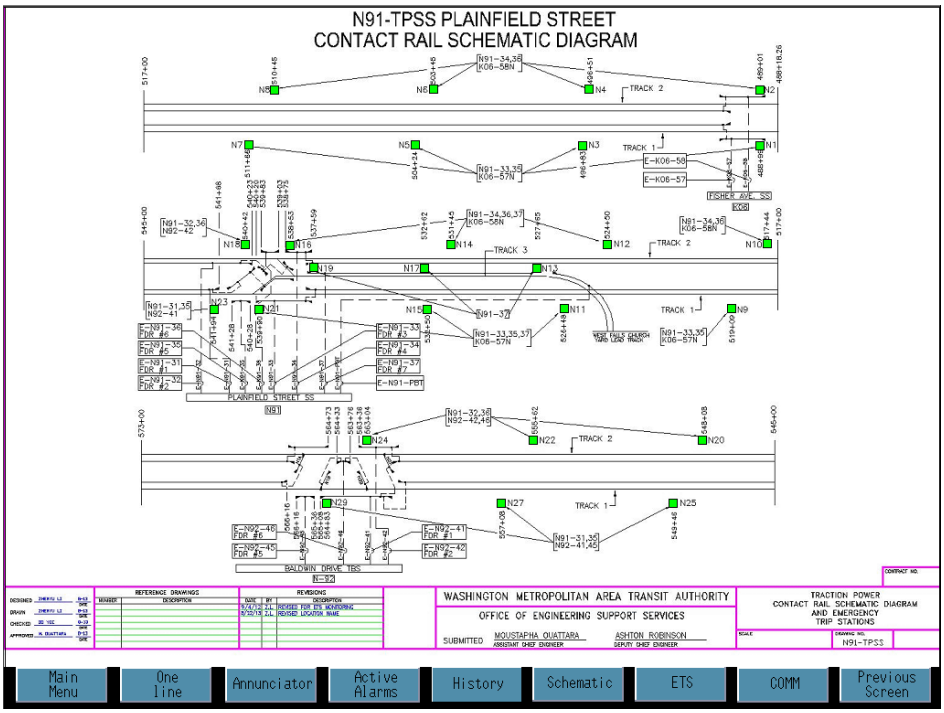


TBS ANNUNCIATOR PANEL SCREEN

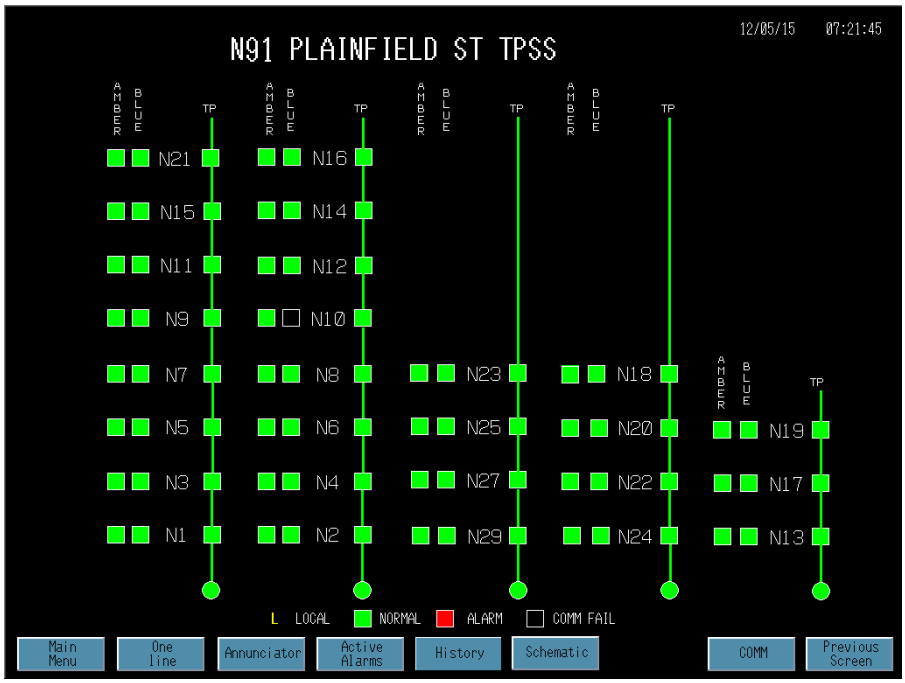


ACTIVE ALARM SCREEN

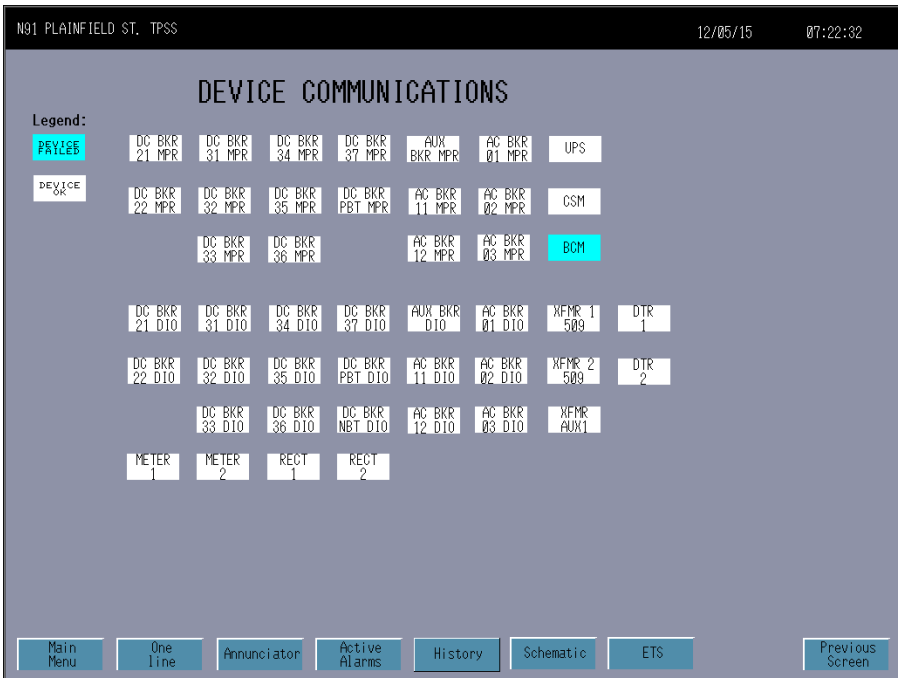
EVENT HISTORY SCREEN



SCHEMATIC DIAGRAM SCREEN

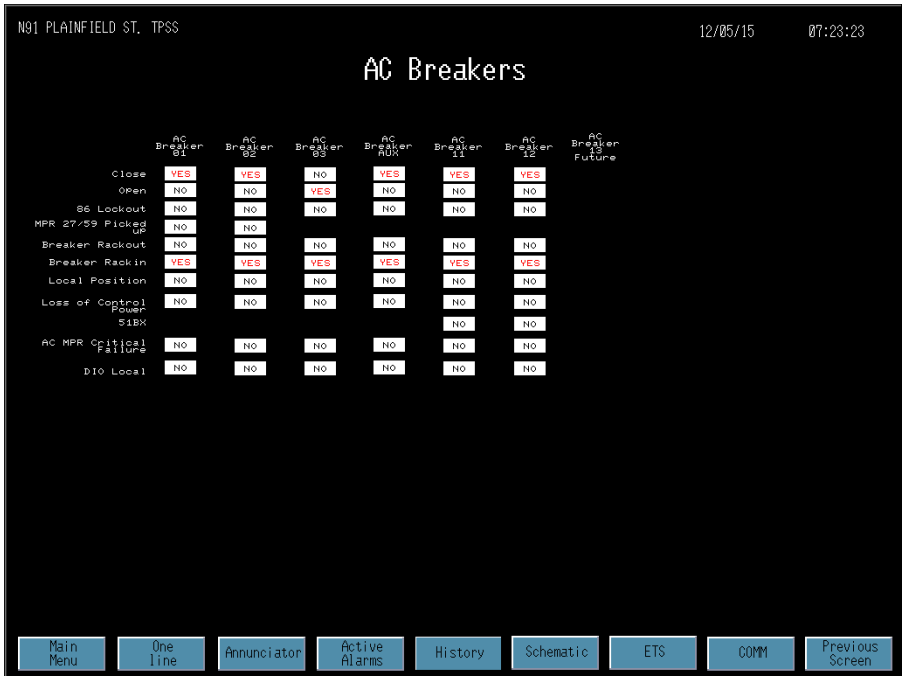


ETS SCREEN

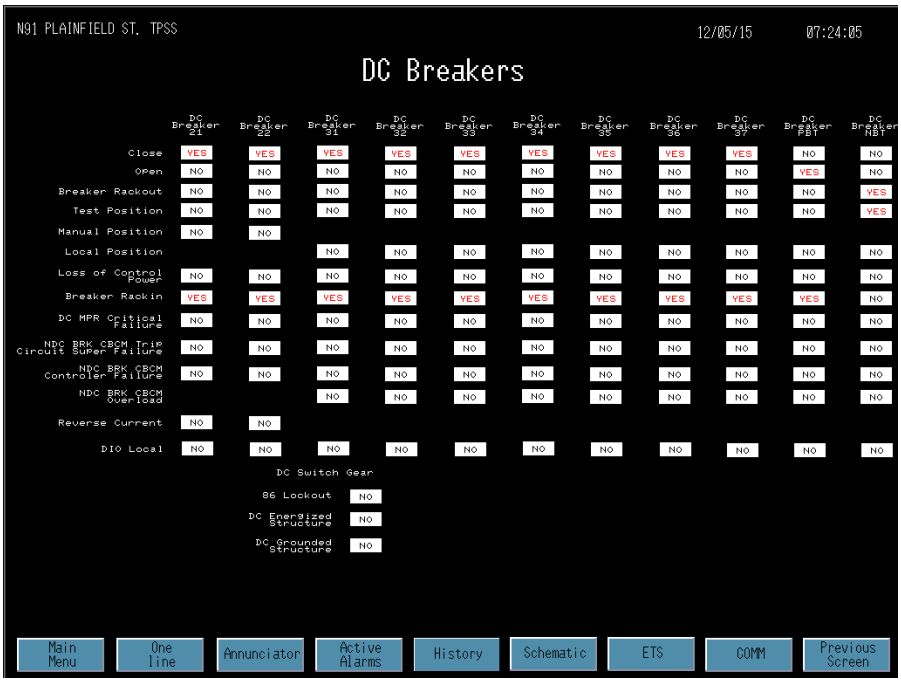


DEVICE COMMUNICATION SCREEN

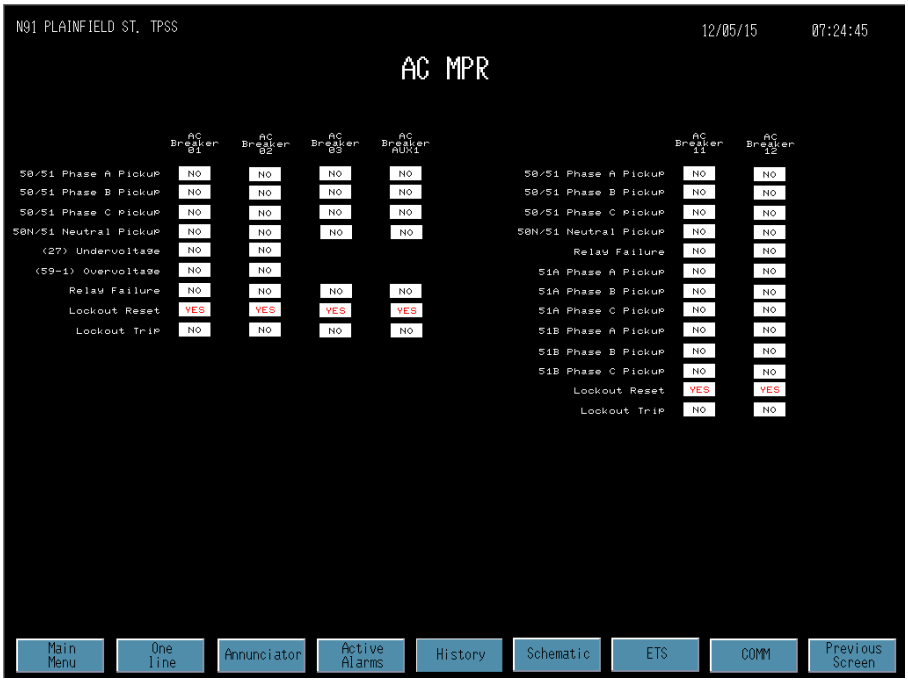
