

**SECTION 16051D
SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SCOPE OF WORK**

PART 1 – GENERAL

1.01 SUMMARY

- A. The scope of this section includes the design, furnishing, installing and testing of equipment and network to support the protection, control and monitoring of Tie-breaker Stations (TBS) equipment by the Advanced Information Management System (AIM), Supervisory Control and Data Acquisition (SCADA) and Automated Energy Management System (AEMS) in JGB/CTF OCC.
- B. The network will serve a purpose of a remote controlling or status monitoring of equipment inside the facilities as specified here or in the other sections. The network will connect together various devices like Multi-purpose Protection Relays (MPR) and other Intelligent Electronics Devices (IED) specified here and in other sections to the SCADA system via the SCADA RTU installed in each station. The scope further includes furnishing of gateways (network switches or routers), Programmable Relays, Timers, etc... as required to meet the functional requirement as defined here and on the other sections of SCADA Specifications.
- C. The TBS local area network serves as a communication medium between station devices like protective/metering devices, HMI and distributed I/O of the station electrical system and the station SCADA RTU. Each device in the station connects with the Wide Area Network (WAN) through the station Network Switch to provide remote control and monitoring from the OCC and remote monitoring from Engineering/Maintenance consoles .
- D. The SCADA system inside TBS will mainly control and/or monitor as applicable DC switchgear, Digital trace recorders, uninterruptable power supplies (UPS), battery cycle monitor, emergency trip system, feeder cable shield monitor, and ancillary equipment installed inside the station.

E. Related Sections:

- 1. Section 01110 - Scope of Work AM1
- 2. Section 16052 - Basic Materials and Methods for Traction Power. AM1
- 3. **DELETED**
- 4. Section 16149 - Wire, Cable and Termination Panel For SCADA System AM1
- 5. Section 16265 - Battery and Battery Monitoring Systems AM1
- 6. Section 16291A - Human Machine Interface (HMI) Panel For Traction Power
- 7. Section 16341 - Metal Enclosed D.C. Switchgear For Traction Power
- 8. Section 16602 - RTU for Traction and AC room Systems.
- 9. Section 16603 - DC Digital Trace Recorder for Traction Power.
- 10. Section 16604 - Network Switch For SCADA and Automation Systems
- 11. Section 16605 - Distributed input output (DIO) module for Traction Power
- 12. Section 16606 - SCADA Systems Site Acceptance Test Plan
- 13. **Section 16266 - Battery Charger** AM1

1. Have 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. Have manufactured and supported standard lines of microprocessor based control and monitoring equipment and application software continuously for the last five years.
3. Have in existence at the time of bid, an 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. Provide system hardware components and software packages of fully developed, field proven standardized designs and therefore shall furnish a system that is not a highly unique, custom one-of-a-kind system.
5. Have a minimum of five years of experience in hardware application and programming of Remote Terminal Units and data highway systems.
6. Provide standard course offerings in general control applications and in operation, programming and maintenance of the control system and equipment.
7. Have a system of traceability of the manufactured units, of "Burn-In" for all components and available supportive documentation which proves that the proposed equipment meets all of the manufacturer's testing codes and standards, operational, functional, environmental (physical and electrical) and configuration requirements of these specifications.
8. Have a demonstrated record of prompt response to field failures, documented program of failure analysis.
9. Have a record of prompt shipments in accordance with contract obligations required for previous projects.
10. Have a certificate that show the proposed Remote Terminal Unit conforms to IEC 61850 communication networks and systems in substation at the time of bid.

F. 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 representatives 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 certification for IEC61850 protocol.
5. Describe standard software packages proposed, including any customized software required to meet the functional intent of the system specifications. Descriptions shall address the following:
 - a. Overview of system software including the functions, organization and interrelationship of

AM1

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, 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 to 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. Contracting Officer Representative 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 Contracting Officer 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.

1.06 SCADA SYSTEM TRAINING

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to perform and coordinate all required training at times acceptable to WMATA. No part of the training shall be construed as a substitution for complete and comprehensive Operations and Maintenance (O&M) manuals, but should follow the same organizational structure as the O&M manuals.
- B. CONTRACTOR shall retain the services of the RTU Manufacturer or their authorized representative (the SCADA System Integrator) to provide training for all SCADA equipment as specified herein. |AM1
- C. For equipment items not manufactured by the RTU manufacturer, the Supplier shall provide for on-site training by an authorized representative of the equipment manufacturer as part of the Supplier's services. The manufacturer's representative shall be fully knowledgeable in the engineering, operation and maintenance of the equipment.
- D. CONTRACTOR shall be responsible for all costs for training OWNER personnel and shall provide all required materials, texts and required supplies. All OWNER training shall be conducted at the OWNER's facility.
- E. All training shall be conducted to meet the needs of the OWNER personnel during all shifts.
- F. CONTRACTOR shall submit his plan for training OWNER maintenance Personnel and engineers. Included in the plan shall be course outlines and schedules for training to be provided at the Owner's facilities.
- G. SCADA SYSTEM MAINTENANCE TRAINING COURSE:
 - a. Provide on-site operation and maintenance training by Supplier and the equipment manufacturer representatives prior to placing the equipment in continuous operation. The services of equipment manufacturer's representatives shall be provided for a minimum of eight hours for each type of instrument provided or as specified in the general section of the contract.
 - b. Provide course covering preventive and troubleshooting maintenance for the system components. The course shall familiarize the student with diagnostic capabilities of the system,

both software and hardware, and also the routine maintenance procedures on the system and the common peripheral devices.

