Metrolinx Electrification Project

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Electrification Performance Specification
EPS-08000 SCADA System
Final Version

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Submitted to:

Metrolinx

Submitted by:

PARSONS BRINCKERHOFF
Revision History

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1. PURPOSE

Metrolinx intends to implement traction power electrification within the Lakeshore and Kitchener corridors of GO Transit routes serving metropolitan Toronto. Studies have determined that this shall consist of a 2x25 kV ac system with a 1x25kV spur delivering power to trains by means of an overhead contact system (OCS), and collected by roof-mounted pantograph current collectors on each train’s locomotive or electric multiple unit (EMU) rail vehicles.

The performance specifications, 13 in all, have the purpose of establishing the basis for electrification design such that an efficient, safe, and cost-effective installation shall result.

The purpose of EPS-08000 Rail System Requirement SCADA System is to address the technical requirements of a Traction Electrification Supervisory Control and Data Acquisition (SCADA) system. This document provides the basis of a design for a system integrator to develop the necessary hardware and software; build the system, and install it in the Operations Control Centre and at remote locations; and test and commission the system in accordance with these specifications and recognized standards. This is a high-level document that describes system characteristics and behaviour from a Traction Power Director’s view. How the system itself functions is a matter of concern to the developer of the system, in conjunction with Metrolinx oversight. This SCADA system shall be exclusively for the control and monitoring of the TES.
2. SCOPE

EPS-08000 Performance Specification will cover the standards and design requirements for the SCADA system for the TES of Metrolinx.

The design of the SCADA for the TES shall be coordinated with the other portions of the TES, as prescribed within this document.

The SCADA system shall comply with IEC 61850.

The SCADA associated communication network and its Network Management System (NMS), is separate from the SCADA system.

The SCADA requirements for non-TES related subsystems are not included in this section.
3. REFERENCE DOCUMENTS

A reference document used as a source in preparing EPS-08000 is listed in Table 1: Reference Documents. Established standards for electrified railways and related topics relevant to SCADA are listed in Appendix A: Standards, at the end of this document. Other materials supporting the understanding of this document are provided in Appendix B: Definitions and Appendix C: Abbreviations and Acronyms.

Table 1: Reference Documents

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<th>Date of Issue</th>
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<td>Long Island Rail Road Power Supervisory Control and Data Acquisition Concept of Operations dated 4 November 2004</td>
<td>PB</td>
<td>Nov 2004</td>
</tr>
<tr>
<td>EPS-01000 Traction Power Supply System Final Version</td>
<td>PB</td>
<td>April 2014</td>
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<td>EPS-03000 Grounding and Bonding Final Version</td>
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<td>EPS-04000 Electromagnetic Compatibility and Interference Final Version</td>
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<tr>
<td>EPS-09000 Operations Control Centre Final Version</td>
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4. RESPONSIBILITIES

The EPS-08000 Rail System Requirements SCADA System plan and specifications are the responsibility of the Systems Engineering Team. It is the responsibility of all users of this document to:

- Develop detailed specifications and designs based upon the principles outlined in this document;
- Support all design work with back-up calculations which shall be made available to Metrolinx on request; and
- Inform Metrolinx in the event of any conflict between the contents of this document and any other document produced for the Metrolinx Electrification Project.
5. GENERAL REQUIREMENTS

This section shall include a general overview of the SCADA subsystem and its purpose within the TES system.

The SCADA system is the master system that monitors and controls remote data input/output units to and from the Operations Control Centre (OCC).

The SCADA system shall be comprised of a master station located at the OCC and remote SCADA equipment located in the field. Communications between the master station and the remote SCADA equipment shall use a fibre optic communications network and the appropriate communications equipment/protocols.

Bi-directional communications between each field device and the remote SCADA equipment shall form part of a local network using fibre optic cable, and in cases where a network interface is not available a report-processing module shall be used to connect to the field device.

Remote SCADA equipment and the master station shall contain communications signal processing and power supply equipment. The power supply equipment may be integral or located close by.

The SCADA system shall be a fully redundant system.

The SCADA system shall transmit metering data, indications, alarms, and controls in real time between trackside facilities and equipment and the OCC, via the fibre optic network. These transmissions shall include:

1. Metering information;
2. TES alarm and control signals and status indications;
3. TES related auxiliary and emergency power alarms and signals; and
4. TES related fire detection system monitoring signals.