(*) INCLUDE IED FACEPLATES IF FEATURE IS AVAILABLE IN SOFTWARE



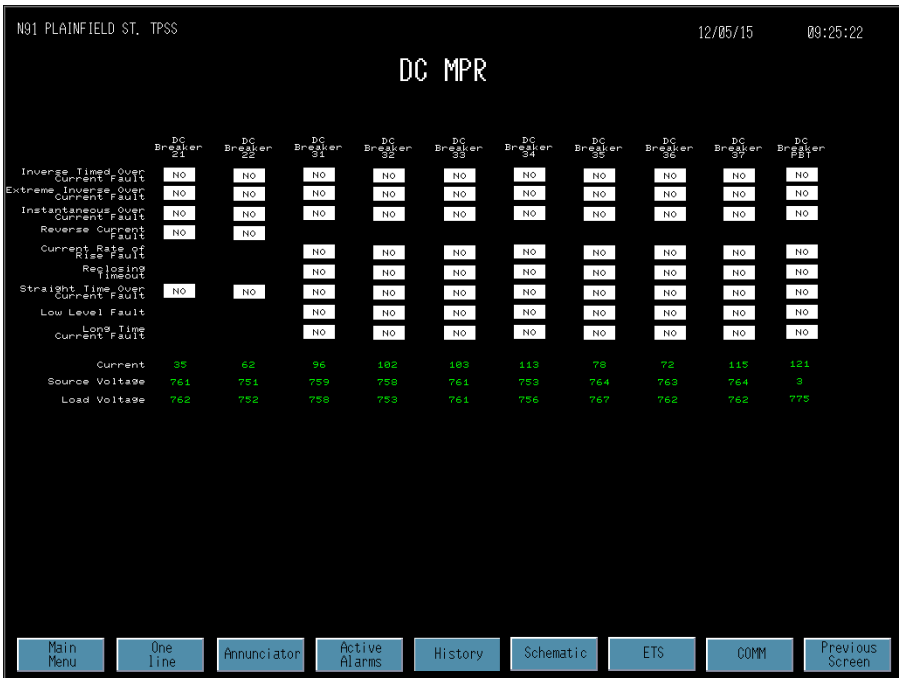
AC SWITCHGEAR DIO SCREEN (*)



DC SWITCHGEAR DIO SCREEN (*)

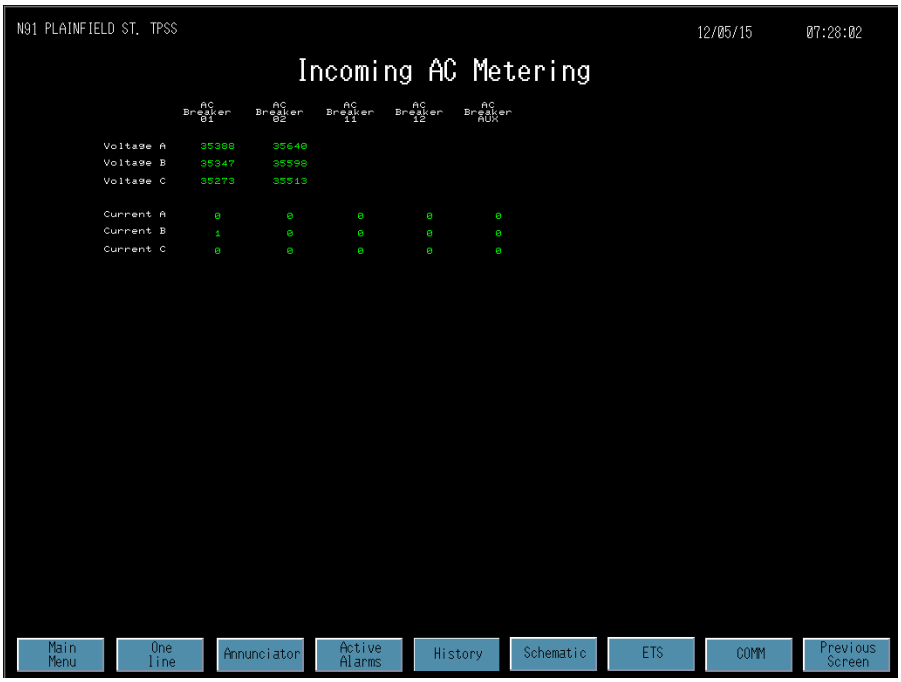


AC MPR SCREEN (*)

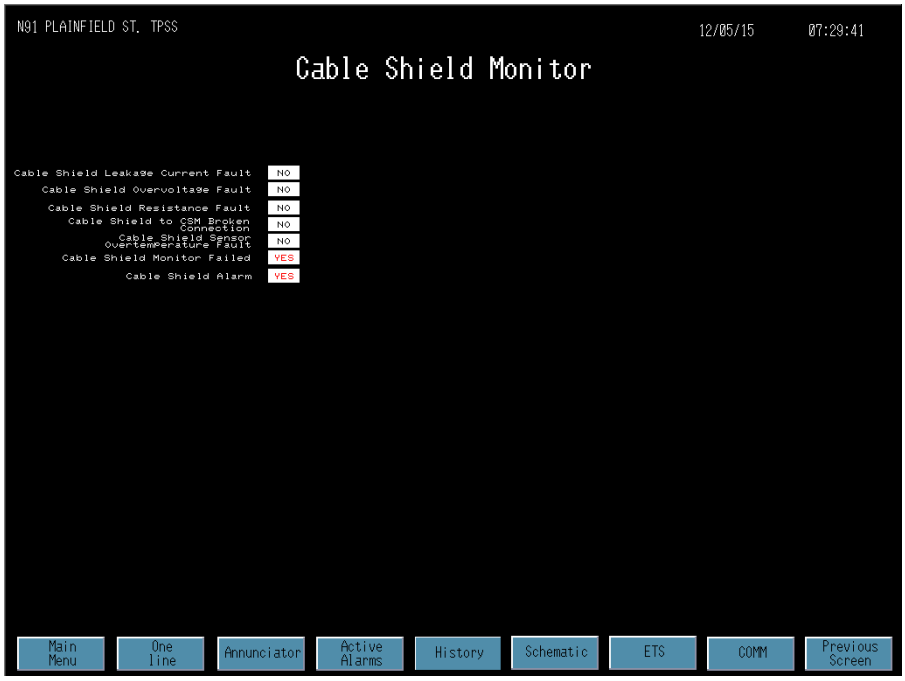


DC MPR SCREEN (*)

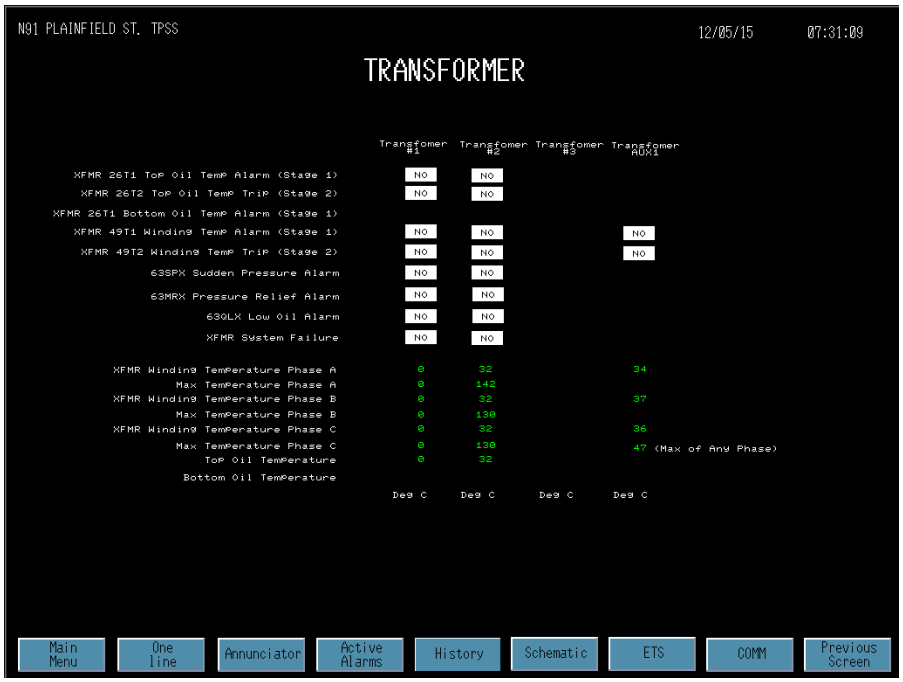
LOCAL REMOTE POSITION STATUS SCREEN



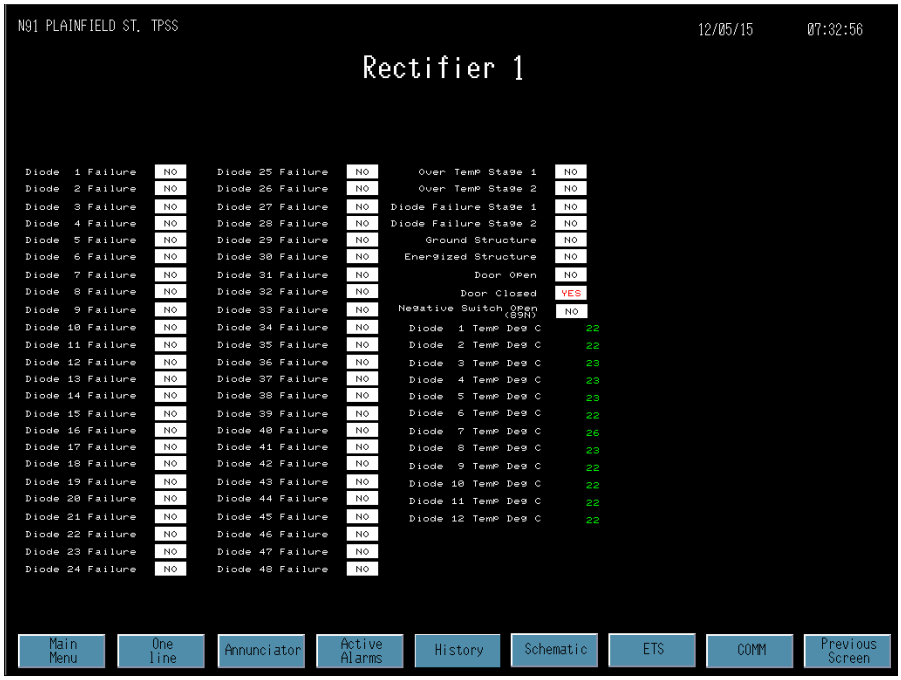
AC PQM METERING SCREEN (*)