c. Training shall cover the following topics:

1. System overview description including the power subsystems and logic components of the processor bus.
2. Description of the maintenance and troubleshooting aids of the system. Provide instruction covering procedures for routine, preventive and troubleshooting maintenance including equipment calibration.
3. Description of peripheral and interface devices.
4. Development and use of system displays.
5. Provide instruction covering use and operation of the equipment to perform the intended functions.
6. Explain procedures for placing the equipment in and out of operation and replacing equipment/components.
7. Explain necessary actions and precautions to be taken regarding the overall facility monitoring and control system.
8. Provide all instructions necessary to operate and utilize all system components.
9. Provide all instruction necessary to monitor and control the system from the HMI panel.
10. Provide instructions for regular caretaking operations.

H. ENGINEER TRAINING:

- a. The SCADA System Supplier shall retain the services of the SCADA RTU manufacturer or their authorized representative to provide training as follows: | AM1
1. Provide an overview of system hardware and software.
 2. Overview of systems functional capabilities.
 3. Equipment overview including system component functions, operating principals and proper use.
 4. Loading and start-up of the digital system hardware components.
 5. Training in configuration, operation, use of system commands and programming processors.
 6. The emphasis shall be placed on how to perform set point changes, programming, programming changes, range changes, diagnostics and upkeep of documentation.
 7. Description of the maintenance and troubleshooting aids of the system, including software diagnostic programs.

8. Description and review of all RTU and SCADA system software programs

1.07 GENERAL SYSTEM DESCRIPTION

The SCADA system provides for remote control and monitoring of the Tie Breaker Station systems from the Operational Control Centre (OCC) and from the SCADA /Automated Energy Management System (AEMS) located in the Jackson Graham Building and Carmen Turner Facility (JGB/CTF). Block diagram of the SCADA architecture is provided separately for reference. A dedicated fiber optic WAN connects the SCADA master stations at the JGB/CTF to SCADA systems at remote sites like tie breaker stations.

- A. At each site a SCADA RTU is provided to act as a data concentrator. Network Switches shall also be provided to connect all fiber and Ethernet cables from traction power and Electrical Room equipment also serves as a gateway to connect the site LAN to the SCADA WAN router. The CONTRACTOR will provide the RTU, HMI, fiber and copper products as specified and shown in the drawings for each site unless otherwise specified by the general section of the contract.
- B. WMATA will provide the network switches unless otherwise specified by the general section of the contract.
- C. 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.
- D. The new SCADA system shall be designed in such a way that it will be fully compatible to tie in to the existing Advanced Information Management System (AIM) and Automated Energy Management System (AEMS) using DNP3 communication protocol.
- E. All hard-wired connections to the SCADA system are made through the SCADA RTU.
- F. All Ethernet (fiber or copper) connections to the SCADA are made through the Network Switch directly.

1.08 SCOPE OF THE WORK:

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, program, calibrate, test, start-up and place in satisfactory operation a complete Supervisory Control and Data Acquisition (SCADA) System.
- B. 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 and start-up of all 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 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. AM1

2.04 DEVICE MEASURING AND MONITORING REQUIREMENTS

The SCADA system shall be capable of displaying meter values concerning TBS 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. 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 and start-up of all 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 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. | AM1
- B. Tie Breaker Station RTUs will be furnished by the Contractor. The CONTRACTOR must install these RTU's as required by the Contract Documents. The programming and integration of the RTU's will be done by the manufacturer of RTU or the representative. | AM1
- C. RTU interface circuitry shall be installed in conformance with the typical RTU control and indication circuits shown on the Contract Drawings and connected to the RTU as indicated on the approved RTU Scan Sheets submitted.
- D. Contractor shall furnish, install and terminate two six pair single-mode fiber optic cables, between the Communication room Data Switch and the Network Switch provided at Greenwich ST and Benning RD TBS | AM1
- E. The CONTRACTOR shall provide and install Multi-mode fiber optic cables specified by WMATA IT to link each DC switchgear MPR, DIO, DTR, IED, SCADA RTU and equipment with fiber ports to the facility's Network Switches as specified in Section 16604.
- F. The WMATA IT will install the WMATA furnished network switches on the RTU equipment rack, the contractor shall provide control power the network switches.
- G. The CONTRACTOR shall provide and install fiber patch panel and connectors for the DC switchgear, SCADA RTU and the Network Switch. The CONTRACTOR shall also provide and install pre-fabricated jumper fiber cables between patch panels and end devices.
- H. The CONTRACTOR shall provide and install Human Machine Interface (HMI) as specified in the technical specification 16291A in each Tie Breaker Station. The programming and integration of the HMI's will be done by the Contractor.
- I. Microprocessor based DC relays (MPR), Distributed Input output modules (DIO), DC Trace Recorders (DTR), Track Feeder shielded cable monitors (CSM) installed by the manufacturer of the DC switchgear shall be integrated to the TBS SCADA system by the contractor.