Status reports, information storage and retrieval, alarm process, incident reports, and operations reports shall be provided at the OCC.
6. FUNCTIONAL REQUIREMENTS

This section shall include any requirements on which functions the SCADA subsystem shall fulfill within the TES system.

The system shall be capable of transmitting digital status and control data, and analog measurement data.

All processing equipment shall be individually addressable.

SCADA shall be based upon an open modular architecture approach, which is compliant with the Open Software Foundation Distributed Computing environment for distributed computing functions and portable among hardware platforms of different origin. The modular architecture shall permit expandability for:

1. Future extensions to the TES; and
2. Future non-TES applications.

The typical SCADA architecture is shown in Figure 1: Traction Power SCADA System Architecture Diagram.

The SCADA system in the Operations Control Centre shall include:

1. A minimum of two graphical user interface and two dedicated printers at the OCC’s Traction Power Director Consoles.
2. A minimum of one graphical user interface and one dedicated printer at the OCC’s equipment room.
3. The redundant Traction Power servers, Testing server, Large Display Server and Redundant Traction Power Programmable Logic Controller (PLC) shall in located in the OCC SCADA equipment room.
4. The display technology for the Large Screen Display shall be selected to achieve the best compromise between appearance, readability, and whole life cost. And subject to owner’s engineer for approval.

The SCADA system shall provide a minimum of one workstation per station to communicate with Field Level PLCs.
Figure 1: Traction Power SCADA System Architecture Diagram
The SCADA system shall:

1. Be self-monitoring (i.e. failure of any piece of equipment down to the individual printed circuit boards shall cause an alarm locally and at the OCC).

2. Incorporate hardware and software for access control features that prevent access by unauthorized persons; the unsuccessful login shall be alarmed and logged at OCC.

3. Employ industry standards for network interfaces (i.e. hardware and software).

4. Shall utilize bidirectional data transmission between the OCC and RTUs; indications and alarms shall be transmitted from RTU to OCC, control commands shall be sent from OCC to RTUs.

5. Have status reporting, information storage and retrieval, alarm processing, trending and incident and operations reports functions available at OCC SCADA consoles.

6. Allow playback function to replay historic/recorded files for post event analysis;

7. Be compatible with the Train Control System (at the OCC) and permit data exchange in real time.

8. Be expandable for future upgrade, and permit SCADA database generation and configuration update.

9. Include a four-digit 24-hour clock and Gregorian calendar.

**Traction Power Facilities**

Table 2: Minimum Traction Power Monitoring and Control Functions to be Accommodated by the SCADA System, lists the traction power minimum monitoring and control functions that shall be accommodated by the SCADA system.
### Metering

1. Traction Power Substations
   - a. Watts
   - b. Kilowatt-Hours
   - c. Kilovar-Hours
   - d. Amperes - line and feeder currents
   - e. Kilovolts - line and bus voltages
   - f. Kilovolts - power utility voltage

2. Switching and Paralleling Stations
   - a. Kilovolts - 25 kV ac line and bus voltages

### Functions

1. Traction Power Substations
   - a. 230 V Disconnect Switch (see note 1)
   - b. 230 kV Circuit Breaker (see note 1)
   - c. 230 kV Circuit Breaker Pressure Low (see notes 1 and 6)
   - d. Transformer Temperature 1st Stage (see note 1)
   - e. Transformer Temperature 2nd Stage (see note 1)
   - f. Transformer Door Open (see note 1)
   - g. Transformer's Automatic On-load Tap Changers (see note 1)
   - h. Transformer Oil Pressure (see note 1)
   - i. Transformer Oil Level (see note 1)
   - j. Transformer Fans On (see note 1)
   - k. 25 kV Main Circuit Breaker (see note 1)
   - l. 25 kV Tie Circuit Breaker (see note 1)
   - m. 25 kV Feeder Circuit Breaker (see note 1)
   - n. 25 kV Disconnect Switch (see note 1)
   - o. Fire Alarm
   - p. Intrusion Detection Alarm
   - q. SCADA System Alarm (see note 2)
   - r. Communication System Alarm (see note 2)
   - s. Auxiliary Power Alarm (see notes 3 and 4)
   - t. Emergency Power Alarm (see notes 3 and 4)
   - u. Remote Control
   - v. Local Control
   - w. Protection Relay Indication
   - x. 125 V dc System Trouble Alarm
   - y. 24 V dc System Trouble Alarm
   - z. Traction Power Substation Trouble Alarm