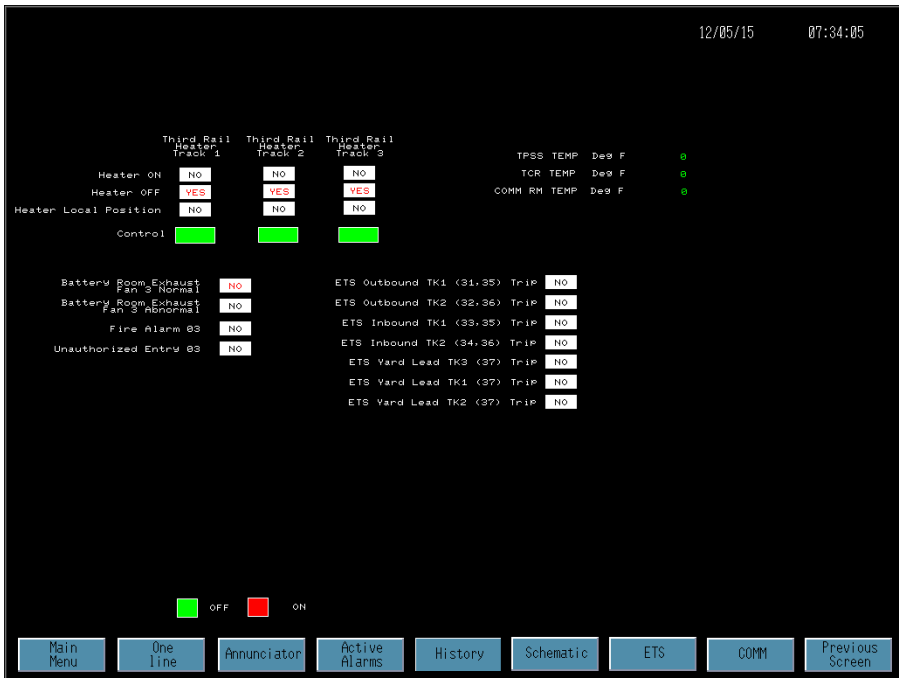
DC CABLE SHIELD MONITOR SCREEN (*)



TRANSFORMER MONITOR SCREEN (*)



RECTIFIER MONITOR SCREEN (*)



MISCELLANEOUS MONITORING SCREEN

END OF SECTION

Section 28 40 08

WIRE, CABLE, CABLE TRAY AND TERMINATION PANEL FOR SCADA SYSTEMS

PART 1 – GENERAL

1.01 SUMMARY

A. This document describes the standards, products and execution requirements relating to furnishing and installing Telecommunications, Supervisory Control and Data Acquisition (SCADA) systems cabling at Electrical facilities and Telecommunication Rooms (TR).

B. These standards are used in conjunction with current published ANSI/EIA/TIA standards, which prescribe mandatory requirements for copper conductor and Fiber Optics telecommunication cable to be used for Control application in electrical facilities outside the plant. As technology changes, this document will be amended to provide the most current and applicable information available. Any aspects of communications wiring or design which are not sufficiently addressed in this document shall be brought to the attention of the manager of SCADA and System Integration in the department of Chief Engineer and Infrastructure.

a. Backbone and other cabling comprised of copper and fiber cabling, and support systems are covered under this document.

b. All cables and related terminations, and support and grounding hardware shall be furnished, installed, wired, tested, labeled, and documented by the note contractor/installer as detailed in this document unless otherwise noted.

c. Product specifications, general design considerations, and installation guidelines are provided in this document. Typical installation details and cable routing will be provided as an attachment to this document. If bid documents are in conflict, this specification shall take precedence. The contractor/installer shall meet or exceed all requirements for the cable system described in this document.

1.02 REFERENCES

A. All work and materials shall conform in every detail to the rules and requirements of the National Fire Protection Association, the local Electrical Code, and present manufacturing standards.

B. All materials shall be UL Listed and shall be marked as such. If UL has no published standards for a particular item, then other national independent testing standards shall apply and such items shall bear those labels. Where UL has an applicable system listing and label, the entire system shall be so labeled.

C. The cabling system described in this document is derived from the recommendations made in recognized telecommunications industry standards. The following documents are incorporated by reference:

1. ANSI/TIA-568-C.0, Generic Communications Cabling for Customer Premises, February 2009
2. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
3. ANSI/TIA-568-C.2, Commercial Building Telecommunications Cabling Standard Part 2: Balanced Twisted-Pair Cabling Components
4. ANSI/TIA-568-C.3, Commercial Building Telecommunications Cabling Standard Part 3: Optical Fiber Cabling Components
5. ANSI/TIA-569-C, Commercial Building Standard for Telecommunications Pathways and Spaces
6. TIA-527, Measurement of Optical Power Loss of Installed Single-mode Fiber Cable Plant, OFSTP-7
7. TIA-526-14-A, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant OFSTP-14A
8. TIA-598-C, Optical Fiber Cable color Coding, January 2005
9. ANSI/TIA – 570-B, Residential Telecommunications Infrastructure Standard, April 2004
10. ANSI/TIA – 606 - B, Administration Standard for Commercial Telecommunications Infrastructure, April 2012
11. ANSI/TIA- 607-B - Commercial Building Bonding and Grounding (Earthing) Requirements for Telecommunications, August 2011
12. TIA– 758-A, Customer-Owned Outside Plant Telecommunications Infrastructure Standard, August 2004
13. National Fire Protection Agency (NFPA – 70)
14. National Fire Protection Agency (NFPA-130) Standard for Fixed Guideway Transit and Passenger Rail Systems, 2007

15. BICSI - TDMM, Building Industries Consulting Services International, Telecommunications Distribution Methods Manual (TDMM) – 13th Edition, 2014
16. National Fire Protection Agency (NFPA – 70)
17. National Electrical Code (NEC), 2014
18. National Fire Protection Agency (NFPA-130) Standard for Fixed Guideway Transit and Passenger Rail Systems, applicable version
19. WMATA Information Technology/ Network & Communications Services (IT/NCS) specification section: Infrastructure design & wiring standards.

1.03 APPROVED PRODUCTS

A. Superior Essex and Legrand/ Ortronics have been listed here as a WMATA preferred solution; however, other manufacturers' solutions that meet or exceed the listed criteria may be submitted for review and approval. Any solution submitted must also be capable of providing a manufacturer's warranty equal to, or greater than the preferred Superior Essex-Legrand/ Ortronics solutions. The Approved Material List in Appendix A represents WMATA's most commonly used products. Note that this is not an all-inclusive list.

1.04 SCOPE

A. The work included under this specification consists of furnishing all labor, equipment, materials, and supplies and performing all operations necessary to complete the installation of the SCADA system cabling in compliance with the specifications and drawings. The contractor/installer shall provide and install all of the required material to form a complete system whether specifically addressed in the technical specifications or not.

The work shall include, but not be limited to the following:

1. Furnish and install a complete SCADA wiring infrastructure.
2. Furnish, install, and terminate all Cables provided under this contract.
3. Furnish and install all patch panels, terminal blocks, patch cords, and jumper cables.
4. Furnish and install all required cabling cabinets (termination panels) and/or racks as required and as indicated.
5. Furnish and install all required communication cable trays.
6. Furnish all the necessary materials needed to form a complete, fully functional system.

7. Adhere and comply with all requirements of the Legrand/ Ortronics Certification program.

1.05 SUBMITTALS

A. All contractors/installers shall submit the following for approval in accordance with Subcontract Documents and additional requirements as specified for each:

1. All appropriate manufacturer data, cut sheets, and samples for all products, hardware, and cables.
2. Shop Drawings: Submit shop drawings for each type of cable installation and equipment.
3. Samples: Specified smoke-density test sample will become property of the Owner.
4. Certifications:
   a. Certified Fiber Optic Technician: A Certification from a recognized organization that the Fiber cable installer has demonstrated extensive basic knowledge of fiber optics and demonstrated skills and abilities in processes used in the industry.
   b. Certified flame retardancy test reports on actual cable or identical cable type as furnished. The test dates shall not be older than 12 months prior to submittal.
   c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced applicable Standards.
   d. Certificates from manufacturers and UL verifying that products conform to specified requirements. This shall include a certificate with submittal of shop drawings and with each cable shipment.
5. Test procedures.
6. The contractor/installer shall receive approval from WMATA on all substitutions of material. No substituted materials shall be installed except by written approval from the Chief engineer office.

1.06 QUALITY ASSURANCE

A. The Legrand/Ortronics CIP / CIP-ESP telecommunications contractor/installer shall be a company specializing in communication cabling installation. The contractor must be in good standing with a minimum of 30% of the technicians on site and at least one manager current with the required training.

B. In order to effectively install or repair fiber optics systems, the contractor must understand the limitations of bending, effects of temperature, how to effectively splice and connect fiber cables, and how to confirm the quality of a connection. The contractor/installer shall be a Certified Fiber Optic Technician.

C. Labeling: The labeling system shall clearly identify all components of the system, including, but not limited to cabinets, patch panels, cables, and if applicable, racks. The labeling system shall designate cable origin and destination with a unique identifier for the cable within the system. Jumper fiber cables shall be labeled at both patch panel and equipment ends. Backbone cables shall have an identifying number that is labeled at each end. Labels shall be the same color on each end. Cable identifier must be linked to all pathways to which it runs.

Cable strands, cores, racks, terminals, and patch panels shall be labeled to identify the location within the cable system infrastructure. All labeling information shall be recorded on the as-built drawings and test documentation. The following information must be provided on construction drawings:

a) Overall Plan of the system layout.

b) Pathways and spaces type, size, and location.

c) Media type, size and number.

d) Cable schematic layout/detail.

e) Type and layout of building entrance protected terminal.

f) Equipment and accessories type and layout.

g) The communication grounding system layout.

h) General Notes/Legend/Abbreviation

All label printing shall be machine generated by a label maker or software (such as Ortronics Label MO software) using indelible ink ribbons or cartridges. Self-laminating labels shall be used on cable jackets, appropriately sized to the OD of the cable, and placed within view at the termination point on each end. Patch panel and wiring block labels shall be installed on or in the device.

D. Cable Installation Quality Control Process

1. QA Phase 1 - Cable Installation Practices

   Inspect and ensure the following conform to TIA/EIA, NFPA 70, WMATA Design & Wiring Standards and all Local codes

   a. Cable bend radius
   b. Conduit sizing/ bend radius
   c. Cable tray fill
   d. Cable support in ceiling (Hangers/J hooks/ladder racks)
   e. Cable slack at the work area and the Telecommunication Room (TR)
   f. TR Configuration (Proper cable placement based on scope of work)

2. QA Phase 2 - Cable Termination Practices

   Inspect and ensure the following conform to TIA/EIA, WMATA Design & Wiring Standards, and all Local codes

   a. Correct jack pin out configuration
   b. Correct TR termination: Pin out, Hardware, and placement
   c. Correct fiber backbone and jumper termination (Per SCADA and Remote Monitoring Network & Termination Diagrams)

3. QA Phase 3 Final Testing and Inspection.

   a. All cables and terminations shall be tested for defects in installation and to verify cabling system performance under installed conditions according to the requirement of ANSI/TIA/EIA.
   b. All pairs of each installed cable shall be verified prior to system acceptance. Any defect in the cabling system installation including but not limited to cable, connectors, patch panels, and connector blocks shall be corrected such that 100% of conductors in all cables installed shall be usable.
   c. Copper Testing: All twisted pair copper cable links shall be tested for continuity, pair reversals, shorts, opens and performances as specified in Section 3.02.B of this specification.
   d. Fiber Testing: All fiber testing shall be performed on all fibers in the completed end to end system as specified in Section 3.02.C of this specification.
   e. All cables shall be tested in accordance with this document, the ANSI/TIA/EIA standard and best industry practice.