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

3.03 INTEGRATION WITH OCC SCADA SYSTEM

- A. TBS SCADA RTU mapping shall be verified for full integration and compatibility with the existing AIM/AEMS SCADA systems at OCC.

3.04 SCADA SYSTEM START-UP AND FIELD TEST

- A. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install all equipment and coordinate all activities necessary to perform check-out and start-up of the equipment.
- B. 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 and start-up of all 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 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. | AM1
- C. CONTRACTOR, under the supervision of the SCADA System integrator and other manufacturers' representative shall perform the following:
 - a. Check and approve the installation of all SCADA System components and all cable and wiring connections between the various system components prior to placing the various processes and equipment into operation.
 - b. Conduct a complete system checkout and adjustment, including calibration of all instruments, 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 Contracting Officer Representative may witness any or all of this checkout and testing.
 - c. Upon completion, complete documentation for this checkout and testing shall be submitted.
 - d. CONTRACTOR shall provide test equipment necessary to perform the testing during system checkout and start-up. CONTRACTOR shall transfer the Laptop, software and the High Current test set to WMATA the after all final testing and commissioning.
 - e. 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.
 - f. CONTRACTOR shall furnish to the Contracting Officer Representative certified calibration reports for field instruments and devices specified in Section 16606 and other sections as soon as calibration is completed.
 - g. CONTRACTOR shall furnish Contracting Officer Representative an installation inspection report certifying that all equipment has been installed correctly and is operating properly. The

- 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 shielded 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 an approved hand held tester from an industry recognized test equipment manufacturer. AM1
 - b. The cables shall be tested from patch panel to patch panel and patch panel to workstation 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 clearly defined in an RFI.
3. Testing shall be conducted in accordance with the latest revision of TIA-526-7, Method B for single-mode fibers.
4. Test 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. These tests also include continuity checking of each fiber.
7. 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.
8. Where links are combined to complete a circuit between devices, the Contractor/Installer shall test each link from end to end to ensure the performance of the system. ONLY LINK TEST IS REQUIRED.
9. The contractor/installer can optionally install patch cords to complete the circuit and then test the entire channel.
10. 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.
11. Attenuation testing shall be performed with an approved hand held tester from an industry recognized test equipment manufacturer. Fiber cable characterization report shall be generated for each installed fiber and submitted as detailed in the System Documentation section of this specification. AM1
12. A minimum of 0.11dB or higher headroom/margin is required AM1

3.03 SYSTEM DOCUMENTATION

- A. Upon completion of the installation, the contractor/installer shall provide three (3) full documentation sets 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. In the event the "birth certificate" was destroyed or lost the contractor/installer is responsible for contacting the factory of origin for a certified duplicate copy.
- C. Documentation shall be submitted within ten (10) working days of the completion of each testing phase (e.g. subsystem, cable type, area, floor, etc.). This is inclusive of all test result and draft as-built drawings.

APPENDIX B: SAMPLE TEST REPORTS



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 12:23 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

AM1

REJECTED

REJECTED



1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:

1. Equipment for each facility shall be delivered after its completion and in accordance with the Special Provisions and shall be coordinated with the Authority.
2. Ship each unit securely packaged braced and labeled for safe handling in shipment and to avoid damage or distortion.
3. Temporary Bracing: Where necessary, brace switchgear for hoisting, lowering and skidding into position. Label temporary internal bracing: TEMPORARY-REMOVE BEFORE OPERATION
4. Protection against Concealed Damage: Include within shipping container mechanical impact recorder of rating recommended by manufacturer for shipment by railroad and submit impact record chart with manufacturer's instructions for disposition of damaged material.
5. Assembly for Shipment:
 - a. Design enclosures to permit lifting by jacks or slings and moving horizontally on rollers or skidding in any direction.
 - b. Maximum dimensions of shipping sections to be coordinated with the dimension of doors and access hatches to ensure shipping dimension will allow movement of switchgear through structure without damage to equipment or structure or undue difficulty.
 - c. Draw-out relays mounted in their proper cases with moving parts properly secured and packed for shipment.
 - d. Removable circuit breaker elements packaged separately.
 - e. For shipping split, interconnecting wiring coiled on one side of the shipping split with matching terminal block on other side of split. Wiring and terminal block points identified for reconnection.
6. Store switchgear in secure and dry storage facility.
7. Temporary Bracing: Where necessary, brace switchgear for hoisting lowering and skidding into position