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<tr>
<th>Function</th>
<th>Control</th>
<th>Indication</th>
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<td>Local</td>
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<tr>
<td></td>
<td></td>
<td>OCC Local</td>
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<tr>
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<tr>
<td>a. Watts</td>
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<td>X</td>
</tr>
<tr>
<td>b. Kilowatt-Hours</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>c. Kilovar-Hours</td>
<td>X</td>
<td>X</td>
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<tr>
<td>d. Amperes - line and feeder currents</td>
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<tr>
<td>e. Kilovolts - line and bus voltages</td>
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<td>X</td>
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<tr>
<td>f. Kilovolts - power utility voltage</td>
<td>X</td>
<td>X</td>
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<td>2. Switching and Paralleling Stations</td>
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<td></td>
</tr>
<tr>
<td>a. Kilovolts - 25 kV ac line and bus voltages</td>
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<td>X</td>
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<tr>
<td><strong>Functions</strong></td>
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<td>b. 230 kV Circuit Breaker (see note 1)</td>
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<td>c. 230 kV Circuit Breaker Pressure Low (see notes 1 and 6)</td>
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<td>d. Transformer Temperature 1st Stage (see note 1)</td>
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<td>e. Transformer Temperature 2nd Stage (see note 1)</td>
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<td>f. Transformer Door Open (see note 1)</td>
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<td>g. Transformer's Automatic On-load Tap Changers (see note 1)</td>
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<td>h. Transformer Oil Pressure (see note 1)</td>
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<td>i. Transformer Oil Level (see note 1)</td>
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<td>j. Transformer Fans On (see note 1)</td>
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<td>k. 25 kV Main Circuit Breaker (see note 1)</td>
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<td>l. 25 kV Tie Circuit Breaker (see note 1)</td>
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<td>m. 25 kV Feeder Circuit Breaker (see note 1)</td>
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<tr>
<td>n. 25 kV Disconnect Switch (see note 1)</td>
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<td>o. Fire Alarm</td>
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<td>X</td>
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<tr>
<td>p. Intrusion Detection Alarm</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>q. SCADA System Alarm (see note 2)</td>
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<tr>
<td>r. Communication System Alarm (see note 2)</td>
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<td>s. Auxiliary Power Alarm (see notes 3 and 4)</td>
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<td>t. Emergency Power Alarm (see notes 3 and 4)</td>
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<tr>
<td>u. Remote Control</td>
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<td>X</td>
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<tr>
<td>v. Local Control</td>
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<td>X</td>
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<tr>
<td>w. Protection Relay Indication</td>
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<tr>
<td>x. 125 V dc System Trouble Alarm</td>
<td>X</td>
<td>X</td>
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<tr>
<td>y. 24 V dc System Trouble Alarm</td>
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<tr>
<td>z. Traction Power Substation Trouble Alarm</td>
<td>X</td>
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Table 2: Minimum Traction Power Monitoring and Control Functions to be Accommodated by the SCADA System
Notes are provided following Table 3: Minimum Traction Power Monitoring and Control Functions to be Accommodated by the SCADA System.

Table 3: Minimum Traction Power Monitoring and Control Functions to be Accommodated by the SCADA System, lists the minimum monitoring and control functions that shall be accommodated by the SCADA system.

<table>
<thead>
<tr>
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<th>Control</th>
<th>Indication</th>
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<td>Local</td>
<td>OCC</td>
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<td>1. Motorized Disconnect Switches</td>
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<td>2. Wayside Power Control Cubicles (WPC)</td>
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<tr>
<td>a. Fire Alarm</td>
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<td></td>
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<tr>
<td>b. Intrusion Detection Alarm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. SCADA System Alarm (see note 2)</td>
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<td></td>
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<tr>
<td>d. Communication System Alarm (see note 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Auxiliary Power Alarm (see notes 3 and 4)</td>
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<td></td>
</tr>
<tr>
<td>f. Emergency Power Alarm (see notes 3 and 4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Battery Trouble Alarm</td>
<td></td>
<td></td>
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<tr>
<td>h. WPC Trouble Alarm - e.g. thermostat, vent fan failure etc.</td>
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Table 3: Minimum Traction Power Monitoring and Control Functions to be Accommodated by the SCADA System