4. Final sign off**:** WMATA Information Technology/Network & Communication Services (IT/NCS) will sign documents provided by the contractor/installer, thereby approving the installation process and materials demonstrated in this project.

1.07 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) REQUIREMENTS

A. All internal wire and cable installed in tunnels and passenger stations shall meet the requirements of Chapter 5 and 6 of the 2003 or applicable Edition of NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems.

B. All external wire and cable installed in stations and passenger stations shall meet the requirements of Chapter 6 of the 2003 Edition or applicable of NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems.

C. In the event of conflicting specification requirements, the NFPA requirements shall take precedence.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Cable shall be stored according to manufacturer's recommendations. In addition, cable must be stored in a location protected from vandalism. Contractor shall ensure manufacturer’s recommendations are strictly adhered to when storing cable in non-climate controlled environments. If necessary, cable shall be stored off-site at the contractor's own expense.

B. The Owner shall not be required to provide storage space; however, if the contractor/installer wishes to have a trailer on site for storage of materials, arrangements shall be made with the Owner.

1.09 DRAWINGS

A. It shall be understood that the electrical details and drawings provided with the specification package are diagrammatic. They are included to show the intent of the specifications and to aid the contractor/installer in contract bidding. The contractor/installer shall make allowance in the bid proposal to cover whatever work is required to comply with the intent of the plans and specifications.

PART 2 – PRODUCTS

2.01 EQUIVALENT PRODUCTS

A. All products, including but not limited to patch panels, racks, and blocks, for the purpose of this document, shall be manufactured by Legrand/Ortronics. All copper and optical fiber cable products shall be manufactured by Superior Essex. Refer to Appendix A for the list of approved products.

B. WMATA's recommended product for ETS RS-485 cable shall be manufactured by Blake Cable, LLC.

2.02 MATERIALS

A. 20 AWG 10 PAIRS SHIELDED 300V NON-ARMORED RS-485 CABLE FOR ETS

Description: 20 AWG (minimum), 10 pairs, overall shielded, 300V power limited tray cable; with an overall aluminum/Mylar shield with 20 AWG stranded tinned copper drain wire, and an overall LSZH jacket. Cable installed in open air, in ducts or conduits, in trays or troughs and listed for outdoor, 75°C Wet or Dry, applications. Suitable for NFPA 130 applications. Jacket shall be sunlight resistant.

1. Conductor:
   a. AWG Size & Stranding: 20 AWG, Class B7 Strands
   b. Material: Annealed Bare Copper
2. Insulation:
   a. Material: Foamed Polyethylene (FPE)
   b. Wall Thickness: 0.015"
3. Color Code
   a. Code: Blue x White/Blue, Orange x White/Orange, Green x White/Green, Brown x White/Brown, Gray x White/Gray, Blue x Red/Blue, Orange x Red/Orange, Green x Red/Green, Brown x Red/Brown, Gray x Red/Gray
4. Pairs Assembly
   a. Pair Lay Length: 1.75" Left Hand Lay Each Pair, Nominal
   b. Cable Drain Wire: 20 AWG, 7 Strand Tinned Copper
5. Overall Assembly
   a. Cable Lay Length: 6.75" Left Hand Lay, Nominal
   b. Cable Fillers: Fibrillated Polypropylene, as necessary for a circular cross-section
   c. Cable Shield: Aluminum/Mylar, 100% Coverage (Foil Facing Out)

d. Cable Drain Wire: 20 AWG, 7 Strand Tinned Copper (Outside Foil)

6. Jacket
   a. Material: Low Smoke Zero Halogen (LSZH) Polyolefin (LSZH-)
   b. Wall Thickness: 0.060”
   c. Diameter: 0.560”
   d. Color: Black
   e. Ripcord: Kite Twine Ripcord
   f. Weight: Approximately 159 Lbs/Mft
7. Markings
   a. Type: Cable permanently identified via surface inkjet print
   b. Legend: the cables listing with spelled out description ”
   c. Markers: Sequential footage markers
8. Typical Test Values
   a. Tensile strength of un-aged jacket material- 1958 PSI (>1800)
   b. Elongation at rupture- 170% (>154%)
   c. Aging- Tensile strength after 240 hrs @110 deg C`- 104% of un-aged
   d. Aging - Elongation after aging for 240 hrs @110 deg C- 85% of un-aged
9. Nominal Electrical Values
   a. Impedance: 120 Ω
   b. Capacitance: 10.7 pF/ft (conductor to conductor)
   c. Capacitance: 19.8 pF/ft (conductor to shield)
   d. Resistance: 9.3 Ω/Mft @ 20°C
   e. Velocity of Propagation: 78%
10. Standards
   a. Cable compliant with EIA/TIA-485 requirement
   b. Cable Suitable for Sunlight Resistant & Low Smoke applications
   c. Cable meets UL1685 flame test with smoke requirements
   d. Cable meets NFPA 130 Flame test requirements
   e. RoHS compliant

B. 20 AWG 10 PAIRS SHIELDED 300V ARMORED RS-485 CABLE FOR ETS

Description**:** 20 AWG, 10 pairs shielded 300V power limited tray cable, with an overall aluminum/mylar shield with 20 AWG stranded tinned copper drain wire, a low smoke flame retardant zero halogen polyolefin jacket, an aluminum interlocked armor, and an

overall LSZH jacket. Cable installed in open air, in ducts or conduits, in trays or troughs and approved for outdoor, 75°C Wet or Dry, applications. Jacket is sunlight resistant. Suitable for NFPA 130 applications.

1. Conductor:
    a. AWG Size & Stranding: 20 AWG, Class B 7 Strands
    b. Material: Annealed Bare Copper
2. Insulation:
    a. Material: Foamed Polyethylene (FPE)
    b. Wall Thickness: 0.015”
3. Color Code
    a. Code: Blue x White/Blue, Orange x White/Orange, Green x White/Green, Brown x White/Brown, Gray x White/Gray, Blue x Red/Blue, Orange x Red/Orange, Green x Red/Green, Brown x Red/Brown, Gray x Red/Gray
4. Pairs Assembly
    a. Pair Lay Length: 1.75” Left Hand Lay Each Pair, Nominal
    b. Cable Drain Wire: 20 AWG, 7 Strand Tinned Copper
5. Overall Assembly
    a. Cable Lay Length: 6.75” Left Hand Lay, Nominal
    b. Cable Fillers: Fibrillated Polypropylene, as necessary for a circular cross-section
    c. Cable Shield: Aluminum/Mylar, 100% Coverage (Foil Facing out)
    d. Cable Drain Wire: 20 AWG, 7 Strand Tinned Copper (Outside Foil)
6. Jacket
    a. Material: Low Smoke Zero Halogen (LSZH) Polyolefin
    b. Wall Thickness: 0.030”
    c. Diameter: 0.500”
    d. Color: Black
    e. Ripcord: Kite Twine Ripcord
7. Interlocked Armor
    a. Material: Interlocked Aluminum
8. Outer Jacket
    a. Material: Low Smoke Zero Halogen (LSZH) Polyolefin ()
    b. Wall Thickness: 0.050” - The minimum at any point shall not be less than 80% of the Specified wall Thickness
    c. Diameter: 0.850”

d. Color: Black
e. Ripcord: Kite Twine Ripcord
f. Weight: Approximately 320 Lbs/Mft

9. Markings
   a. Type: Cable permanently identified via surface inkjet print
   b. Legend: the cables listing with spelled out description
   c. Markers: Sequential footage markers
10. Typical Test Values
   a. Tensile strength of un-aged jacket material- 1958 PSI (>1800)
   b. Elongation at rupture- 170% (>154%)
   c. Aging- Tensile strength after 240 hrs @110 deg c- 104% of un-aged.
      Aging - Elongation after aging for 240 hrs @110 deg C- 85% of un-aged
11. Nominal Electrical Values
   a. Impedance: 120 Ω
   b. Capacitance: 10.7 pF/ft (conductor to conductor)
   c. Capacitance: 19.8 pF/ft (conductor to shield)
   d. Resistance: 9.3 Ω/Mft @ 20°C
   e. Velocity of Propagation: 78%
12. Standards
   a. Cable compliant with EIA/TIA-485 requirement
   b. Cable Suitable for Sunlight Resistant & Low Smoke applications
   c. Cable meets UL1685 flame test with smoke requirements
   d. Cable meets NFPA 130 Flame test requirements
   e. All materials used in the manufacture of this cable are RoHS compliant

C. ETS TIA/EIA – 485 Termination Panels:
   1. TIA/EIA–485 termination panels shall be provided inside each AC room for terminating the ten twisted, shielded pairs of ETS monitoring system TIA/EIA – 485 cables
   2. TIA/EIA–485 terminal panel equipment shall be housed in NEMA 12 enclosures sized to accommodate four sets of ten twisted, shielded pairs of ETS monitoring system TIA/EIA – 485 cables.

D. 20 AWG 2 PAIRS SHIELDED 300V RS-485 CABLE FOR MISCELLANEOUS INSTALLATIONS WITH IN AC ROOMS

Two pair twisted pair cables for serial interconnection cables internal use between Intelligent Electronic Devices (lED's)/ Multi-Purpose Relay's (MPR's)/ Device Servers/ Media Convertors and SCADA RTU within Electrical rooms as needed shall meet RS-485 requirements in Section 2.02. B. of this specification.

E. FIBER CABLES, CONNECTORS AND PANELS

1. FIBER DISTRIBUTION CABLE

All horizontal fiber data cables shall be terminated on patch panels, mounted in their respective equipment enclosures as specified in each equipment specifications, and shown on the drawings.

2. Indoor/Outdoor Optical Fiber Plenum (OFNP) with Laser Optimized 50/125µm Multimode Optical Fibers

a. Multimode Optical Fibers type OM3 50/125µm shall be used within facilities.

b. Each Multimode Fiber shall be:

1) Graded-index Multi-mode optical fiber wave-guide with bend resistant technology (TeraFlex Bend Resistant or approved equal), Laser Optimized 50/125nm-core/cladding diameter.

2) Approved products as specified in section 1.03 of this specification.

3) Shall comply with the latest revision of ANSI/EIA/TIA-492AAAB.

4) Shall comply with the latest revision of ANSI/ICEA S-104-696.

5) Attenuation shall be measured in accordance with ANSI/EIA/TIA-455-78.

6) Information transmission capacity shall be measured in accordance with the latest revision of ANSI/EIA/TIA-455-204 or –455-220.

7) Maximum attenuation dB/Km @ 850/1300 nm: 2.4/0.7. or lower

c. Physical Characteristics:

1) Shall be available in either tight buffered or loose tube construction for use in both outdoor and indoor applications without the use of a transition at the building entrance.

2) Shall be suitable for use in risers, plenums, and horizontal applications.

3) Shall have a dry water blocking system for cable core and buffer tubes.

4) Shall be available with a fiber strand count range from 6 to 24.

5) Shall have and be marked with an UL-OFNP and OFN FT6 Flame Rating.