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer List:

1. The switchgear/breakers shall be manufactured by the following or pre-approved equal:
 - a. Secheron

| AM1

SECTION 16602

REMOTE TERMINAL UNIT (RTU) FOR TIE BREAKER STATIONS

PART 1 - GENERAL

1.01 SUMMARY

- A. This section provides requirements for vendors who will design, supply, manufacture, install and configure Remote Terminal Units (RTU) required at Tie Breaker Station (TBS), for Supervisory Control and Data Acquisition (SCADA).
- B. The specification 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 is applicable to all new SCADA system RTU and to those that are replacing existing RTUs.
- D. The RTUs interface to the electrical within TBS 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 optic cable.
- E. The RTUs interface into Intelligent Electronic Devices (IEDs) such as Distributed Input Output (DIO) and electrical protection relays, provide for control outputs to switch circuit breakers, lighting contactors and Emergency Trip Station (ETS) amber light systems.
- F. Provide at the time of bid, a certificate from an independent testing company that the RTU has not shown to be non-conforming to IEC 61850 communication networks and systems in substation. AM1

- G. Related Sections:
 - 1. DELETED AM1
 - 2. Section 16051D- Scope of Work For Supervisory Control and Data Acquisition Systems
 - 3. Section 16052- Basic Materials and Methods For Traction Power
 - 4. DELETED AM1
 - 5. Section 16128- Wire and Cable For Traction Power
 - 6. Section 16130 - Raceways, Boxes and Cabinets
 - 7. Section 16145 - Wiring and Control Devices
 - 8. Section 16149 - Wire, Cable and Termination Panel For SCADA System

1. Provide at the time of bid, a certificate from an independent testing company that the RTU has not shown to be non-conforming to IEC 61850 communication networks and systems in substation.
2. Shop Drawings: Show the following as a minimum:
 - a. Equipment layouts
 - b. Electrical wiring diagrams and detailed control schematics.
 - c. Electrical and mechanical details
 - d. Wire and cable schedules, interconnection diagrams, point assignment charts, and connection diagrams
 - e. RTU point count for various facilities in accordance with Table-1.
 - f. Composite control/status and telemetering sensing equipment schedule.
3. Product Data: Submit annotated product data for each item of equipment and revise resubmittal required when mechanical or electrical equipment are revised or modified.
4. IEC 61850 protocol certification: Provide a certificate from an independent testing company that conformance test has been successfully performed on the proposed RTU according to the IEC 61850 conformance test procedures.
5. As-Built Documents: Prior to Substantial Completion develop as-built documents as follows:
 - a. As-built drawings of the installation: Submit as-built drawings of all the works done under this specification for approval. Submit approved as built drawings in both printed hard copies and as digital copies on approved medium. 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.
 - 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:
Operations and Maintenance Manuals:

AM1

- B. Instructional Period: One day per session, three (3) Sessions AM1

- C. Instruction:
 - 1. Train personnel in preventative maintenance on systems and to recognize malfunctions.
 - 2. A minimum of one day devoted to hands-on demonstration of the equipment operation, trouble analysis, repair, adjustment and maintenance.
 - 3. Provide copies of the O & M manuals as specified above for each person being trained. Use these manuals in organizing the instruction.

1.07 TRAINING OF RTU MAINTAINERS:

- D. Training of SCADA System maintainers in the operation and maintenance of RTUs may be required. This shall be required normally for any new RTU products, but may also be required for familiarity training as part of a refresher course for both new and existing personnel.

- E. The courses shall cover aspects of the RTU design sufficient for the maintainers to maintain the RTU over its design life. Contents shall include:
 - 1. RTU operation and data communications protocols
 - 2. Diagnostic tools provided with the RTU and test equipment to fault find an RTU
 - 3. Failure modes
 - 4. Configuration of the RTU

- F. Instruction Period: One day per session, three (3) sessions AM1
- G. 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 the project or contract.

1.08 ENGINEERS' TRAINING COURSE:

- A. Provide on the Owner's premises, one course sessions of classroom and hands-on instruction in the development of RTU configurations files, the programming of the RTU. The course session shall be three days in length. The presentation of the course shall accommodate up to 7 engineers designated by the Owner.

- B. The presentation of the course shall occur before the installation of the first RTU.

Course Description: In depth discussion of the configuration Software, development of complete configuration files for the TBS in the contract.