Notes for Table 2: Minimum Traction Power Monitoring and Control Functions to be Accommodated by the SCADA System and Table 3: Minimum Traction Power Monitoring and Control Functions to be Accommodated by the SCADA System:

1. Each piece of similar equipment shall be individually monitored and/or controlled.
2. A failure in the redundant SCADA equipment shall annunciate an event alarm.
3. When the emergency power source is activated due to loss of normal power, an event alarm shall be enunciated.
4. Where an uninterruptible power supply (UPS) is used, the following alarms shall be enunciated:
a. UPS Loss of Incoming ac Power;
b. UPS Low Battery Reserve;
c. UPS Rectifier Failure;
d. UPS Automatic Switch to Bypass Mode;
e. UPS Manual Switch Set to Bypass Mode;
f. UPS Switch to Bypass; and
g. UPS Switch to On-line.
h. UPS Status of External Maintenance Bypass Switch

Metering functions shall be analog and all other SCADA points shall be digital.

**SCADA Training Facilities**

A dedicated SCADA training facility shall be provided. The hardware platform for the Training setup shall be physically separated from the all systems to avoid system interruption. The Training Software shall provide the identical functions as the revenue SCADA software. Dedicated training manuals shall be provided.
7. OPERATIONAL REQUIREMENTS

This section includes any requirements on how the SCADA system will be operated.

The SCADA system design shall achieve the following operational objectives:

1. Permit complete control of the TES;
2. Indicate unambiguously the position of every controllable circuit breaker and switch on the TES and the status of equipment and/or subsystems;
3. Indicate the value of pre-determined analog quantities;
4. Provide an alarm condition if some pre-set value is exceeded;
5. Provide an alarm condition if a circuit breaker is automatically operated due to a fault condition;
6. Provide an alarm if an unintentional operation takes place; and
7. Indicate geographically the electrical condition (i.e. energized, isolated or grounded) of the TES.

Operational requirements also include the following:

1. At the OCC, all alarms shall be required to be acknowledged by the central control operator (power director/dispatcher), before they are cleared from the SCADA’s alarm summary list at the user interface.
2. The SCADA shall provide three levels of severity for alarm information: Minor/Major/Critical
3. At each user interface, a full-featured software program for defining and controlling user access to the SCADA system shall be provided. A system administrator shall define access capabilities for each user, user interface and each SCADA application and support function via access control displays.
4. Minimum two graphical user interfaces shall be provided at each traction power facility’s Control and Relay Room Equipment Enclosure.
5. No permanent user interface is required for Wayside Power Control Cubicles (WPC). However, the local SCADA equipment shall include a
laptop computer connection to permit connectivity by a portable laptop computer when necessary.

6. Communications design shall follow standard industry-accepted open and non-proprietary network communication protocols, i.e. Transmission Control Protocol/Internet Protocol (TCP/IP) or equivalent, and field communications protocols (between network and field equipment) shall be used.

**Operations Control Centre Space Requirements**

The size of the room depends upon the requirements of the Traction Power Director. A requirement’s study would need to be performed by the OCC designer to finalize this, but for planning purposes, a 20m by 30m room is sufficient. A second room, 20 metres x 15 metres is required for the SCADA communications equipment. Space shall be provided for a SCADA Service Centre, for the testing and repair of the SCADA system’s components.

**Operations and maintenance manuals**

SCADA manual shall provide instruction using step by step method, using figures to illustrate concepts, system operation/maintenance, and instructions for monitoring and controlling the SCADA system.
8. PERFORMANCE REQUIREMENTS

This section includes performance requirements for SCADA system, including response time, expandability, and spare provision.

SCADA system shall be:

- Provided with the processing capability and memory required for the Metrolinx Electrification including hardware platform, application programs, database, displays and logs
- Designed to have the capability to support minimum 30% additional processing increase in numbers of I/O without degrading performances
- Designed to operate 24 hours per day, seven days a week

The SCADA system shall be immune to electromagnetic interference (EMI) from nearby high current electrical equipment, to ensure safe and reliable operation under all loads and faults. Busbars shall be provided for grounding of all SCADA cabinets.

The SCADA equipment shall be capable of accommodating variations (without degradation in communications) in line impedance, delay distortion, or other causes that may be expected on these types of circuits.
9. EXTERNAL INTERFACE REQUIREMENTS

This section includes requirements with regards the interface to external (Non Metrolinx Electrification system) systems/bodies / authorities / agencies / companies, for instance Hydro One, and Bell.