6) Shall comply with the requirements of the latest revision of ANSI/ICEA S-104-696
7) Strength members shall be dielectric
8) Suitable for underground or above ground conduits.
9) Cable shall be color coded in accordance with the latest revision of ANSI/TIA-598 with an overall black jacket.
10) Suitable for operation between -40°C to +70°C
11) Shall be UV resistant
12) Shall be available in either aluminum interlock or steel construction armor.

3. Indoor/Outdoor Optical Fiber Low Smoke Zero Halogen (LSZH) Loose Tube with Laser Optimized OM3 50/125 Optical Fibers - use in NFPA-130 required environments

a. Each Multimode Fiber shall be:
1) Graded-index Multi-mode optical fiber wave-guide with bend resistant technology (Tera Flex Bend Resistant or approved equal) Laser Optimized 50/125nm-core/cladding.
2) As described in section 1.4, Approved Products
3) Shall comply with the latest revision of ANSI/ICEA S-104-696-2013.
4) Attenuation shall be measured in accordance with the latest revision of ANSI/TIA-455-78.
5) Information transmission capacity shall be measured in accordance with the latest revision of ANSI/TIA-455-220.
6) Maximum attenuation dB/Km @ 850/1300 nm: 2.4/0.7. or lower

b. Physical Characteristics:
1) Shall be suitable for use in NFPA-130 tunnel, subway passages, and passage station environments, including both outdoor and indoor applications without the use of a transition at the building entrance.
2) Shall be suitable for use in low smoke zero halogen applications.
3) Shall have a dry, fully water blocked core and buffer tubes water blocked with Polymer Filling Matrix (PFM).
4) Shall be available with a fiber strand count range from 6 to 288.
5) Shall have and be marked with an UL-1666 and OFNG-LS (OFCG-LS for armored) Flame Rating.

6) Shall comply with the requirements of the latest revision of ANSI/ICEA S-104-696.
7) Strength members shall be dielectric and of suitable material such as aramid yarn.
8) Suitable for installation in underground or above ground conduits.
9) Loose Tube fibers shall be color coded in accordance with TIA-598-C with an overall black jacket.
10) Suitable for operation between -40°C to +70°C
11) Shall be flame and sunlight resistant
12) Shall be available in Corrugated Steel Armor construction as needed.

4. Indoor/Outdoor Optical Fiber Plenum (OFNP) With Enhanced (Low Water Peak) Single-mode Optical Fibers

a. Single-Mode Optical Fibers shall be used to link Electrical rooms to communications rooms.

b. Each Single-mode Fiber shall be:

1) Low Water Peak type (IVa dispersion - unshifted) single mode optical fibers with bend resistant technology (TeraFlex Bend Resistant or approved equal), and bending-loss insensitive single-mode optical fiber (complying with G657.A1) complying with the latest revision of ANSI/ICEA S-104-696.
2) Approved Products as specified in section 1.03 of this specification.

c. The zero dispersion wavelengths shall be between 1300 nm and 1320 nm. The ANS/TIA-455-168 maximum value of the dispersion slope shall be no greater than 0.090 ps/km-nm2. Dispersion measurements shall be made in accordance with the latest revision of ANSI/TIA-455-175.

d. Transmission Characteristics:

1)Maximum cabled attenuation dB/km @ 1310/1550 nm: 0.5/0.4
2)The cabled cutoff wavelength shall be ≤1260 nm when measured in accordance with ANSI/EIA/TIA-455-80.

e. Physical Characteristics:

1) Shall be suitable for use in both outdoor and indoor applications without the use of a transition at the building entrance.

2) Shall be suitable for use in risers, plenums and horizontal applications.
3) Shall have a dry water blocking system for cable core and buffer tubes.
4) Shall be available with a fiber strand count of 6 to 24.
5) Shall have and be marked with an OFNP (OFCP for armored) and OFN (OFC for armored) FT-6 Flame Rating.
6) Shall comply with the latest revision of ANSI/ICEA S-104-696.
7) Strength members shall be dielectric.
8) Suitable for underground or above ground conduits.
9) Cable shall be color coded in accordance with the latest revision of ANSI/TIA-598 with an overall black jacket.
10) Shall have a ripcord for overall jacket.
11) Suitable for operation between -40oC to +70o C
12) Shall be UV resistant
13) Shall be available in either aluminum interlock or steel construction armor.

5. Indoor/Outdoor Optical Fiber Plenum (OFNP) Loose Tube With Enhanced (Low Water Peak) Single-mode Optical Fibers - use in NFPA-130 required environments

a. Each Single-mode Fiber shall be:

1) Class IVa dispersion - unshifted single mode optical fibers with TeraFlex Bend Resistant (or approved equal bend resistant cable technology) G657.A1 complying with the latest revision of ANSI/ICEA S-104-696.
2) Be as described in section 1.4, Approved Products
3) The zero dispersion wavelengths shall be between 1300 nm and 1320 nm. The ANSI/TIA-455-168 maximum value of the dispersion slope shall be no greater than 0.090 ps/km-nm2. Dispersion measurements shall be made in accordance with the latest revision of ANSI/TIA-455-169 or ANSI/TIA-455-175.

b. Transmission Characteristics:

1) Maximum cabled attenuation dB/km @ 1310/1550 nm: 0.5/0.4

2) The cabled cutoff wavelength shall be ≤1260 nm when measured in accordance with the latest revision of ANSI/TIA-455-80.

c. Physical Characteristics:

1) Shall be suitable for use in NFPA-130 tunnel, subway passages and passage station environments both outdoor and indoor applications without the use of a transition at the building entrance
2) Shall be suitable for use in low smoke zero halogen applications.
3) Shall have a dry, fully water blocked core and buffer tubes water blocked with PFM.
4) Shall be available with a fiber strand count range from 6 to 288.
5) Shall have and be marked with an UL-1666 and OFNG-LS (OFCG-LS for armored) Flame Rating.
6) Shall comply with the latest revision of ANSI/ICEA S-104-696.
7) Strength members shall be aramid/yarn.
8) Suitable for underground or above ground conduits.
9) Loose Tube fibers shall be color coded in accordance with TIA-598-C with an overall black jacket.
10) Suitable for operation between -40°C to +70°C
11) Shall be flame and sunlight resistant
12) Shall be available in Corrugated Steel Armor construction as needed.

6. FIBER PATCH CORDS (JUMPERS)

a. The contractor shall provide factory terminated and tested, 50/125µm, multimode, duplex, OM-3 type pre-terminated (SC-ST or SC-LC), connectors depending on the end devices (IEDs, MPR, Meters, network switch, etc.) to their respective equipment patch panels. Each fiber patch cord shall:

1) Contain two (2) optical fibers.
2) Meet the requirements of the ‘Approved product’ list as specified in section 1.03.
3) Feature insertion loss figures printed on the package

7. FIBER OPTIC CONNECTORS

a. Each Fiber Connector shall:

1) Meet WMATA's standard multimode and single-mode fiber optic connector (SC style connector).
2) Be available in single-mode and multimode versions.
3) Be in 'Approved Products' list as specified in section 1.03 of this specification.
4) Has insertion loss of 0.3 dB or less for multimode and 0.2 dB or less for single-mode
5) Be stable over an operating range of -40°C to +75°C.

8. FIBER OPTIC PATCH PANELS

a. All Locations

1) Multimode distribution fiber cables and single-mode backbone fiber optic cables shall be run between fiber patch panels inside the Network Switch enclosure and the fiber patch panels of each equipment as shown on drawings. Fibers interconnecting the network switch to the equipment shall be connected to the rear of the patch panels, Fiber Jumpers to devices and Network switches shall be connected to the front of the patch panels per the WMATA Network termination diagrams drawings.
2) Network switch fiber patch panels:
   a) Ortronics #OR-FC01U-C with Ortronics' s #OR-OFP-SCD12AC adapters for single mode fiber cables.
   b) Ortronics #OR-FC02U-C with Ortronics' s #OR-OFP-SCD12AL adapters for multimode fiber cables.
   c) Quantities are specified on contract drawings.

3) AC/DC Switchgear Patch Panels:
   a) Patch panels can be installed on the external side wall of the AC/DC switchgear when wall space is not available.
   b) One Ortronics #OR-615SMFC-48P/S fiber patch panel with Ortronics' s #OR-OFP-SCD12AL adapters to terminate outgoing multimode fiber to network switch patch panels.
   c) Minimum number of panel adaptors as defined in the contract drawings.

4) Patch Panels in Rectifier / RTU:

a) One (1) Corning's Wall-Mount Housing # SPH-01P with one (1) 6 SC duplex 50um 10gig multimode fiber coupling connector mounted close to the RTU cabinet or factory mounted inside the RTU.

F. COMMUNICATION CABLE TRAY

1. In AC electrical rooms, communication cables will be installed in conduits.

G. FIRESTOP

1. A fire stop system shall be comprised of the item or items penetrating the fire rated structure, the opening in the structure, and the materials and assembly of the materials used to seal the penetrated structure. The fire stop system shall comprise components for an effective blocking of fire, smoke, heat, vapor and pressurized water stream from channeling through the penetration.

a) All penetrations through fire rated building structures (walls and floors) shall be sealed with an appropriate fire stop system. This requirement applies to through penetrations (complete penetration) and membrane penetrations (through one side of a hollow fire rated structure). Any penetrating item (i.e., riser slots and sleeves, cables, conduit, cable tray, and raceways, etc.) shall be properly fire stopped.

b) Fire stop systems shall be UL Classified to ASTM E814 (UL 1479) and shall be approved by a qualified Engineer.

c) A drawing showing the proposed fire stop system shall be provided to the Owner's Technical Representative prior to installing the fire stop system(s).

PART 1 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. CABLE INSTALLATION

1. Cable shall be installed in accordance with manufacturer's recommendations and best industry practices.

2. A pull cord (nylon; 1/8" minimum) shall be co-installed with all cable installed in any conduit.
3. Cable raceways shall not be filled more than the ANSI/TIA/EIA-569-A maximum fill for the particular raceway type or 40%.
4. Cables shall be installed in continuous lengths from origin to destination (no splices) except for transition points, or consolidation points.
5. Where transition points or consolidation points are allowed, they shall be located in accessible locations and housed in an enclosure intended and suitable for the purpose.
6. Install RS485 and Fiber cable in communication cable tray/conduit and segregated from power/control cables.
7. The cable's specified minimum bend radius and maximum pulling tension shall not be exceeded.
8. Use hook and loop wraps to bundle and secure fiber and twisted pair cable located in panelboards, cabinets, switchboards, switchgear and control panels; ensure that wraps are not over tightened on the cables.
9. Cables shall be identified by a self-adhesive label in accordance with the contract network and termination diagrams. The cable label shall be applied to the cable behind the faceplate on a section of cable that can be accessed by removing the cover plate.
10. Unshielded twisted pair cable shall be installed so that there are no bends smaller than four times the cable outside diameter at any point in the run and at the termination field.

B. OPTICAL FIBER TERMINATION HARDWARE

1. Fiber slack shall be neatly coiled within the fiber patch panel. No slack loops shall be allowed external to the fiber panel.

2. Each cable shall be individually labeled and attached to the respective patch panel by mechanical means. The cables strength member shall be securely attached to the cable strain relief bracket in the enclosure.

3. Each fiber bundle shall be stripped of its jacket and tube upon entering the patch panel and the individual fibers routed in the patch panel.

4. Terminate fiber optic cables using the pre-manufactured terminations and plug into the patch panels in accordance with the manufacturer's recommendations.

5. All spare strands shall be installed into spare connector.

C. BACKBONE CABLE INSTALLATION

1. Refer to WMATA Information Technology/Network & Communications Services Design & Wiring Standards for all Single mode fiber installations.