1.09 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 RTU manufacturers are pre-qualified to manufacture and supply RTUs to WMATA on the condition the proposed equipment meet all the requirements in this specification. A certificate from an independent testing company that the RTU has not shown to be non-conforming to IEC 61850 communication networks and systems in substation must be provided at the time of bid for the propose RTU to be considered. AM1
- B.
 - 1. CG Automation Solutions (CGA)
 - 2. Schweitzer Engineering Laboratories (SEL)
 - 3. Novatech
- C. RTU SIZE AND EXPANDABILITY
 - 1. RTU shall be equipped for the 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.
- D. **TABLE 1: RTU CONNECTION POINT REQUIREMENTS**

RTU TYPE by Location	Control Points		Status Points	Analog Points		Accum Points
	Momentary	Latching		0-1mA	4-20mA	
Tie Breaker Station	8	8	24	16	16	8

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

2.04 RTU CONFIGURATION

- A. CONTRACTOR shall retain the services of the SCADA RTU manufacturer or their authorized representative to be the system integrator, develop RTU configuration files, supervise and/or perform check-out and start-up of all system components. | AM1
- B. The contractor's proposal shall include two weeks of services from the RTU manufacturer for the development of the TBS RTU configuration file template.
- C. The first week: The system integrator shall develop the RTU configuration file template and initial testing at their factory.
- D. The second week: The system integrator shall demonstrate at the WMATA SCADA LAB, that the provided RTU and configuration meet all requirements in this specification.
- E. The contractor shall provide a full functional RTU on an open rack for the tests at WMATA | AM1
- F. The RTU test Laptop and software specified in this section shall be used by WMATA SCADA engineers for the LAB tests and site tests.
- G. In addition to a lump sum price for configuration, an hourly rate should be quoted for assistance with configuration and commissioning. This rate shall be used for telephone assistance where the person providing assistance will not be required to attend site.

2.05 SENSORS AND TRANSMITTERS:

- A. General:
 - 1. Power the transmitters by a 24 dc loop power supply located in the RTU interface cabinet.
Auxiliary power supply, 120-volt AC input, 24-volt DC output shall be provided with each RTU for all transmitters.
DC power rating shall be capable of supplying the connected load plus 20-percent spare capacity.
- B. Sensors and Transmitters supply by others:
 - 1. Room air temperature transmitters shall be an element contained within a cover, suitable for mounting on a wall
Insulated base temperature range: Minus 20F to plus 120F
Accuracy of calibrated points: Plus or Minus 0.5F.
Sensing elements: Platinum wire resistance type.
Transmitter output signal: 4 to 20 milliamperes DC.

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.

2.10 SPARE PARTS:

- A. In accordance with special conditions and the following:
 1. Provide 20% spare of each type of circuit card, and 2 power supplies, 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, certified test results for the tests on each unit of Remote Terminal Unit supplied under this contract.
- B. CONTRACTOR shall retain the services of the RTU manufacturer to be the system integrator, supervise and/or perform check-out and start-up of all system components.

3.02 INSTALLATION

- A. RTUs shall be delivered and installed as shown in accordance with approved shop drawings at the following facilities:
 1. 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. **DELETED** AM1
- E. 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. **DELETED** AM1

SECTION 16603

Digital Trace Recorder (DTR) for Tie Breaker Stations

PART 1 - GENERAL

1.01 SUMMARY

- A. This section provides requirements for vendors who will design, supply, manufacture, install and configure Digital Trace Recorder (DTR), a data acquisition system for 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.
1. The data acquisition system records and saves DC currents, voltages and system disturbances on local hard drive securing data even if communications are lost during an even. All data will periodically be pulled into a central server location, for long-term archiving.
 2. The DTR shall be interfaced with DC switchgear current and voltage transducers, relays, switches and contacts. These units are not to provide remote control of switchgears thru LAN/WAN.
 3. The Digital Trace Recorder (DTR) shall be connected to the substation Network switch with fiber cable.
 4. The DTR analysis software shall have the functionality of a power analyzer, a data logger, a transient recorder and a FFT harmonic analyzer.
- B. Related specification sections include the following:
1. Section 16051D - Scope of Work For Supervisory Control and Data Acquisition Systems
 2. Section 16149 - Wire, Cable, Cable Tray and Termination Panel For SCADA System
 3. Section 16341 Metal Enclosed DC Switchgear
 4. Section 16602 RTU for Traction Power Systems
 5. Section 16604 Network Switch For SCADA and Automation Systems
 6. Section 16606 SCADA system integration site acceptance test plan

AM1

1. The DTR accessory parts or interfaces to 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.
- D. The Contractor shall develop test procedures based on the section 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 viewed and analysis using the approved software..
- G. Submit certified test report within ten days after completion of field tests.