The SCADA system shall have interface with Automatic Train Supervision system. Details of the interface shall be conducted during the Conceptual Design and Preliminary Design stages.

The electrification SCADA application shall be coordinated with TCS (Train Control System) SCADA and other Metrolinx SCADA systems for all interface including: software, hardware, and networking.

**Utility Interface:** The SCADA system shall not monitor nor control equipment owned, operated, and maintained by Hydro One but shall monitor the voltage on the high-voltage (HV) side of the main transformers at the traction power substations.
10. RELIABILITY, AVAILABILITY, MAINTAINABILITY REQUIREMENTS

This section includes relevant Reliability, Availability, and Maintainability (RAM) target requirement for SCADA system.

The SCADA system shall have a design life of at least 25 years.

SCADA equipment at traction power facilities (TPF) and WPC shall be housed in dedicated enclosures that can be incorporated into an equipment line-up or wall mounted. Cabinets within rooms shall be located so that rack-mounted equipment can be accessed via the front and the back of the cabinet. Equipment mounted within wall mounted enclosures or cabinets shall be mounted such that both front and rear access to the equipment is possible via swing-out equipment rack mounting. The design shall be such that maintenance of components can be performed easily in the field. All equipment, including motherboards or back planes shall be so arranged as to be readily accessible for inspection, maintenance, faultfinding, and repair.

Separate redundant communication, processing, power supply equipment, and input-output interface components, necessary as part of the SCADA system, shall be provided at each traction power facility, at WPC, and at the OCC.

Any single point failure within the SCADA system, hardware, or software, major or minor, including nodes common to primary or on-line and secondary or “hot-standby” equipment, shall not cause complete failure of its associated equipment or any other equipment.

During abnormal or contingency operations (e.g. modem or fibre optic cable failure), the SCADA system shall automatically switch to the secondary “hot-standby” equipment without loss of data.

All secondary “hot-standby” equipment shall be continuously monitored to the same extent as the primary on-line equipment.

The SCADA equipment at the OCC shall be powered from two 120 V ac, 60 Hz power sources, i.e. normal and emergency. The SCADA equipment at trackside facilities shall be powered from a battery or from an integral battery-backed power supply with preferred voltage of 24 V dc; or a 125 V dc control power source.
120 V ac circuits to SCADA equipment shall not provide power to other subsystems. Additionally primary on-line and secondary “hot-standby” equipment shall not be fed from the same 120 V ac circuit.

The SCADA system’s hardware and software shall be sized to include thirty percent spare equipment, points, and 100% system expandability for future growth and expansion of the TES.

The SCADA system shall be at least five years proven reliability of system and components in service in the industry before installation in the Metrolinx TES.

The SCADA system contractor and system integrator shall provide SCADA system design document and SCADA system maintenance manual document to Metrolinx TES.

Following RAM numbers for SCADA system will be defined during the Preliminary Design stage:

- Mean Time Between Service-affecting Failures (MTBSF) shall be more than:
- Mean Time Between Failure (MTBF) shall be:
- Mean Time To Repair (MTTR) shall be less than:
11. SAFETY REQUIREMENTS

This section includes requirement regarding safety.

SCADA system shall ensure a Safety Integrity Level for all functions.

Equipment associated with the SCADA system shall be located in secured enclosures or rooms to prevent unauthorized access. Failure of the SCADA software or hardware shall not create a less safe condition. Indication of such a loss shall be provided at the OCC. The safety aspects of alarm and redundancy features prescribed elsewhere in this specification shall be recognized in operations and maintenance features of the SCADA system, in order to facilitate safe responses under ordinary and emergency conditions.
12. ENVIRONMENTAL REQUIREMENTS

This Section includes requirements regarding Environmental, Electromagnetic Compatibility, Noise, and Vibration.

Environmental Requirements: Extremes

- Temperature Range: -40 °C to + 70 °C
- Maximum rainfall in 24 hours: 98.6 mm
- Maximum snowfall in 24 hours: 483 mm
- Humidex: 44.5
- Elevation: 77 metres

Cabinets and equipment that are not located within environmentally and particulate-controlled equipment rooms shall be NEMA-4 rated. These cabinets and enclosures shall be enclosed and lockable and be designed to meet the environmental requirements of the housed equipment.