D. CABLE LABELING AND TERMINATIONS

1. The labeling system shall clearly identify all components of the system including, but not limited to equipment, cables, and panels.

2. The labeling system shall designate the cables origin and destination and a unique identifier for the cable within the system.

3. Racks and patch panels shall be labeled to identify the location within the cable system infrastructure.

4. All labeling information shall be recorded on the as-built drawings and all test documents shall reflect the appropriate labeling scheme.

5. Labeling shall follow the guidelines of ANSI/TIA/EIA-606-A.

6. All label printing shall be machine generated by Ortronics Label software or approved equal using indelible ink ribbons or cartridges or equivalent.

7. Self-laminating labels will be used on cable jackets, appropriately sized to the OD of the cable, and placed within view at the termination point on each end.

8. Patch panel and wiring block labels shall be installed on or in the space provided on the device.

3.02 TESTING AND ACCEPTANCE

A. General

1. All cables and termination hardware shall be 100% tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of ANSI/TIA/EIA-568-C.

2. All pairs of each installed cable shall be verified prior to system acceptance.

3. Any defect in the cabling system installation including but not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced to the extent 100% of connected conductors/fibers and a minimum of 97% of spares in all cables installed are usable. The defective conductors/fibers shall be identified and properly labelled.

4. All cables shall be tested in accordance with this document, the ANSI/TIA/EIA standards, the Ortronics Certification Program Information Manual and best industry practice. If any of these are in conflict, the Contractor/Installer shall bring any discrepancies to the attention of the Owner representative for clarification and resolution.

B. Copper Testing

1. All twisted-pair copper cable links shall be tested for continuity, pair reversals, shorts, opens and performance as indicated below. Additional testing is required to verify Category performance.
2. Horizontal cabling shall be tested using a Level III test unit for category 6 performance compliance.
3. The basic tests required are:
   a. Wire Map
   b. Length
   c. Attenuation
   d. NEXT (Near end crosstalk)
   e. Return Loss
   f. ELFEXT Loss
   g. Propagation Delay
   h. Delay skew
   i. PSNEXT (Power sum near-end crosstalk loss)
   j. PSELFEXT (Power sum equal level far-end crosstalk loss)
4. Continuity:
   a. Each pair of each installed cable shall be tested using a test unit that shows opens, shorts, polarity and pair-reversals, crossed pairs, and split pairs.
   b. Shielded cables shall be tested with a device that verifies shield continuity in addition to the above tests.
   c. The test shall be recorded as pass/fail as indicated by the test unit in accordance with the manufacturers' recommended procedures, and

referenced to the appropriate cable identification number and circuit or pair number.

d. Any faults in the wiring shall be corrected and the cable re-tested before final acceptance.

5. Length:

a. Each installed cable link shall be tested for installed length using and held tester from an industry recognized test equipment manufacturer.

b. The cables shall be tested from patch panel to patch panel and patch panel to end device as appropriate.

c. The cable length shall conform to the maximum distances set forth in the ANSI/TIA/EIA-568-C.2 and B.3 standard.

d. Cable lengths shall be recorded, referencing the cable identification number and circuit or pair number.

e. For multi-pair cables, the shortest pair length shall be recorded as the length for the cable.

6. Category 6 Performance:

Shall meet the channel requirements outlined below for a 100-meter, 4-Connector channel. Frequency (MHz)	Maximum Insertion Loss (dB)	Minimum NEXT (dB)	Minimum PSNEXT (dB)	Minimum ELFEXT (dB)	Minimum PSELFEXT (dB)	Minimum Return Loss (dB)
1.0	2.1	70.0	67.0	68.3	65.3	24.0
4.0	4.0	68.0	65.5	56.2	53.2	24.0
10.0	6.3	61.6	59.0	48.3	45.3	24.0
20.0	9.0	56.6	54.0	42.2	39.2	24.0
31.25	11.3	53.4	50.7	38.4	35.4	22.1
62.5	16.4	48.4	45.6	32.3	29.3	19.1
100.0	21.2	44.9	42.1	28.3	25.3	17.0
155.0	26.6	41.7	38.8	24.4	21.4	15.1
200.0	31.5	39.8	36.9	22.2	19.2	14.0
250.0	36.0	38.1	35.2	20.3	17.3	13.0

C. Fiber Testing

1. Fiber testing shall be performed on all fibers in the completed end-to-end system.

2. There shall be no splices unless indicated on the approved design drawings.

3. Testing shall be conducted in accordance with the latest revision of TIA-526-7, Method B for single-mode fibers.

4. Tests shall be conducted in accordance with the latest revision of ANSI/TIA-526-14 Standard for multimode fibers.
5. System loss measurements shall be provided at 850 and 1300 nanometers for multimode fibers and 1310 and 1550 nanometers for single mode fibers.
6. Backbone multimode fiber cabling shall be tested at both 850 nm and 1300 nm (or 1310 and 1550 nm for single-mode) in both directions.
7. Where links are combined to complete a circuit between devices, the Contractor/Installer shall first test each link individually and afterwards from end to end, by providing connection by way of patch cords if necessary, to ensure the performance of the system.
8. The test method shall be the same used for the test described above. The values for calculating loss shall be those defined in the latest revision of the ANSI/TIA Standard.
9. Attenuation testing shall be performed with an approved hand held tester from an industry recognized test equipment manufacturer.
10. Fiber cable characterization report shall be generated for each installed fiber and submitted as detailed in the System Documentation section of this specification.
11. A minimum of 0.11dB or higher headroom/margin is required

3.03 SYSTEM DOCUMENTATION

A. Upon completion of the installation, the contractor/installer shall provide three (3) sets of the complete all documentation to the Engineer for approval. Documentation shall include the items detailed in the sub-sections below.

B. Manufacturer's original certificate of origin with each fiber's factory attenuation results must be submitted. No site installation of the cables shall commence without first securing the Owner's approval on the manufacturer conducted test reports submitted by the Contractor.

C. Documentation shall be submitted within ten (10) working days of the completion of each site testing phase (e.g. subsystem, cable type, area, floor, etc.). This is inclusive of all test result and draft as-built drawings.

D. Draft drawings may include annotations done by hand. Machine generated (final) copies of all drawings shall be submitted within 30 working days of the completion of each testing phase.

E. The contractor/installer shall provide all test reports.

F. The Engineer may at its own discrimination request a witnessed field re-test of any part of the report up to 50 separate tests or 10% of the report, whichever is lower, to verify the submitted reports at no additional cost to the Owner.

G. Re-test(s) shall use the same procedures as the original tests. If re-test findings contradict the submitted test documentation resulting in the reversal of any one of the submitted test results, the Engineer shall be entitled to request an additional ten (10) more re-tests per reversed test result. If five (5) or more instances or 1% or more of the test report, whichever is lower, result in test report reversal, the entire submitted test report shall be rejected.

H. Test(s) shall be conducted at 100% of the installation and the report submitted until the condition in 3.03.G of this specification is satisfied. This new test(s) and the accompanying report submission(s) shall be at no additional cost to the Owner.

3.04 TEST RESULTS

A. The results shall include a record of test frequencies, cable type, conductor pair and cable I.D., measurement direction, reference setup, and crew member name(s).

B. The test equipment name, manufacturer, model number, serial number, software version and last calibration date shall be included. Test equipment calibration report dated not older than one year from the date the test is conducted or the test equipment manufacturer's recommended calibration frequency, whichever is more stringent, shall accompany each test report.

C. The test document shall detail the test method used and the specific settings of the equipment during the test as well as the software version being used in the field test equipment. Refer to Appendix B for sample test report.

D. The field test equipment shall meet the requirements of ANSI/TIA/EIA-568-C including applicable TSB's and amendments.

E. The appropriate Level III tester shall be used to verify Category 6 cabling systems.

F. Printouts generated for each cable by the wire (or fiber) test instrument shall be submitted as part of the documentation package.

G. The contractor/installer must furnish this information in electronic form (CD-ROM) or acceptable pre-approved media.

H. When repairs and re-tests are performed, the problem found and corrective action taken shall be noted, and both the failed and passed test data shall be documented.

3.05 AS-BUILT DRAWINGS

A. The drawings shall include cable routes and outlet locations superimposed on properly diminished room/space layout.

B. Numbering, icons, and drawing conventions used shall be consistent throughout all documentation provided.

C. The owner will provide floor plans in paper and electronic (DWG, AutoCAD rel. 14) formats on which as-built construction information can be added.

D. The Chief Engineer Infrastructure SCADA and remote monitoring Standard drawing, Network & Termination Diagrams shall be used as template.

3.06 WARRANTY AND SERVICES

A. An Extended Product Warranty shall be provided which warrants functionality of all components used in the system for 25 years from the date of registration. The Extended Product Warranty shall warrant the installed horizontal and/or backbone copper, and both the horizontal and the backbone optical fiber portions of the cabling system.

B. The Application Assurance Warranty shall cover the failure of the wiring system to support the applications that are designed for the link/channel specifications of ANSI/TIA/EIA–568-C.1. These applications include, but are not limited to, 10BASE-T, 100BASE-T, 1000BASE-T, and 155 Mb/s ATM.

C. The contractor/installer shall provide a warranty on the physical installation.

APPENDIX A: APPROVED PRODUCTS

Item Description	**Manufacturer**	**(MFR.) Part Number**
Fiber Optic Cable and Connectivity		
Indoor/Outdoor Optical Fiber Plenum (OFNP) with Laser Optimized 50/125µm Multimode Optical Fibers	Superior Essex	Coordinate with IT for approved part number
Indoor/Outdoor Optical Fiber Low Smoke Zero Halogen (LSZH) Loose Tube With Laser Optimized OM3 50/125 Optical Fibers - use in NFPA-130 required environments	Superior Essex	Coordinate with IT for approved part number
Indoor/Outdoor Optical Fiber Plenum (OFNP) With Enhanced (Low Water Peak) Single-mode Optical Fibers	Superior Essex	Coordinate with IT for approved part number
Indoor/Outdoor Optical Fiber Plenum (OFNP) Loose Tube With Enhanced (Low Water Peak) Single-mode Optical Fibers - use in NFPA-130 required environments	Superior Essex	Coordinate with IT for approved part number
Fiber Optic Connectors		
SC Multimode Unicam 50 Micron Organizer Pack	Corning	95-050-41-X-Z
SC Singlemode (Pretium) Unicam Organizer Pack (25)	Corning	95-200-42-Z
Fiber Optic Coupler Panels		
12 Port SC Coupler Panel, Single mode	Ortronics	OR-OFP-SCD12AC
12 Port SC Coupler Panel, Multimode, 50 micron	Ortronics	OR-OFP-SCD12LC
Fiber Optic Termination Enclosures		
Three Slot Rack Mount Enclosure; 1RU patching & Splice (2 splice trays)	Ortronics	OR-FC01U-C
Six Slot Rack Mount Enclosure; 2RU patching & splice (6 splice trays)	Ortronics	OR-FC02U-C
Patch Cabinet , Wall Mount 48 port & splice	Ortronics	OR-615SMFC-48P/S
Fiber Patch Cords FPC MM 50 10G 2F SC-LC 3M CERAMIC ZIP (2.0MM) AQUA (Patch Cords)		
LC to SC 50um (OM3), duplex patch cord	Ortronics	