AM1

AM1

1.04 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements in accordance with Special Provisions 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 control/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 which changes as a result of required modification.
 - a. Manufacturer's technical specification of the DTR product or its subassembly indicating all parameters, including frequency responses, maximum sampling rate capability, A/D conversion speeds etc... and when requested, impulse responses of DTR component or its accessory
 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.
 - d. Provide As-built drawing in both AutoCAD and PDF formats on CD in sleeves.
 4. Operation and maintenance (O & M) manuals:
 - a. Operation manuals should contain information pertaining to the operation of the facility. The maintenance manual is 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

AM1

- 13) Step-by-step detailed adjustment instructions for any mechanism or circuit found to be out-of-adjustment.
6. 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
 7. 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
- 1.05 TRAINING:
- A. Engineers and Operation and maintenance training may be required. This shall be required normally for any new DTR products, but may be required for familiarity training as part of a refresher course for both new and existing personnel. AM1
 - 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 an DTR
 3. Failure modes
 4. Configuration of the DTR
 5. Software
 - C. Instruction Period: 3 days, 3 sessions. The training courses shall be broken into individual days. The courses may be conducted on single days or multiple days, with multiple days not necessarily being consecutive days. AM1

- 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.

	TBS DTR CONNECTION POINT COUNTS				Maximum Required DTR Connections
	DC SWITCHGEAR		NEGATIVE SWITCHBOARD		
	BREAKER CURRENTS	BUS VOLTAGES	RETURN CURRENTS	RUNNING RAIL VOLTAGES	
Maximum number of Analog inputs	7	1	NA	NA	8
Maximum number of Digital Inputs from Relays	7	0	NA	NA	8
THE MINIMUM NUMBER OF ANALOG AND DIGITAL INPUTS SHALL BE PROVIDED ON DTR PROVIDED FOR TBS. REFER TO CONTRACT DRAWINGS FOR SITE SPECIFIC CONNECTION COUNTS. ADDITIONAL ANALOG AND DIGITAL INPUT MODULES SHALL BE PROVIDED AS REQUIRED					

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

1. 5000A :50mV
2. 7500A :50mV
3. 10000A :50mV
4. 15000A :50mV
5. 20000A 50mV

- C. Digital Trace Recorder Unit

1. Provided in wall mount cabinet
2. Power Source: 125VDC control power.

2.02 DC TRACE RECORDER

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A. GENERAL REQUIREMENTS

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.
2. Network synchronization method shall be used to allow the DTR's internal time clock to be synchronized over the substation LAN with the network time-synch master using the methods specified by the protocol.
3. The DTR shall include a Sequence of Event Recorder's (SOE) function to gather and time tag operational data from substation relays, as they react to a system event
4. Storage Methods: DTR shall be designed to store recorded data on a local solid state disk (SSD) storage device to give users adequate time to retrieve the records. Data may need to be stored on the recorder for up to 60 days under limited events situations and a minimum of 7days when the DTR are recording at its maximum sampling rate at each of its connected channel. The DTR's operating system installed on an internal flash disk is desirable.
 - a. 64 GB internal flash disk for OS is recommended
 - b. 240 GB removable SSD for data storage is recommended as a minimum storage capacity for TBS DTR.
5. All channels from each facility must be recorded and saved as a single file on a single hard drive to allow viewing and analysis of all data on a single screen. Software manipulations to combine DC switchgear data with DC switchboard data is not approved.
 - a. DTR module installed on the Negative switchboard shall therefore be connected to the positive switchgear DTR for data recording. Communication cable between the two units must enter the DC switchboard DTR through FRE conduit if it is copper.
 - b. For DTR systems that combines all input modules in a single main unit for both the DC switchgear and the DC switchboard, the DTR cabinet can be mounted on the substation wall. The contractor shall identify a new location for the DTR on the submittal drawings.
6. The DTR shall allow complete or partial data retrieval by way of connecting an appropriate device such as a laptop to the DTR while in the substation, or remotely, by using Ethernet access to the DTR from an approved terminal. The DTR shall also allow to setup for auto-data archiving to a central remote data archiving computer; a central server will call the recorder periodically to transfer data. No proprietary software shall be required to download the data files.
7. 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 a native file format. Software conversion from Excel or other file formats to the proposed software file format to view, and analyze is not acceptable.

8. The DTR shall be suitable for working on DC electrified areas, where the DC switchgear enclosure is ungrounded with +25VDC floating ground voltage.
9. The system shall be capable of working in a traction power facilities' environment where an ambient temperature ranges of -10 deg. C to +70 deg.C and relative humidity up to 95% at ambient temperature of 40deg. C. Special protection against ingress of dust, moisture etc. shall be provided.
10. The DTR shall interface with the substation Remote Terminal Unit (RTU) for alarm monitoring.
11. 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
 - d. Minimum 24 bit A/D (Preferably arranged as Dual A/D).
 - 1.
12. DTR system shall be provided with all required software for data acquisition. 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.