The SCADA system shall be immune from EMI. The communications network shall be protected from EMI by the use of a fibre optic network and if necessary, all other equipment shall be shielded.
13. TESTING REQUIREMENTS

This section includes any requirement regarding the Testing and Commissioning of the SCADA system.

At any time, the testing and commissioning of the SCADA system shall not impact the existing all operation systems.

These test requirements apply to all components, hardware and software as well as the final system. The SCADA system shall allow performance of routine tests at any time to verify that the equipment is in correct working order, without interfering with the wiring and without removal of any primary on-line or secondary “hot-standby” equipment.

The SCADA system contractor and system integrator shall provide SCADA Testing Plan and SCADA Testing Report document. Both these two documents are subject to Metrolinx for approval.
14. TECHNICAL REQUIREMENTS

This section includes technical requirement regarding to the architecture of the SCADA system, in terms of redundancy, equipment hardware, and technology to be adopted.

Table 4: Description of the TES Equipment that is Controlled and/or Monitored by the TES SCADA System and its General Location, gives a description of the TES equipment that is controlled or monitored by the TES SCADA system and its general location.

<table>
<thead>
<tr>
<th>TES Equipment</th>
<th>Function</th>
<th>General Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Transformers</td>
<td>Transform voltage of incoming supply to 2x25 kV</td>
<td>Traction power substations (TPS)</td>
</tr>
<tr>
<td>Autotransformers</td>
<td>Boost the OCS voltage</td>
<td>Switching stations (SWS) and paralleling stations (PS) located along the right of way (ROW)</td>
</tr>
<tr>
<td>HV circuit breakers</td>
<td>To disconnect HV supply under load conditions and for protection of the system</td>
<td>HV side of the TPS</td>
</tr>
<tr>
<td>HV disconnect switches</td>
<td>To disconnect HV supply under no-load conditions</td>
<td>HV side of the TPS</td>
</tr>
<tr>
<td>25 kV circuit breakers</td>
<td>To disconnect 25 kV supply under load conditions and for protection of the system</td>
<td>At all TPS, SWS and PS</td>
</tr>
<tr>
<td>Motorized disconnect switches</td>
<td>To disconnect 25 kV supply under no-load conditions</td>
<td>At all TPS, SWS, PS, at railway stations and wayside crossovers, in storage yards, and in maintenance facilities</td>
</tr>
</tbody>
</table>

Table 4: Description of the TES Equipment that is Controlled and/or Monitored by the TES SCADA System and its General Location
Apart from the Train Control System and TES equipment interfaces, the TES SCADA system shall be a standalone system with no other external interfaces.

Redundant hardware shall be provided for SCADA system.

Equipment associated to SCADA system shall include, but not limited to the following:

- Servers with Quadruple CPUs or higher
- Data Storage Units
- High Speed Printers
- Workstations

The detail for SCADA hardware recommendation will be provided during the Conceptual Design and Preliminary Design Stages.

SCADA Remote Terminal Unit (RTU) shall operate in a full duplex mode with live scanning and reporting of the related system status.

Analog input, Digital input, and Contact inputs/outputs interfaces shall be provided.

The RTUs shall be able to interface with local and remote devices.

The RTUs shall be able to support various protocols using Ethernet, Serial links, and/or Wired/Wireless connections.

The RTUs shall have the capability to eliminate single bit errors and detect double bit errors.

Operating and application software shall be compliant with industry standards produced by standards organizations, such as the IEEE. All software shall be standard commercial off the shelf (COTS) software.

The software shall run in a Microsoft Windows operating environment and shall include standard application support programs as included in Microsoft Windows Office or other Metrolinx-approved application software packages.

Anti-virus/spam software shall be provided at all user interfaces and system servers.

All software licenses shall be supplied to Metrolinx.
User interfaces shall have the following features:

1. The user interface design shall be a graphical, intuitively user familiar Microsoft Windows based operating system.

2. A graphical user interface shall comprise a monitor, computer, keyboard, and cursor control device.

3. The user interface displays shall mimic the system single line diagrams and equipment symbols depicted on design documentation, including equipment and cable designations.

4. Energized and de-energized power equipment and/or conductors (i.e. circuit breakers, disconnect switches, 25 kV feeder and OCS circuits) shall be depicted by red and green respectively.

5. Operational and non-operational communication equipment and fibre optic cables shall be depicted by blue and green respectively.