Item Description	**Manufacturer**	**(MFR.) Part Number**
SC to ST 50um (OM3) duplex patchcord	Ortronics	
Cable Tray		
12" Trapeze Bracket	Cablofil	FAS P 450
24" Trapeze Bracket	Cablofil	FAS P 600
90 Deg. Raduis TEE Bend KIT	Cablofil	RADT90KIT 4
1/4" Nut & Bolt	Cablofil	EZ BN 1/4
Square Splice Washer	Cablofil	CE-40
Splice for sweep's	Cablofil	FASLOCKS
EDRN Tool	Cablofil	EDRNTOOL
EDRN Fast Splice	Cablofil	EDRN
Cable Tray 4" x 8" x 10'	Cablofil	CF-105/200
Cablofil Tray cutters	Cablofil	COUPFIL
Elevation Change Hinge	Cablofil	EAC
90 Deg. (Hard) TEE Bend KIT	Cablofil	EZT 90 KIT
Tray drop out kit	Cablofil	DROPOUTKITPG
2" x 12" x 10' Cable Tray	Cablofil	CF54/300EZ
4" x 12" x 10' Cable Tray	Cablofil	CF54/105EZ
4"x8"x10' Cable Tray	Cablofil	Cf-105/200
12" Cable Tray Splice (50 pk)	Cablofil	EDRNEZ
Hold down Bracket	Cablofil	CE-25
Nut and Bolt	Cablofil	EZ BN 5/16
J Bolt (To mount to top of rack)	Cablofil	EZJB-5/16

APPENDIX B: SAMPLE TEST REPORT

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Cable ID	Summary	Test Limit	Length	Headroom	Date / Time
SWITCHBOARD 1 - COMM RM01	PASS	TIA-568-C Singlemode ISP	114 ft	1.12 dB (Loss Margin)	05/19/2015 04:27 AM
SWITCHBOARD 1 - COMM RM02	PASS	TIA-568-C Singlemode ISP	114 ft	1.50 dB (Loss Margin)	05/19/2015 04:27 AM
SWITCHBOARD 1 - COMM RM03	PASS	TIA-568-C Singlemode ISP	114 ft	1.00 dB (Loss Margin)	05/19/2015 04:30 AM
SWITCHBOARD 1 - COMM RM04	PASS	TIA-568-C Singlemode ISP	114 ft	1.26 dB (Loss Margin)	05/19/2015 04:30 AM
SWITCHBOARD 1 - COMM RM05	PASS	TIA-568-C Singlemode ISP	115 ft	1.12 dB (Loss Margin)	05/19/2015 04:31 AM
SWITCHBOARD 1 - COMM RM06	PASS	TIA-568-C Singlemode ISP	115 ft	1.35 dB (Loss Margin)	05/19/2015 04:31 AM
SWITCHBOARD 1 - COMM RM07	PASS	TIA-568-C Singlemode ISP	114 ft	0.88 dB (Loss Margin)	05/19/2015 04:33 AM
SWITCHBOARD 1 - COMM RM08	PASS	TIA-568-C Singlemode ISP	114 ft	0.86 dB (Loss Margin)	05/19/2015 04:33 AM
SWITCHBOARD 1 - COMM RM09	PASS	TIA-568-C Singlemode ISP	115 ft	0.22 dB (Loss Margin)	05/19/2015 04:35 AM
SWITCHBOARD 1 - COMM RM10	PASS	TIA-568-C Singlemode ISP	115 ft	1.32 dB (Loss Margin)	05/19/2015 04:35 AM
SWITCHBOARD 1 - COMM RM11	PASS	TIA-568-C Singlemode ISP	115 ft	1.16 dB (Loss Margin)	05/19/2015 04:37 AM
SWITCHBOARD 1 - COMM RM12	PASS	TIA-568-C Singlemode ISP	115 ft	1.37 dB (Loss Margin)	05/19/2015 04:37 AM
SWITCHBOARD 1 - LVSWGR-01	PASS	TIA-568-C Multimode	58 ft	0.52 dB (Loss Margin)	05/18/2015 12:23 AM
SWITCHBOARD 1 - LVSWGR-02	PASS	TIA-568-C Multimode	58 ft	0.36 dB (Loss Margin)	05/18/2015 12:23 AM
SWITCHBOARD 1 - LVSWGR-03	PASS	TIA-568-C Multimode	58 ft	0.29 dB (Loss Margin)	05/18/2015 01:02 AM
SWITCHBOARD 1 - LVSWGR-04	PASS	TIA-568-C Multimode	58 ft	0.59 dB (Loss Margin)	05/18/2015 01:02 AM
SWITCHBOARD 1 - LVSWGR-05	PASS	TIA-568-C Multimode	58 ft	0.05 dB (Loss Margin)	05/18/2015 01:04 AM
SWITCHBOARD 1 - LVSWGR-06	PASS	TIA-568-C Multimode	58 ft	0.77 dB (Loss Margin)	05/18/2015 01:04 AM
SWITCHBOARD 1 - MV-F60-01	PASS	TIA-568-C Multimode	65 ft	0.52 dB (Loss Margin)	05/18/2015 01:09 AM
SWITCHBOARD 1 - MV-F60-02	PASS	TIA-568-C Multimode	65 ft	0.58 dB (Loss Margin)	05/18/2015 01:09 AM
SWITCHBOARD 1 - MV-F60-03	PASS	TIA-568-C Multimode	65 ft	0.53 dB (Loss Margin)	05/18/2015 01:11 AM
SWITCHBOARD 1 - MV-F60-04	PASS	TIA-568-C Multimode	65 ft	0.75 dB (Loss Margin)	05/18/2015 01:11 AM
SWITCHBOARD 1 - MV-F60-05	PASS	TIA-568-C Multimode	65 ft	0.00 dB (Loss Margin)	05/18/2015 01:13 AM
SWITCHBOARD 1 - MV-F60-06	PASS	TIA-568-C Multimode	65 ft	0.79 dB (Loss Margin)	05/18/2015 01:13 AM
SWITCHBOARD 1 - RTU DROP	PASS	TIA Cat 6 Perm. Link	15 ft	7.6 dB (NEXT)	05/18/2015 02:16 AM
SWITCHBOARD 1 - RTU-01	PASS	TIA-568-C Multimode	34 ft	0.54 dB (Loss Margin)	05/18/2015 12:15 AM
SWITCHBOARD 1 - RTU-02	PASS	TIA-568-C Multimode	34 ft	0.26 dB (Loss Margin)	05/18/2015 12:15 AM
SWITCHBOARD 1 - RTU-03	PASS	TIA-568-C Multimode	34 ft	0.54 dB (Loss Margin)	05/18/2015 12:18 AM
SWITCHBOARD 1 - RTU-04	PASS	TIA-568-C Multimode	34 ft	0.21 dB (Loss Margin)	05/18/2015 12:18 AM
SWITCHBOARD 1 - RTU-05	PASS	TIA-568-C Multimode	35 ft	0.68 dB (Loss Margin)	05/18/2015 12:20 AM
SWITCHBOARD 1 - RTU-06	PASS	TIA-568-C Multimode	35 ft	0.16 dB (Loss Margin)	05/18/2015 12:20 AM
SWITCHBOARD 2 - COMM RM01	PASS	TIA-568-C Singlemode ISP	642 ft	1.34 dB (Loss Margin)	05/19/2015 04:19 AM
SWITCHBOARD 2 - COMM RM02	PASS	TIA-568-C Singlemode ISP	642 ft	1.37 dB (Loss Margin)	05/19/2015 04:19 AM
SWITCHBOARD 2 - COMM RM03	PASS	TIA-568-C Singlemode ISP	641 ft	1.43 dB (Loss Margin)	05/19/2015 03:15 AM
SWITCHBOARD 2 - COMM RM04	PASS	TIA-568-C Singlemode ISP	641 ft	1.11 dB (Loss Margin)	05/19/2015 03:15 AM
SWITCHBOARD 2 - COMM RM05	PASS	TIA-568-C Singlemode ISP	641 ft	1.21 dB (Loss Margin)	05/19/2015 03:12 AM
SWITCHBOARD 2 - COMM RM06	PASS	TIA-568-C Singlemode ISP	641 ft	1.13 dB (Loss Margin)	05/19/2015 03:12 AM
SWITCHBOARD 2 - COMM RM07	PASS	TIA-568-C Singlemode ISP	642 ft	0.96 dB (Loss Margin)	05/19/2015 03:09 AM
SWITCHBOARD 2 - COMM RM08	PASS	TIA-568-C Singlemode ISP	642 ft	1.31 dB (Loss Margin)	05/19/2015 03:09 AM
SWITCHBOARD 2 - COMM RM09	PASS	TIA-568-C Singlemode ISP	641 ft	1.48 dB (Loss Margin)	05/19/2015 03:06 AM
SWITCHBOARD 2 - COMM RM10	PASS	TIA-568-C Singlemode ISP	641 ft	1.05 dB (Loss Margin)	05/19/2015 03:06 AM
SWITCHBOARD 2 - COMM RM11	PASS	TIA-568-C Singlemode ISP	641 ft	1.39 dB (Loss Margin)	05/19/2015 03:03 AM
SWITCHBOARD 2 - COMM RM12	PASS	TIA-568-C Singlemode ISP	641 ft	1.21 dB (Loss Margin)	05/19/2015 03:03 AM
SWITCHBOARD 2 - LVSWGR-01	PASS	TIA-568-C Multimode	76 ft	0.57 dB (Loss Margin)	05/17/2015 11:26 PM
SWITCHBOARD 2 - LVSWGR-02	PASS	TIA-568-C Multimode	76 ft	0.51 dB (Loss Margin)	05/17/2015 11:26 PM
SWITCHBOARD 2 - LVSWGR-03	PASS	TIA-568-C Multimode	76 ft	0.52 dB (Loss Margin)	05/17/2015 11:29 PM
SWITCHBOARD 2 - LVSWGR-04	PASS	TIA-568-C Multimode	76 ft	0.59 dB (Loss Margin)	05/17/2015 11:29 PM
SWITCHBOARD 2 - LVSWGR-05	PASS	TIA-568-C Multimode	76 ft	0.50 dB (Loss Margin)	05/17/2015 11:31 PM
SWITCHBOARD 2 - LVSWGR-06	PASS	TIA-568-C Multimode	76 ft	0.42 dB (Loss Margin)	05/17/2015 11:31 PM
SWITCHBOARD 2 - MV-F60-01	PASS	TIA-568-C Multimode	56 ft	0.50 dB (Loss Margin)	05/17/2015 11:34 PM
SWITCHBOARD 2 - MV-F60-02	PASS	TIA-568-C Multimode	56 ft	0.62 dB (Loss Margin)	05/17/2015 11:34 PM
SWITCHBOARD 2 - MV-F60-03	PASS	TIA-568-C Multimode	56 ft	0.59 dB (Loss Margin)	05/18/2015 12:00 AM
SWITCHBOARD 2 - MV-F60-04	PASS	TIA-568-C Multimode	56 ft	0.76 dB (Loss Margin)	05/18/2015 12:00 AM
SWITCHBOARD 2 - MV-F60-05	PASS	TIA-568-C Multimode	56 ft	0.38 dB (Loss Margin)	05/17/2015 11:48 PM
SWITCHBOARD 2 - MV-F60-06	PASS	TIA-568-C Multimode	56 ft	0.76 dB (Loss Margin)	05/17/2015 11:48 PM
SWITCHBOARD 2 - RTU DROP	PASS	TIA Cat 6 Perm. Link	57 ft	3.6 dB (NEXT)	05/18/2015 02:22 AM
SWITCHBOARD 2 - RTU-01	PASS	TIA-568-C Multimode	81 ft	0.60 dB (Loss Margin)	05/17/2015 11:19 PM
SWITCHBOARD 2 - RTU-02	PASS	TIA-568-C Multimode	81 ft	0.57 dB (Loss Margin)	05/17/2015 11:19 PM
SWITCHBOARD 2 - RTU-03	PASS	TIA-568-C Multimode	81 ft	0.62 dB (Loss Margin)	05/17/2015 11:21 PM
SWITCHBOARD 2 - RTU-04	PASS	TIA-568-C Multimode	81 ft	0.54 dB (Loss Margin)	05/17/2015 11:21 PM
SWITCHBOARD 2 - RTU-05	PASS	TIA-568-C Multimode	82 ft	0.16 dB (Loss Margin)	05/17/2015 11:22 PM
SWITCHBOARD 2 - RTU-06	PASS	TIA-568-C Multimode	82 ft	0.25 dB (Loss Margin)	05/17/2015 11:22 PM