2.03 **DTR MODULE INPUTS:**

- A. Transducers installed in DC switchgear and switchboard provide the analog inputs and the DC protective relays provide the digital inputs to the DTR
 1. Voltage Transducers Characteristics :
 - a. A magnetic amplifier type transducers with the following characteristics are installed by the DC switchgear/switchboard manufacturer to provide complete isolation of the DTR input signal.
 - 1) Normal Operation Input range: -1000V to +1000 V
 - 2) Normal Operation Output range: -1mA to +1mA
 - 3) Disturbance/Fault Input range: -2000V to +2000V
 - 4) Disturbance/Fault Output range: -2mA to +2mA
 - 5) Input Impedance: 5000 ohms/Volt
 - 6) Load Impedance: Any load between 0-10K
 - 7) Accuracy: $\pm 0.5\%$ Rated Output @ 25°C
 - 8) Temperature Range: -10°C to + 70°C
 - 2.
 - b. Refer to Tables for point assignments.
2. Current Transducers Characteristics:

AM1

- a. Magnetic amplifier type current transducers with the following characteristics are installed by the DC switchgear/switchboard manufacturer to provide complete isolation of the DTR input signal.
 - 1) Normal Operation Input range: -100mV to +100 mV
 - 2) Normal Operation Output range: -2mA to +2mA
 - 3) Disturbance/Fault Input range: -250mV to +250 mV
 - 4) Disturbance/Fault Output range: -5mA to +5mA
 - 5) Input Impedance: 5000 ohms/Volt
 - 6) Load Impedance: Any load between 0-10K
 - 7) Accuracy: $\pm 0.5\%$ Rated Output @ 25°C
 - 8) Temperature Range: -10°C to + 70°C
 - b. Refer to Tables for point assignments.
3. Digital Input:
- a. Trigger contact from each breaker relay is connected to the DTR per Tables to trigger the DTR record in event mode.
- B. 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.
- C. 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.
- D. Digital Trace Recorder Units are provided to the DC switchgear and Switchboard manufacturers in wall mount cabinets for factory installation on the DC switchgears and switchboards.

AM1

2.04 Cabinets

- A. DTR Cabinet:
 - 1. Construction: NEMA 12.
 - 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 power source 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. Cabinet Size: 24" h x 20" w x 10" d
 - 6. Terminal Blocks:
 - a. Terminal blocks located within the DTR cubicle shall define the point of separation between DTR and the substation electrical system.

AM1

7. Field Wiring Terminals:
 - a. Terminate field wiring to terminal block according the DTR layout drawings.
8. 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.
9. 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.

CAUTION: DATA ACQUISITION SYSTEM SHALL BE SHIPPED SEPARATELY TO AVOID DAMAGES TO THE ELECTRONICS.

2.05 WIRING:

- A. Use shielded twisted pair cable for analog inputs and outputs.
- B. Use Multimode Fiber jumper cable from DTR to the DC switch patch panel.
- C. Use Ethernet fiber cable from DTR to substation network switch.

2.06 SOFTWARE:

Software shall be provided with each DTR system for the configuration of the DTR to measure and record data on internal storage device, to provide remote viewing, used for playback and analysis.

- A. DTR Configuration Application:
 1. Portable Laptop with the appropriate software shall be used to connect to DTR units after they are installed to configure with initial network parameters. The software used for such initial configuration shall be provided together with its license. .
 2. The application shall include as a minimum the following to perform setup and configurations of the DTR's:
 - a. A startup screen: This shall bring drop down menus to allow operations such as to create, modify current setup/configuration, download new setup or copy 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.

AM1

- i. Configure trigger points with external trigger.
- j. Configure math/calculated channels.
- 3. DTR Recorded 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 by the viewing 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_YMMMDD_HHMM, where LLLL is location code, YMMMDD 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.
- 4. Screen Shots: For information only

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B. Viewing and analysis Application:

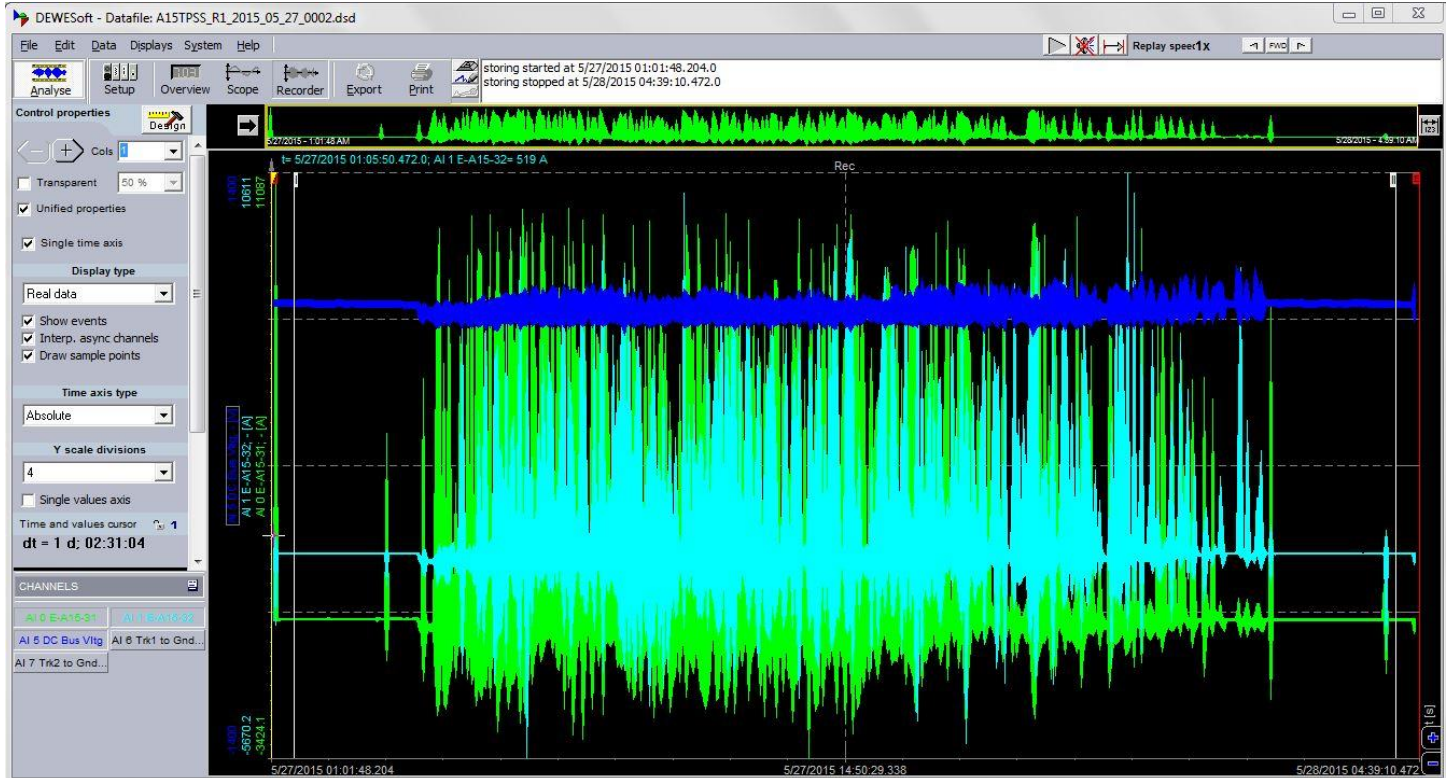
1. Licensed Software shall be provided to view, analyze and document recorded data.
2. The application shall display graphs and trends of the recorded analog data collected from DTRs. At a minimum, the application shall include the following:
 - a. Tracing/graphing of the trace file data into a two dimensional 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 24hours of recorded data.
 - b. By default, all channels shall graph in a single view window with option to select individual channel to display.
 - c. The software shall be capable of creating multiple view windows with option to select individual channel to display.
 - d. Each windows 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 whether or not the graphed data is viewable. 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. 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.
 - i. Standard engineering calculation accompanying report generation for each channel shall include; minimum, maximum average and maximum rate of change along with the plotted graph, These 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.
 - j. If displayed data is anything other than all, the application shall add a horizontal scroll bar to scroll left-right.
 - k. Provide hot keys for panning and zooming through mouse interaction. Panning shall be left-click and drag.
 - l. The software shall enable composite graphing of selected number channels in one window. This feature shall be accessible through appropriate drop down menu where its invoking shall cause the opening up of a new window separate 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 non similar 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

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- composite graph is viewable. A second Y-axis with a different range to accommodate for overlaying two different channel types (voltage and current).
- m. The software shall be capable of generating virtual channels using any number of recorded channels. For example it shall be possible to graph a composite graph of Traction power substation load by calculation using: $((\text{Cathode 1 current}) + (\text{Cathode 2 current})) \times \text{Bus Voltage}$.

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1. Sample Screen Shots: For information only



- C. Historical Server Data Storage Application:
2. 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.
 3. 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.
 4. Servers play vital role in making the DTR data available for multiple groups simultaneously.
 5. The SCADA historian Server will connect to the DTRs at predetermined intervals, to download and archive the recorded files to long term storage.
 6. 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.
 7. Default file naming shall be in the form LLLLL_YMMMDD_HHMM, where LLLL is location code, YMMMDD is the year, month and date of data collection, and HHMM is recording start time.
 8. The DTR files shall be archived in the historian servers in their native file format.
 9. The provided software or Dewesoft shall be used for data retrieval for view and analysis.
- D. Failure: DTR shall be monitored by the TBS SCADA system for communication failure as well as DTR failures.

E. DC Positive 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.

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3.04 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.

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TABLE 1: TBS POSITIVE SWITCHGEAR DTR POINTS FOR CGA DTR			
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			TB2-21-22

END OF SECTION