6. Equipment that is switched to local control shall be depicted by yellow.

7. Equipment locked and tagged out by the power dispatcher shall be indicated by blue.
APPENDIX A: STANDARDS

The SCADA system shall be designed and implemented in accordance with codes and standards specified by the following organizations.

- **AREMA**  
  American Railway Engineering and Maintenance-of-Way Association
- **CENELEC**  
  European Committee for Electro-technical Standardization
- **CSA**  
  Canadian Standards Association
- **EEMAC**  
  Electrical and Electronic Manufacturers’ Association of Canada
- **IC**  
  Industry Canada
- **IEC**  
  International Electrotechnical Commission
- **IEEE**  
  Institute of Electrical and Electronics Engineers
- **IETF**  
  Internet Engineering Task Force
- **ISO**  
  International Organization for Standardization
- **NEMA**  
  National Electrical Manufacturers Association
- **OESC**  
  Ontario Electrical Safety Code
- **ULC**  
  Underwriters Laboratories of Canada
The contractor shall comply with the latest revision of the codes and standards identified below wherever applicable to the SCADA system at the time of award of the contract.

**IEEE Standard C17.1**
Standard Definition, Specification and Analysis of Systems Used for Supervisory Control, Data Acquisition and Automatic Control

**IEEE Standard 610**
Standard Glossary of Software Terminology

**IEEE Standard 829**
Software Test Documentation

**IEC 61850**
SCADA Protocol

**EN 50121:2000**
Railway Application – Electromagnetic Compatibility

**EN 50126: 1999**
Railway Applications: The specification and demonstration of Reliability, Availability, Maintainability, and Safety (RAMS)

**EN 50128: 2001**
Railway Applications: Communication, Signaling, and Processing systems – software for railway control and protection system

**EN 50159:2010**
Railway applications - Communication, signalling and processing systems - Safety-related communication in transmission systems
APPENDIX B: DEFINITIONS

**Electromagnetic Interference**  
An electrical emission or disturbance that causes degradation in performance or results in malfunctions of electrical or electronic equipment, devices, or systems.

**Operations Control Centre (OCC)**  
The central control and communication centre, consisting of displays and controls that permit all necessary interfaces with the train control and communication subsystems.

**Operations Control Centre Operator (OCC Operator)**  
Any operations staff member whose working area is the OCC and who uses train control equipment and other communication, control, audio, and visual equipment to interact with the System to achieve optimum System performance. The OCC Operator can refer to one or more such persons when describing actions or capabilities.

**Overhead Contact System (OCS)**  
The system that contains and supports the overhead Contact Wire for distributing power to the rail vehicles.

**Paralleling Stations (PS)**  
An installation that helps boost the OCS voltage and reduce the running rail return current by means of the autotransformer feed configuration. The negative feeders (NF) and the catenary conductors are connected to the two outer terminals of the autotransformer winding at this location, with the central terminal connected to the rail return system. OCS sections can be connected in parallel at PS locations.

**Switching Stations (SWS)**  
This is an installation where the supplies from two adjacent TPS are electrically separated and where electrical energy can be supplied to an adjacent but normally separated electrical section during contingency power supply conditions. It also acts as a
paralleling station (PS).

**Traction Electrification System (TES)**

TES is the combination of the traction power supply system (TPSS), the overhead contact system (OCS), and the traction power return system, together with appropriate interfaces to the TES-related supervisory control and data acquisition (SCADA) system. It forms a fully functional 2x25 kV ac traction power supply and distribution system and provides the traction power to the electrically powered vehicles on the Metrolinx electrified railway line.
APPENDIX C: ABBREVIATIONS AND ACRONYMS

ac  Alternating Current
COTS Commercial Off the Shelf
EMI Electromagnetic interference
EMU Electric multiple unit
EPS Electrification Performance Specifications
HV High Voltage
kV kilovolt
NMS Network Management System
OCC Operations Control Centre
OCS Overhead Contact System
PLC Programmable Logic Controller
PS Paralleling Station
RAM Reliability, Availability, and Maintainability
ROW Right-of-way
RTU Remote Terminal Unit
SCADA Supervisory Control and Data Acquisition
SWS Switching Station
TCP/IP Transmission Control Protocol/Internet Protocol
TES Traction Electrification System
TPF Traction Power Facility
TPS Traction Power Substation
UPS Uninterruptible Power Supply
WPC Wayside Power Control Cubicle