FLUKE networks

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Total Length:	11366 ft
Number of Reports:	62
Number of Passing Reports:	62
Number of Failing Reports:	0
Number of Warning Reports:	0
Documentation Only:	0

FLUKE networks

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Cable ID: SWITCHBOARD 1 - COMM RM01

Test Summary: PASS

Date / Time: 05/19/2015 04:27:33 AM n = 1.4690 (1310 nm)
Cable Type: Single-Mode - AB - OS1/2 n = 1.4690 (1550 nm)

Loss (R->M)
PASS

Date / Time: 05/19/2015 04:27:33 AM
Test Limit: TIA-568-C Singlemode ISP
Limits Version: 1.9300
Operator:
DTX-1800 (1173017 v2.7400)
Module: DTX-SFM2(1172023)
Calibration Date: 06/12/2014
DTX-1800R (1173028 v2.7400)
Module: DTX-SFM2(1172028)
Calibration Date: 06/12/2014

Propagation Delay (ns)	170	
Length ft	114	PASS
Limit 16404		
	1310 nm	1550 nm
Result	PASS	PASS
Loss (dB)	0.17	0.41
Limit (dB)	1.53	1.53
Margin (dB)	1.36	1.12
Reference (dBm)	-5.84	-6.31

Number of Adapters: 2
Number of Splices: 0
Patch Type: Single-Mode - AB - OS1/2
Patch Length1 (ft): 3
Patch Length2 (ft): 3
Reference Date: 05/19/2015 04:07:05 AM
1 Jumper

Compliant Network Standards:

1000BASE-LX	100GBASE-ER4	100GBASE-LR4
10GBASE-E	10GBASE-L	10GBASE-LRM
10GBASE-LX4	40GBASE-FR	40GBASE-LR4
Fibre Channel 100-SM-LC-L	Fibre Channel 1200-SM-LC-L	Fibre Channel 1600-SM-LC-L
Fibre Channel 200-SM-LC-L	Fibre Channel 400-SM-LC-L	Fibre Channel 400-SM-LC-M
Fibre Channel 800-SM-LC-I	Fibre Channel 800-SM-LC-L	

LinkWare™ PC Version 9.3

Test Results.flw

FLUKE networks

LINKWARE™ PC
CABLE TEST MANAGEMENT SOFTWARE

Cable ID: SWITCHBOARD 1 - LVSWGR-01
Date / Time: 05/18/2015 12:23:53 AM n = 1.4830 (850 nm)
Cable Type: GIGALite 10XB - XB - OM4+ n = 1.4780 (1300 nm)

Test Summary: PASS
Modal Bandwidth: 4900MHz-km (850 nm)
Modal Bandwidth: 4900MHz-km (1300 nm)

Loss (R->M)
PASS

Date / Time: 05/18/2015 12:23:53 AM
Test Limit: TIA-568-C Multimode
Limits Version: 1.9300
Operator:
DTX-1800 (1173017 v2.7400)
Module: DTX-MFM2(1172040)
Calibration Date: 06/12/2014
DTX-1800R (1173028 v2.7400)
Module: DTX-MFM2(1173007)
Calibration Date: 06/12/2014

Propagation Delay (ns)	88	
Length ft	58	PASS
Limit 6562		
	850 nm	1300 nm
Result	PASS	PASS
Loss (dB)	1.04	0.75
Limit (dB)	1.56	1.53
Margin (dB)	0.52	0.78
Reference (dBm)	-21.72	-22.34

Number of Adapters: 2
Number of Splices: 0
Patch Type: GIGALite 10XB - XB - OM4+
Patch Length1 (ft): 3
Patch Length2 (ft): 3
Reference Date: 05/17/2015 11:11:36 PM
1 Jumper

Compliant Network Standards:

10/100BASE-SX	1000BASE-LX	1000BASE-SX
100BASE-FX	100GBASE-SR10	100GBASE-SR4
10BASE-FL	10GBASE-LRM	10GBASE-LX4
10GBASE-SR	40GBASE-SR4	ATM155
ATM155SWL	ATM52	ATM622 Fiber Optic
ATM622SWL Fiber Optic	FDDI Fiber Optic	Fibre Channel 100-M5-SN-I
Fibre Channel 100-M5E-SN-I	Fibre Channel 1200-M5-SN-I	Fibre Channel 1200-M5E-SN-I
Fibre Channel 133	Fibre Channel 1600-M5-SN-S	Fibre Channel 1600-M5E-SN-I
Fibre Channel 1600-M5F-SN-I	Fibre Channel 200-M5-SN-I	Fibre Channel 200-M5E-SN-I
Fibre Channel 266	Fibre Channel 266SWL	Fibre Channel 400-M5-SN-I
Fibre Channel 400-M5E-SN-I	Fibre Channel 400-M5F-SN-I	Fibre Channel 800-M5-SN-S
Fibre Channel 800-M5E-SN-I	Fibre Channel 800-M5F-SN-I	

LinkWare™ PC Version 9.3

Project: ROSSLYN METRO STATION
Test Results.flw

Site: ROSSLYN METRO STATION

FLUKE networks

END OF SECTION

NOTES:

1. THE DESIGN BUILDER SHALL DESIGN, PERMIT AND CONSTRUCT A PAVED DRIVEWAY FROM POTOMAC GREENS DRIVE/ CARPENTER ROAD TO THE STATION AS SHOWN ON THIS DRAWING, INCLUDING LIGHTING AND PERIMETER FENCING.

2. DRIVEWAY SHALL BE ADA-COMPLIANT FOR PEDESTRIAN USE. SIDEWALKS ARE NOT REQUIRED.

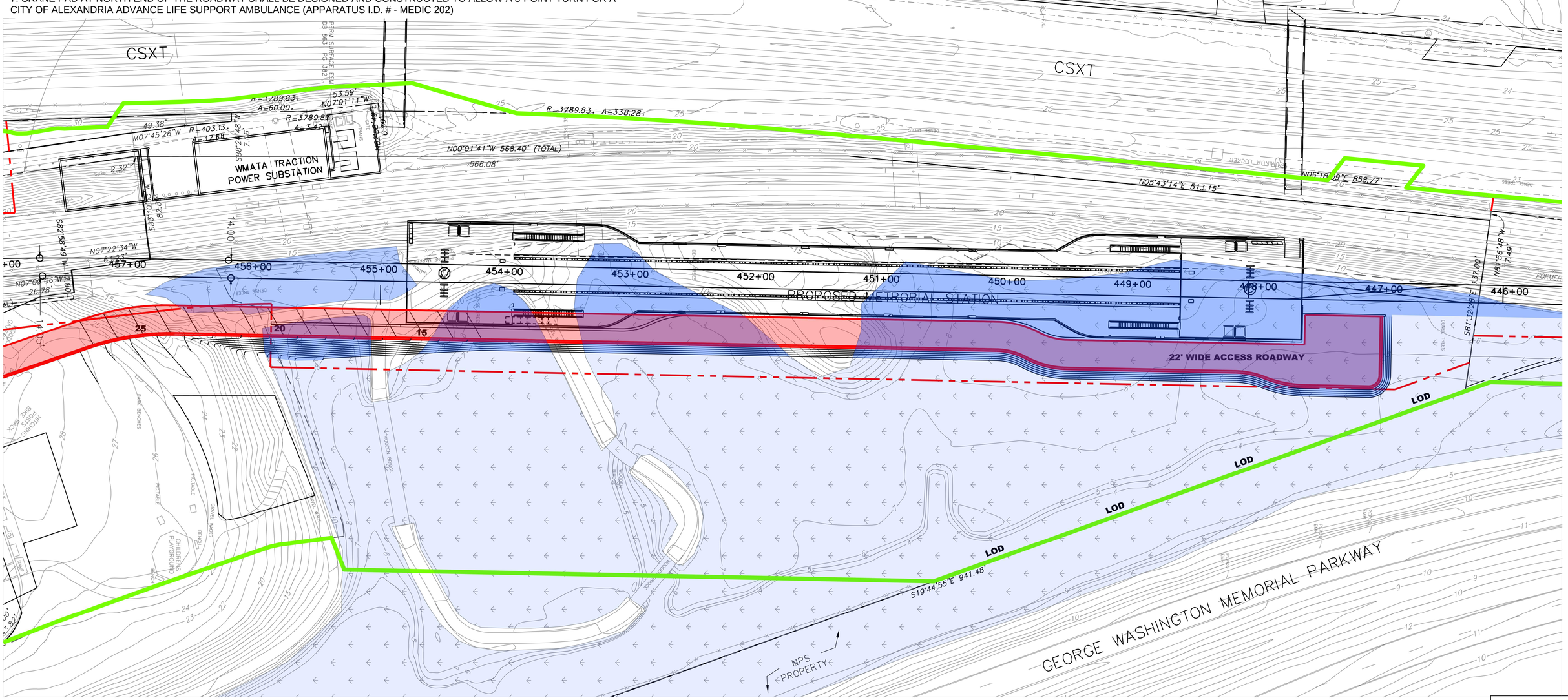
3. DRIVEWAY SHALL BE DESIGNED FOR HS-20 LOADING.

4. PAVEMENT SHALL BE NON-PERMEABLE, AND PROPOSERS ARE NOT BOUND TO THE LOCATIONS OF PERMEABLE SURFACING SHOWN ON DRAWINGS C04 AND C05. THE FINAL DESIGNER HAS DISCRETION TO DEVELOP ALTERNATE SWM SOLUTIONS TO REFLECT THE REDESIGN OF THE STATION ENTRANCES.

5. DRIVEWAY AND GRADING SHALL NOT INCREASE DISPLACEMENT OF WETLANDS.

6. ORIGINAL STATION PLAN SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.

7. CRANE PAD AT NORTH END OF THE ROADWAY SHALL BE DESIGNED AND CONSTRUCTED TO ALLOW A 3-POINT TURN FOR A CITY OF ALEXANDRIA ADVANCE LIFE SUPPORT AMBULANCE (APPARATUS I.D. # - MEDIC 202)



CONTRACT NO.
FQ16146

DESIGNED		DATE
DRAWN	MH	3.29.2018 DATE
CHECKED		DATE
APPROVED		DATE

REFERENCE DRAWINGS		REVISIONS		
NUMBER	DESCRIPTION	DATE	BY	DESCRIPTION

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
OFFICE OF THE CHIEF ENGINEER, INFRASTRUCTURE

SUBMITTED _____ DATE

APPROVED CHIEF ENGINEER _____ DATE

POTOMAC YARD METRORAIL STATION
ACCESS ROADWAY
ALTERNATIVE 4
WETLAND IMPACT AREA: 59,650 SQFT (APPROX.)

SCALE	DRAWING NO.	SHEET NO.
	SK-202	